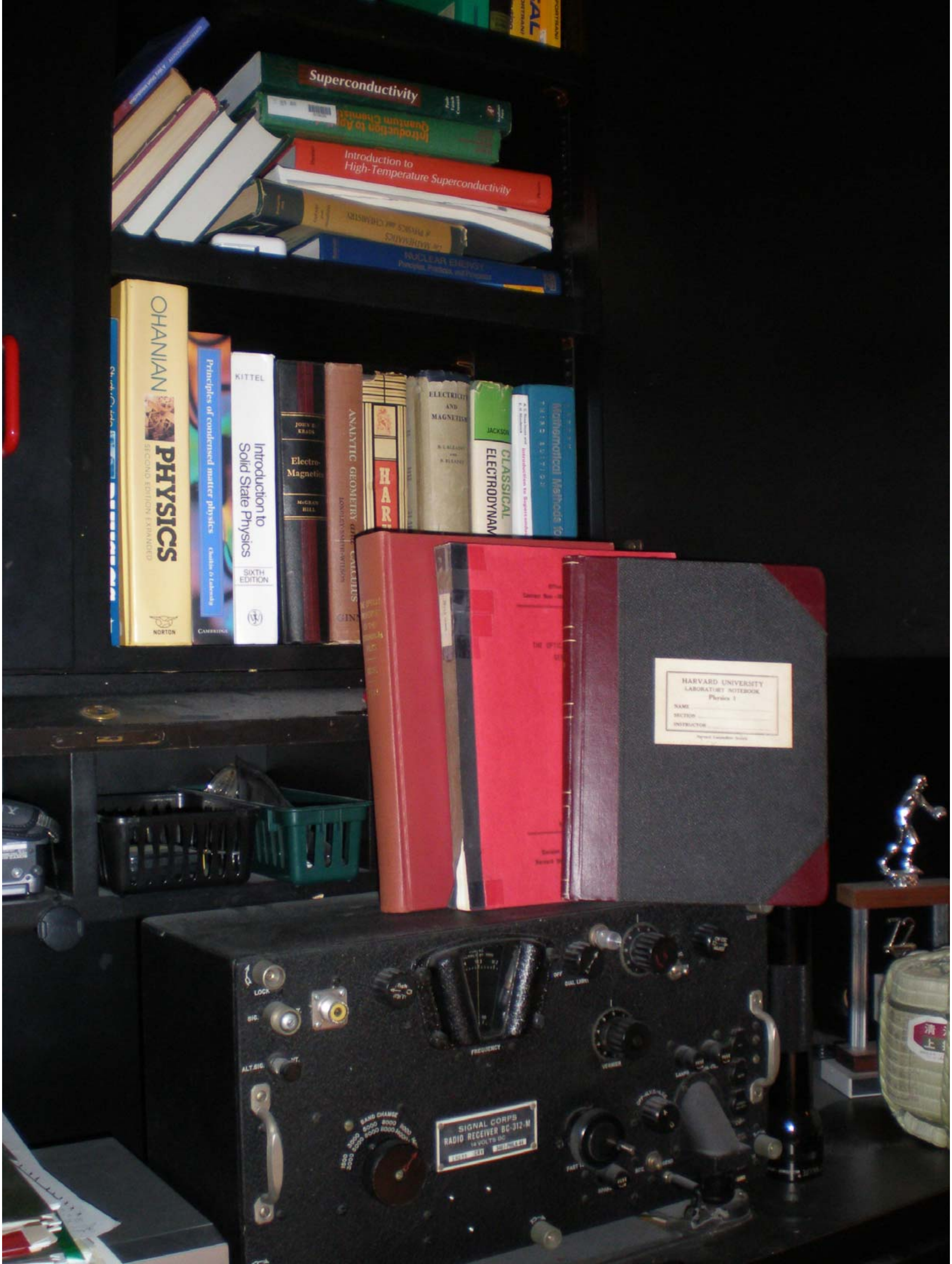

Superconductivity
Introduction to
High-Temperature Superconductivity
OHANIAN
PHYSICS
SECOND EDITION EXPANDED
NORTON
Principles of condensed matter physics
KITTEL
Introduction to
Solid State Physics
SIXTH
EDITION
ELECTRICITY
AND
MAGNETISM
JACKSON
HARVARD UNIVERSITY
LABORATORY NOTEBOOK
Physics 1
NAME
SECTION
INSTRUCTOR
SIGNAL CORPS
RADIO RECEIVER BC-312-M
FREQUENCY
LOCK
VERNIER

Paul M. Grant's Harvard PhD Thesis Lab Notebook
Gordon McKay Notebook, 9 May 1963 - 9 May 1965

All pages (including blanks and covers) scanned in "true color" in mid-December 2009.

Pages 39-46 and 2 tables re-scanned for clarity and appended at end of document.

Photograph of Notebook, "Red ONR Report (Dick Zallen's copy)" and Bill Paul's copy of thesis taken in PMG "W2AGZ Shack" early December 2009.

P

COOP

HARVARD UNIVERSITY
LABORATORY NOTEBOOK
Physics 1

NAME ....

SECTION ....

INSTRUCTOR ....

Harvard Coöperative Society

$1.95

THIS BOOK BELONGS TO

____

____

CLASS OF ______________

____

HARVARD COOPERATIVE SOCIETY
CAMBRIDGE, MASS.

9 MAY 1963

Today I began the checkout of the high-speed optical system. The different components, all drawings and descriptions, and modes of operation are contained in my files. This journal will be concerned only with the operation of the equipment and its use in performing experiments. All spectra shall contain references to this journal by date and possibly page.

I installed an RCA type 1P21 (S4) photomultiplier temporarily for use in checkout. Upon operation, found wiring error in amplifier. Once corrected, I made several scans of the output of the small GE tungsten lamp at slit widths from 100μ to 10μ. The reproducibility at 100μ to 25μ seemed excellent, but was poor at 10μ. This is quite probably due to scattered light because the source optics are as yet uncovered. The noise seems to be limited by the photomultiplier and the scattered light which is (at this time) a good sign.

While looking for the initial trouble in the amplifier, It was noticed that the Sola regulating transformer was causing a great deal of serious 60 cycle noise pick-up. This transformer has been disconnected and the source is now run straight from the line with the ballast tubes providing regulation.

Playing with the notch filter in the amplifier showed it to be quite effective in limiting noise. However, the mistake in wiring in the amplifier has caused some limiting in the low frequency response (it was B+ tied to the grid in the frequency control stage and must have caused drift of some component) but it is not serious and nothing has been done to correct it.

10 May 1963

Today I attempted to calibrate the system using the ultra-violet products low pressure Hg vapour lamp. Used a slit width of 10μ and observed all the lines. I am having some difficulty obtaining the proper line shapes and also some of the lines appear not to be in their proper place. I am still using the RCA 1P21.

Tonight I redid all the Hg lines. I suspect that the lineshape trouble is due to speed variations of some sort in the Jaco wavelength drive.

13 May 1963

Today I did some calculations on the spectra of Friday night in order to place some of the lines. However, these are in error as I assumed a chart speed of 180 in/hr instead of the correct 150 in/hr and I assumed that the scan speeds on the Jaco were exact, which they are not. I timed the chart speed of the LN recorder for 5 minutes and found it to be "on the nose" giving a total feed of 12.5 in. meaning a speed of 2.5 in/min. I then used the recorder as a "clock" to check the scan speeds of the Jaco. The results follow:

Jaco Gear Setting	Average True Scan
2 Å/min	2.4 Å/min
5 Å/min	6 Å/min
10 Å/min	11.9 Å/min
20 Å/min	24.1 Å/min
50 Å/min	59.5 Å/min
125 Å/min	156 Å/min
250 Å/min	313 Å/min
500 Å/min	626 Å/min

14 May 1963

Installed McElroy's photomultiplier assembly today and attempted to perform a new calibration run. Operation of the monochromater is still erratic as before. I noticed that one has trouble finding the line (4046 Hg) at the right place even under manual control. Called JA this afternoon and talked with Stanley Smith, ext. 14 or 15. Found that speed problem was due to the mis-installation of a 50 cycle motor instead of a 60 cycle one. However, the problem of bad lineshape is still unsolved. Smith suggested that dirt on the glass could cause this, but it looks clean.

Today PTM and I also designed a rubber stamp with which to stamp a data entry table onto our spectra.

15 May 1963

A man from JA came this morning and took back the monochromater to the plant for a complete checkout.

I built an adapter that will enable me to use RZ's 7102 (S1) phototube assembly. Also, the appropriate modifications to the Tektronix 514D to convert it to a 514AD were made.

16 May 1963

This morning I went to Laura Roth's talk at Sperry-Rand on the Faraday Effect. Spent the afternoon aligning the vertical section of the 514AD scope. Also brought the small cabinet over to the painters to be painted.

17 May 1963

This morning I calibrated the sweep on the 514AD and she is now an operable scope. Used a 180 time mark generator borrowed from MacDonald.

Got back the monochromater from JA this afternoon and trouble with lineshape was apparently the spring loaded ball joint that holds the sine bar drive screw in place. Normally, one should feel some "give" when pressing button "C" which helps engage the gears.

Tonight I ran some calibration curves with the Hg lamp, but have not analyzed the data. Initially, I noticed the tops of the peaks were distorted, suggesting a saturation effect was taking place. Careful investigation showed that neither the electronics nor the photomultiplier were saturating. The effect disappeared upon widening the slits from 10μ to 20μ suggesting that dust on the small diagonal mirror or its "bad spot" were causing trouble. This distortion could be improved by changing the leveling screws of the monochromater, thus supporting the above hypothesis.

I noted that the Waterman scope loaded the pre-amp output. Also the lines seemed to be broader than before the instrument was repaired although this may now be due to the slower scanning speed and a hot Hg lamp. The 3131 doublet should be looked at again when the lamp is cool. Also, the entire system should be opticaly realigned and the monochromater leveled.

18 May 1963

I have completed computing the position of the lines measured yesterday. The lamp is a Mineralight mercury vapour light with the filters removed. Note that many of the lines do not agree with the JA results. This may be due to heating of the lamp. The other cenco spectrum lamp should perhaps be tried, and the optics realigned.

Results

CRC	JA		17 May ③	
4046.6	4046.6		4045.7	(−.9)
4358.3	4358.5	(+.2)	4357.0	(−1.3)
5460.7	5461.2	(+.5)	5461.1	(+.4)
5769.6	5770.2	(+.6)	5770.2	(+.6)
5790.7	5791.5	(+.8)	5792.2	(+1.5)
8093.2	8094.0	(+.8)	8094.1	(+.9)

Measurements were also taken on the 3131 doublet in both first and second order. In the second order, signals were weak and down in the noise. The line was readily split, but not so nicely as the JA chart showed. In the first order, the signal was strong, but no splitting was seen. However, the line was quite broad. Note how far from 3131 the line is.

Second Order

CRC	17 May ③	
6263.10	6264.0	(+.9)
6263.66	6264.6	(+.9)

First Order

CRC	17 May ③	
3131.55 } 3131.83 }	3128.0	(− 3.7)
3125.66	3121.6	(− 4.1)

At 8PM, I finished a remeasurement of the 3131 line of the mineralight lamp in order to see if any heating effect was taking place. I let the equipment warm up, but only turned on the lamp when ready to run. The results were essentially the same as yesterday. When I narrowed the slits down to 5μ, the first order splitting was discernible in the noise. I just looked at the Hg calibration run of 10 May and the first order 3131 line seems to be slightly split but I cannot be sure that this is not due to the original drive screw trouble.

20 May 1963

Levelled monochromater and adjusted optics. I am now using the Cenco line spectra sources. Late this afternoon, I began another Hg calibration run using the Cenco Geissler tube. I placed the photomultiplier so that the exit slit image was just about focused on the cathode. I am still getting funny looking line shapes and will next try experimenting with slit widths and heights and different time constants. The lines seem to be broader than they should.

The following is the result of the calibration run:

CRC		20 May ①	
3131.7	(avg)	3128.2	(−3.5)
4046.6		4045.1	(−1.5)
4358.3		4357.3	(−1.0)
5460.7		5461.6	(+.9)
5769.6		5771.0	(+1.4)
5790.7		5792.8	(+2.1)
8093.2		8093.6	(+.4)

I also should try running on 5 Å/min.

Made number ② run at night to see effect of slit height and scanning speed and time constant on lineshape. Found very marked improvement in resolution where slit height was lowered to 5 mm. Obtained very good line shape and narrow width. Should test this effect for slit width of 100 μ. A change could mean very bad misalignment. A time constant of "3" seemed to provide good filtering of noise while not being too slow to extend tail of line. 1 and 2 are not suitable in this respect.

Number ③ run is another calibration run made at TC = 3 and SH = 5 mm and SW = 10 μ. The scanning speed was set at 5 Å/min to see what the effect would be on the calibration.

21 May 1963

I have just completed examining the data of 20 May ③ which is the calibration curve taken with a smaller slit height and hence improved resolution. The scan speed was 5 Å/min. The following data can be considered as most representative of the calibration data to date.

CRC	20 May ③	
3125.7	3121.4	(−4.3)
3131.6	3128.0	(−3.6)
3131.8	3128.2	(−3.6)
4046.6	4046.1	(−.5)
4358.3	4357.6	(−.7)
5460.7	5461.3	(+.6)
5769.6	5770.4	(+.8)
5790.7	5792.0	(+1.3)
6263.1	6264.1	(+1.0)
6263.7	6264.7	(+1.0)
8093.2	8094.2	(+1.0)

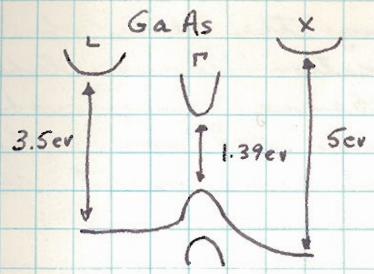
The above data was taken with the Cenco Hg vapour source. The second order 4358.3 (8716.6) and some of the UV lines should now be looked at. The result is that:

CRC	21 May ①	
8716.6	8716.3	(−.3)

Also, at this time, I made a rough reproducibility experiment in re-running the 8093 line after being shut down overnight. It only came back to about 1/3 its original value, but was reproducible after that after the PM had been on for 5 minutes or so.

After this, I tried getting calibration in the UV by using the Philips Hg-Cd-Zn lamp. The lamp was so bright and the scattered light so high that the system overloaded. When I tried to shield the lamp by enclosing it, it apparently overheated and extinguished itself. Will have to wait until a suitable enclosure with adequate cooling can be built.

Late this afternoon, I began to set up for the radiative recombination experiment in GaAs. I borrowed the B&L High Intensity Monochromater from Jim Mery of Bloembergen's group. Had MacLeod prepare a sample which was cemented on a steel block, on which another side held a small Al mirror. The object was to place unfocused light on the GaAs sample at 2500Å and observe the radiative recombination at about 8900 Å. The idea is this:

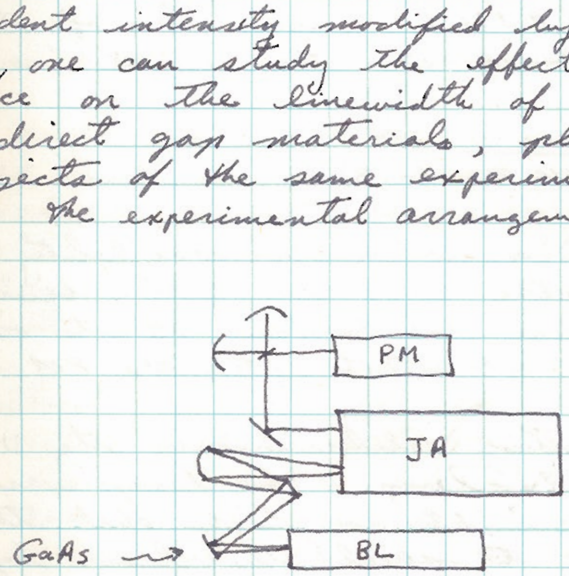


By pumping with monochromatic UV radiation, one should obtain radiative recombination across the direct gap. The 5ev peak (from Ehrenreich) is at about 2500 Å, so that if the incident light were at this wavelength, electrons and holes would be created at the X conduction and valence bands. These electrons and holes would then be scattered to the Γ minima where they would recombine radiatively. A similar process should take place when pumping at the L point (3.5 ev ~ 4500 Å). In fact, by scanning the monochromatic pump light, and by computing the function:

$$\frac{I_{RR}}{I_0(E)} \text{ vs } E$$

one should obtain a corroboration of the gross features of the well-known reflectivity data. I_{RR} is the recombination radiation intensity, and $I_0(E)$ is the incident intensity modified by the reflectivity of GaAs. Also, one can study the effect of a monochromatic pump source on the linewidth of the recombination radiation. All direct gap materials, plus maybe Ge, should be subjects of the same experiment.

The experimental arrangement is:



The exit slit of the BL was set at 1.5 mm, and both the 6256B and 7102 photomultipliers were used.

In general, no radiative recombination was observed, possibly for several reasons:

(1) Inefficiency of the unfocused pump optics.
(2) Low intensity of source
(3) Poor surface of GaAs
(4) GaAs not cooled

Tracings ③ and ④ reveal some of the spectral properties of the BL monochromater. One sees that at high λ (~400 mμ) the purity is very poor while at 2500 Å, the lineshape is very good, centered around 2500 Å with a 1/2 width of 50 Å for an exit slit width of 1.5 mm.

Tracing ④ demonstrates the response of the system to higher orders of 2500 Å.

<u>22 May 1963</u>

Today I attempted to set up for a recombination radiation experiment again. The idea was to gain some feeling for the factors involved. Therefore I decided to illuminate a piece of calcite with the Philips Hg:Cd:Zn lamp and then analyze the resulting flouresence. Because it is difficult to set up the mirrors for a diffuse source, it was decided to try an optical fiber light pipe to bring the flouresence to the entrance slit of the monochromater. Visually, this seemed to work quite well, however, no radiation could be detected with a cooled 7102 at a red frequency. Tests with a bright flashlight gave some output but not nearly as much as expected.

When I substituted the 6256B, an almost saturated output was obtained at 4046 which is an Hg line reflected off the calcite. However, still no red output was observed athough the end of the fiber seemed quite bright red to the eye. I was going to switch back to the 7102 when I noticed that the window was severely covered with frost, so that will have to wait.

<u>23 May 1963</u>

Today BK and I tried to observe any radiative recombination from GaAs illuminated by the Phillips mercury source on Zallen's Perkin-Elmer system. The samples were a polished one and one etched with white etch so that the surface was diffuse. All attempts to observe radiation at the expected band gap failed up to now.

24 May 1963

Today I designed and built the sample holder slide for the thin films and their substrates in preparation for some preliminary film transmission experiments. I have temporarily discontinued the recombination radiation experiments pending further information on Nathan's arrangement from WP.

27 May 1963

Today I made some cursory measurements to discover the limits to the operation of the amplifier. The first test was to discover the limits of linearity as determined by input signal amplitude. The signal used was the 1000 cps signal of the calibrator of the Tektronix 543A scope. The reproduction of the square wave was not perfect due to the inability to get absolute fixed resistors for the "flat" setting of the "bass" and "treble" controls. Also, the scope vertical calibration was not quite true between different voltage ranges. This, and parallax, account for the 3-5% error in gain readings up to the onset of nonlinearity. For reference, the input voltage is refered to an equivalent current thru a 100K resistor to give an idea of the magnitude of photomultiplier anode current involved to give a certain output. All values of voltage and current are peak-to-peak square wave values.

Input (mV)	(μa)	Gain Setting Coarse (db)	Fine	Output (V)	Gain
.2	.002	0	max	.75	3750
			min	.50	2500
		-20	max	.075	375
			min	.050	250
		-40	max	.008	40 } noisy
			min	.006	30 }

Input (mv)	(μa)	Gain Setting Coarse (db)	Fine	Output (v)	Gain	
.5	.005	0	max	1.9	3800	
			min	1.3	2600	
		−20	max	.19	380	
			min	.13	260	
		−40	max	.022	44	} noisy
			min	.015	30	
1	.01	0	max	3.8	3800	
			min	2.6	2600	
		−20	max	.38	380	
			min	.26	260	
		−40	max	.044	44	
			min	.030	30	
2	.02	0	max	7.5	3750	
			min	5.0	2500	
		−20	max	.75	375	
			min	.50	250	
		−40	max	.075	37.5	
			min	.050	25	
5	.05	0	max	19	3800	
			min	13	2600	
		−20	max	1.9	380	
			min	1.3	260	
		−40	max	.19	38	
			min	.13	26	
10	.1	0	max	nonlinear		
			min	nonlinear		
		−20	max	3.8	380	
			min	2.6	260	
		−40	max	.38	38	
			min	.26	26	
20	.2	0	max	nonlinear		
			min	nonlinear		
		−20	max	7.5	375	
			min	5.0	250	
		−40	max	.75	37.5	
			min	.5	25	

Input (mv)	(μa)	Gain Setting Coarse (db)	Fine	Output (V)	Gain
50	.5	0	max	Nonlinear	
			min	Nonlinear	
		-20	max	19	380
			min	13	260
		-40	max	1.9	38
			min	1.3	26
100	1	0	max	Nonlinear	
			min	"	
		-20	max	"	
			min	"	
		-40	max	3.8	38
			min	2.6	26
200	2	0	max	Nonlinear	
			min	"	
		-20	max	"	
			min	"	
		-40	max	7.5	37.5
			min	5.0	25
500	5	0	max	nonlinear	
			min	"	
		-20	max	"	
			min	"	
		-40	max	18	36
			min	13	26
1000	10	0	max	Nonlinear	
			min	"	
		-20	max	"	
			min	"	
		-40	max	21	21
			min	16	16

At the 0 and -20 db settings, the onset of the nonlinear region was plainly visible on the scope as distortion (clipping), whereas the decrease at -40 db for a 1000 mv input showed no visible distortion. This means that the first cutoff is due to saturation of the final stage while at -40 db the cutoff is finally caused by the distortion overiding the negative feedback in the first two stages. Also, at -40 db some peaking is in evidence on the leading and trailing edges is noticed. This is as yet unexplained.

We performed a single measurement of the effect of the twin T filter in the first stage feedback loop. The presence of this filter did not seem to effect the onset of nonlinearity. Maximum low cut was employed in this test also.

Input (mv)	(μa)	Gain Setting Coarse (db)	Fine	Output (V)	Gain	
1	.01	0	max	4.8	4800	
			min	3.2	3200	
		-20	max	.48	480	
			min	.32	320	
		-40	max	.052	52	} Noisy
			min	.038	38	}

The following noise measurements were made with maximum gain. The figures are approximate peak-to-peak values.

	Input	Output	Equivalent Input
Flat	Short Circuit	.04 V	10 μV
Twin T	" "	.004 V	1 μV
Flat	Open Circuit	.2 V	50 μV
Twin T	" "	.06 V	15 μV
Flat	100 K	.1 V	25 μV
Twin T	"	.02 V	5 μV

The next point of investigation will be to find the source of the 1080 cps pick-up appearing in the later stages of the amplifier. The amplitude is unaffected by gain so that it cannot be in the first stage.

<u>28 May 1963</u>

We took the day off.

29 May 1963

Today we gave some consideration to the setting up of a Faraday Effect experiment. We talked to Chen to get some idea of what is involved.

30 May 1963

Now working nights. Began investigation for source of extraneous 1080 cps signal coming from output of the amplifier when the input is shorted. Before starting, made measurements of pertinent voltages:

DC Filaments: 5.9 V (Simpson 260)
+300 : +295 (RCA VTVM)
+300 DC current: 70 ma (Simpson 260)

The peak-to-peak value of the 1080 cps noise is about 20 mv. By pulling tubes in the PSD, we found that the 12BH7 CF stage was introducing the signal. The P-P value of the square wave out of the CF is 63 volts while the cathode resistor is 11 K, giving about 5.7 PP plate current variation. The internal impedance of the Lambda +300 supply is 10 Ω so that about 57 mv of ripple is introduced into the B+ line. This is about what is seen off the scope and is the cause of the 1080 cps extraneous signal.

This signal may make the balance setting of the recorder change with the gain setting of the amplifier. The observed change is about 1% of full scale going from -40 db to -20 db and about 4% of full scale going from -20 db to 0 db.

The solution to this problem lies in either separate power supplies for the amplifier and the PSD, or a redesign of the PSD CF stage with the latter the more reasonable. At this time, however, we will defer action on this matter.

31 May 1963

Beginning the measurement of the frequency response of the amplifier with load connected. Using HP 200 CD oscillator as signal source with HP 400H VTVM for measurement.

The input voltage will be maintained at 1 mv.

f (cps)	Output (V)	Gain	Gain referred to 1080 cps (db)
10	.06	60	-35
20	.21	210	-24
30	.52	520	-16
50	1.95	1950	-4.8
70	4.4	4400	+2.2
100	5.1	5100	+3.5
200	4.1	4100	+1.6
400	3.8	3800	+1.0
700	3.5	3500	+.24
1080	3.4	3400	0
2000	3.3	3300	-.24
4000	3.2	3200	-.5
7000	3.2	3200	-.5
10000	3.2	3200	-.5
15000	3.2	3200	-.5
20000	3.1	3100	-.8
40000	2.9	2900	-1.4
70000	2.4	2400	-3.0
100 000	1.9	1900	-5.0

This data taken with controls set for "flat" response.

10	.01	10	-50
20	.04	40	-38
30	.10	100	-30
50	.37	370	-19
70	.95	950	-11
100	1.2	1200	-9
200	1.0	1000	-10.6
400	1.1	1100	-9.6
700	1.7	1700	-6
1080	3.3	3300	0
2000	.74	740	-13
4000	.27	270	-22
7000	.15	150	-27
10000	.10	100	-30
15000	.07	70	-33
20000	.056	56	-35
40000	.036	36	-39
70000	.026	26	-42
100 000	.022	22	-44

This data taken with 1080 cps Twin T switched in 1st stage fb loop.

The gain settings for all the above data are 0 db for the coarse and "max" for the fine.

The response curve in plotted separately on semi-log paper. Obviously, there is some error in the "bass" circuitry that is causing the hump at 100 cps. What I will do for the present is run with full low cut and the Twin T in. This trouble in the bass circuit is also the cause of the deterioration of the square wave response.

3 June 1963

Today we placed a decoupling network in the B+ lead of the PSD CF. This reduced the fluctuation of the B+ line and now there is no variation of the zero setting with amplifier gain except when going to the 0 db setting when a small variation of about half a division is noticed. It is to be emphasized that this is a temporary solution, the permanent solution being the construction of a separate power supply for the amplifier.

4 June 1963

The following is an investigation of the response properties of the PSD. The idea was to establish a relation between the AC input and the DC output as displayed by the recorder and test some of the features of the device. The fine gain control was used to set the amplifier output so that the recorder read 100 for a slit width of 100 μ.

TC: "3"
Gain: -40 db and -20 db, fine was varied
PM: 6256 @ 800V with C-D1 voltage optomized.
Source: W lamp (small GE) @ 6V, 7.5a.
Amplifier Response "Flat", PSD adjusted for optimum phase.
Slit Hieght: 6 mm
Recorder Battery: 1.60 ma.

Slit Width (μ)	Gain (db)	Amplifier Out (p-p SW)	Recorder (div)
100	-40	.95 v	100
90	"	.78	81
80	"	.60	64
70	"	.47	48.5
60	"	.35	35.5
50	"	.23	24.5
40	"	.15	15.5
30	"	.08	8.5
30	-20	.8 (noisy)	80
20	-40	.04	4.0
20	-20	.36	34
10	-40	–	2.5
10	-20	~.2	17

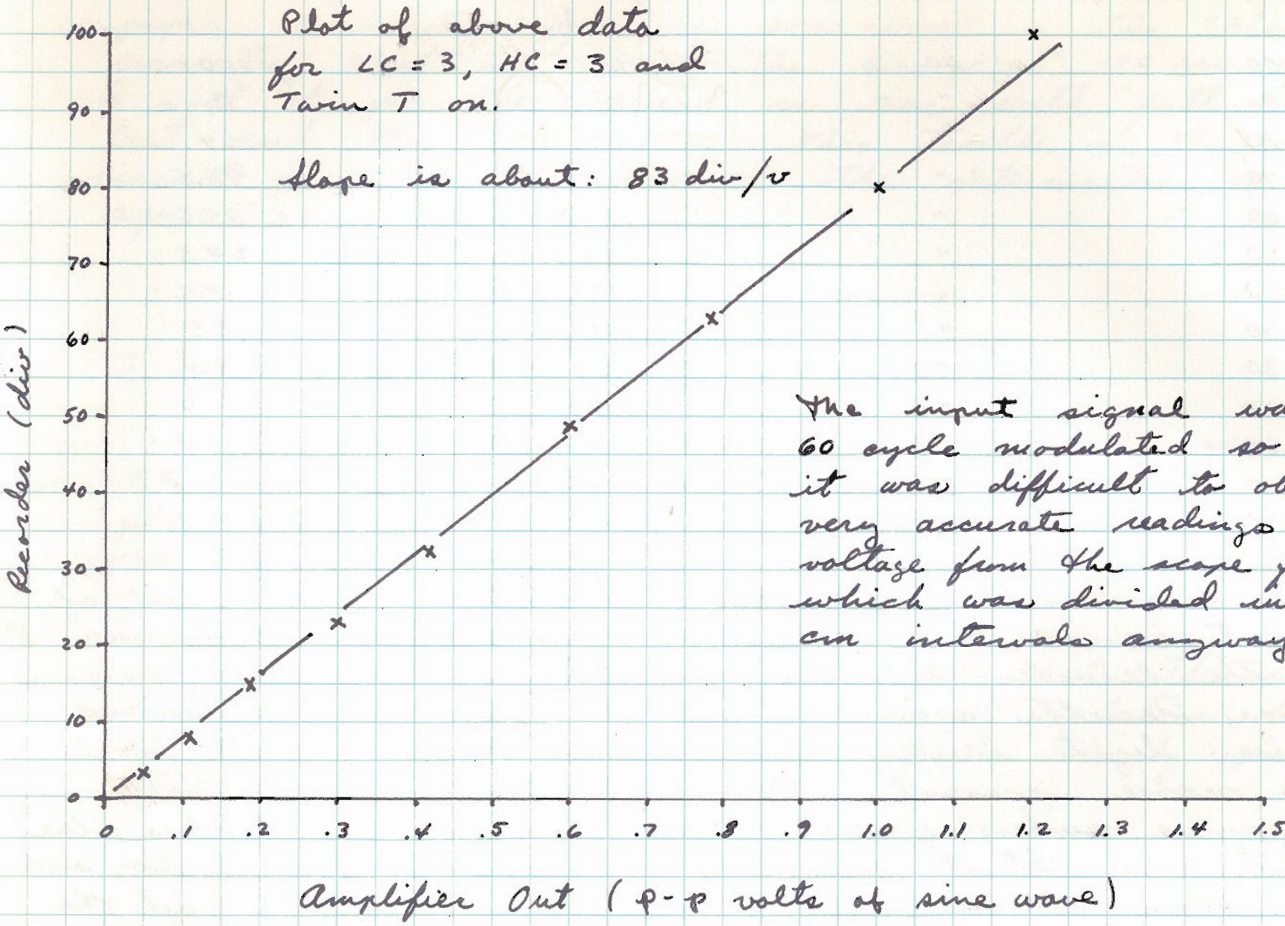
Note: Zero setting drifted 1 div during the run of about 20 minutes. Note the near quadratic behaviour of the Recorder to slit function as expected. However, poor results are obtained for smaller slits and lower light levels. There seemed to be quite a lot of noise present. This motivated trying the response when given a sine wave input. Therefore, the slit was set at 100 μ, the gain adjusted for 100 div, and the upper sideband set at 3, the lower at 3, and the twin T put in. This resulted in a net decrease of DC output of only 1 div (down to 99) after re-optimizing the phase. The following data was taken.

Slit Width (μ)	Gain (db)	Amplifier Out (p-p)	Recorder (div)
100	-40	1.2 v	100
90	"	1.0	80
80	"	.78	63
70	"	.60	48
60	"	.42	34.5
50	"	.30	23.5
40	"	.19	15.0
30	"	.11	8.0
30	-20	1.1	78
20	-40	.05	3.5
20	-20	.45	32
10	-40	–	1.5
10	-20	~.25	16

Note: No zero drift during this run. See how more reproducible the readings are when switching from -40 to -20 db.

Plot of above data for LC = 3, HC = 3 and Twin T on.

Slope is about: 83 div/v



The input signal was 60 cycle modulated so that it was difficult to obtain very accurate readings of the voltage from the scope face which was divided into 1/2 cm intervals anyway.

The effect of the time constant response was hardly noticible at 4, 3, and 2 and I did not really wait long enough at 1 to really observe it.

The drift of the entire system was measured at Gain settings -40 and -20 with the slits adjusted to put the recorder at about mid-scale. The maximum variation at -40 was less than .5% over a 1/2 hour period, and less than .5% at -20 for 10 minutes, however, there was more noise on the latter.

The overall transfer function of the system is:

$$A = A_{PA} A_{PSD} (A_{PM})^{-1}$$

where A_{PM} = (PM anode resistor)$^{-1}$ = 10^{-5} a/V = 10 μa/V

A_{PA} = Amplifier Gain = 4800 for maximum

= 38 for minimum

A_{PSD} = 83 div/V

Hence: A = 40,000 div/μa (maximum A_{PA})

= 316 div/μa (minimum A_{PA})

5 June 1963

Made check of balance drift: no noticable drift over period of 20 minutes.

Took data on Ge Film #6. This is quite a thin film as its deposition period was only two minutes. The film was held in the holder and placed over the face of McElroy's PM tube with a piece of masking tape. This seemed to work quite well. The scan was made at 500 Å/min to get the "big picture". First I_0 was taken, then I, then I_0 again, each run taking about 10 minutes. It was noticed that some parts of I_0 had changed by about 2% between runs. See film log page 50. The following I_0 data is that of the first run.

Wavelength (Å)	I_0 Rec. (div)	I_0 Gain (db)	I Rec. (div)	I Gain (db)	I/I_0
7000	10.2	-20	2.4	-20	.235
6900	11.0	"	3.0	"	.272
6800	12.2	"	4.0	"	.328
6700	15.0	"	5.2	"	.347
6600	19.0	"	6.6	"	.347
6500	24.8	"	8.8	"	.355
6400	34.5	"	12.0	"	.348
6300	58.0	"	19.5	"	.336
6200	12.2	-40	41.9	"	.343
6250	17.2	"	56.0	"	.326
6100	20.5	"	64.2	"	.313
6080	21.5	"	66.0	"	.307
6060	22.1	"	66.5	"	.301
6050	21.9	"	66.2	"	.302
6040	20.5	"	62.8	"	.306
6030	20.5	"	61.2	"	.299
6010	21.0	"	62.0	"	.295
6000	21.5	"	63.0	"	.293
5950	24.4	"	69.1	"	.283
5900	27.5	"	74.5	"	.271
5880	28.9	"	76.0	"	.263
5860	29.9	"	77.5	"	.259
5840	30.8	"	78.2	"	.254
5820	31.4	"	78.5	"	.250
5800	32.0	"	78.2	"	.244
5780	32.2	"	78.1	"	.242
5760	32.6	"	77.9	"	.239
5740	32.9	"	77.6	"	.236
5720	33.0	"	77.0	"	.233
5700	33.2	"	76.8	"	.231

Wavelength (Å)	I_o Rec. (div)	I_o Gain (db)	I Rec. (div)	I Gain (db)	I/I_o
5680	33.6	-40	77.0	-20	.229
5660	34.7	"	77.6	"	.224
5640	35.5	"	78.9	"	.222
5620	36.7	"	81.4	"	.222
5600	38.5	"	84.8	"	.220
5580	41.0	"	89.4	"	.218
5560	43.5	"	95.0	"	.218
5540	47.5	"	—	—	—
5520	51.9	"	10.9	-40	.210
5500	57.1	"	11.9	"	.208
5480	62.4	"	12.8	"	.205
5460	68.2	"	14.0	"	.205
5440	74.2	"	15.0	"	.202
5420	79.0	"	15.6	"	.197
5400	83.8	"	16.4	"	.196
5380	86.8	"	17.0	"	.196
5360	89.2	"	17.5	"	.196
5340	91.1	"	17.7	"	.194
5320	92.2	"	17.7	"	.192
5300	92.5	"	17.5	"	.189
5280	92.2	"	17.3	"	.188
5260	87.0	"	16.9	"	.185
5240	87.0	"	16.2	"	.186
5220	79.8	"	14.8	"	.185
5200	77.1	"	14.1	"	.183
5150	72.4	"	13.1	"	.181
5100	68.9	"	12.5	"	.181
5000	63.6	"	11.2	"	.176
4900	58.4	"	10.2	"	.175
4800	53.2	"	94.8	-20	.178
4700	48.0	"	84.0	"	.175
4600	42.8	"	73.0	"	.170
4500	37.4	"	63.8	"	.171
4400	32.2	"	53.6	"	.166
4300	27.2	"	43.6	"	.160
4200	22.3	"	34.8	"	.156
4100	17.0	"	25.4	"	.149
4000	12.2	"	16.5	"	.135
3900	84.8	-20	10.5	"	.124
3800	71.2	"	8.0	"	.112
3700	57.8	"	6.0	"	.104
3600	41.0	"	4.0	"	.0975
3500	23.5	"	2.2	"	.0936
6650	16.4	"	6.0	"	.367

6 June 1963

Today we plotted up the data on the previous two pages. The plot of I/Io vs. λ indicates an absorption edge in the neighborhood of 5500 Å to 6100 Å which is probably the Λ transition. The data is scattered along the bottom of the edge, thus making it difficult to determine whether the characteristic spin-orbit splitting is observed, although the curve does suggest that it is. Also, it is hard to determine whether or not this is an interference effect.

This afternoon, we ran a recheck of film #6 between 6250 Å and 4750 Å, at a scan of 125 Å/min. Also, a run was taken at 500 Å/min on film #4, a rather thick film, in order to see the "big picture" here.

7 June 1963

The following data is that taken yesterday on Film #6.

Slits: 100μ @ 6mm — TC: 3
Scan: 125 Å/min — Amplifier: NB
Source: W lamp (small)
PM: 6256B @ 800 v (opt)

Wavelength (Å)	Io Rec. (div)	Io Gain (db)	I Rec. (div)	I Gain (db)	I/Io
6250	79.6	-20	27.1	-20	.340
6240	86.2	"	29.5	↓	.342
6230	93.6	"	31.5		.337
6220	—	-40	34.1		—
6210	11.5	↓	36.8		.320
6200	11.8		39.7		.336
6190	12.6		42.5		.337
6180	13.6		44.9		.330
6170	14.4		47.4		.329
6160	15.3		49.8		.325
6150	16.3		52.3		.321
6140	17.0		54.3		.319
6130	17.7		56.3		.318
6120	18.2		57.9		.318
6110	18.8		59.4		.316
6100	19.2		60.6		.316
6090	19.7		61.7		.313
6080	19.9		62.2		.313
6070	20.1		62.8		.312
6060	20.2		62.9		.311
6050	20.2		62.5		.309

Wave length (Å)	I_o Rec. (div)	I_o Gain (db)	I Rec. (div)	I Gain (db)	I/I_o
6040	19.3	-40	59.0	-20	.306
6030	19.1	↓	57.9	↓	.303
6020	19.2		58.1		.303
6010	19.6		58.8		.300
6000	20.0		59.7		.299
5990	20.8		60.5		.291
5980	21.2		61.5		.290
5970	21.6		62.5		.289
5960	22.4		63.7		.284
5950	22.9		64.8		.283
5940	23.5		65.9		.280
5930	24.1		67.0		.278
5920	24.7		67.9		.275
5910	25.2		68.9		.273
5900	25.8		69.8		.271
5890	26.2		70.5		.269
5880	26.8		71.5		.267
5870	27.2		71.9		.264
5860	27.8		72.1		.259
5850	28.2		72.5		.257
5840	28.5		72.9		.256
5830	28.9		73.1		.253
5820	29.1		73.2		.252
5810	29.4		73.1		.249
5800	29.6		73.2		.247
5790	29.8		73.2		.246
5780	29.9		73.2		.245
5770	30.0		73.1		.244
5760	30.1		73.1		.243
5750	30.3		72.4		.239
5740	30.5		72.1		.236
5730	30.5		72.0		.236
5720	30.5		71.8		.235
5710	30.7		71.9		.234
5700	30.8		71.9		.233
5690	31.0		71.8		.232
5680	31.2		71.5		.229
5670	31.4		72.0		.229
5660	31.8		72.5		.228
5650	32.2		72.9		.226
5640	32.7		73.6		.225
5630	33.0		74.3		.225
5620	33.8		75.2		.222
5610	34.2		76.5		.224
5600	35.1		78.0		.222

I/I_0	Wavelength (Å)	I_0 Rec. (div)	I_0 Gain (db)	I Rec. (div)	I Gain (db)	I/I_0
	55 90	36.5	− 40	80.0	− 20	.219
.306	55 80	37.5	↓	82.0	↓	.219
.303	55 70	39.0		84.5		.217
.303	55 60	40.2		87.1		.217
.300	55 50	42.2		90.5		.214
.299	55 40	44.0		93.9		.213
.291	55 30	46.0		97.5		.212
.290	55 20	48.1		—	− 40	—
.289	55 10	50.5		11.1	↓	.219
.284	55 00	53.1		11.3		.213
.283	54 90	55.8		11.8		.211
.280	54 80	58.0		12.2		.210
.278	54 70	60.1		12.7		.211
.275	54 60	62.5		13.1		.210
.273	54 50	65.7		13.8		.210
.271	54 40	68.0		14.0		.206
.269	54 30	70.1		14.5		.207
.267	54 20	72.4		14.9		.206
.264	54 10	74.4		15.3		.206
.259	54 00	76.4		15.8		.207
.257	53 90	78.1		15.9		.204
.256	53 80	79.6		16.0		.201
.253	53 70	81.4		16.4		.201
.252	53 60	82.5		16.5		.200
.249	53 50	83.6		16.5		.197
.247	53 40	84.3		16.6		.197
.246	53 30	84.1		16.5		.196
.245	53 20	84.9		16.5		.194
.244	53 10	85.0		16.4		.193
.243	53 00	85.1		16.4		.193
.239	52 90	85.1		16.3		.192
.236	52 80	84.8		16.2		.191
.236	52 70	84.4		16.1		.191
.235	52 60	83.8		16.0		.191
.234	52 50	82.5		15.9		.193
.233	52 40	79.6		15.1		.190
.232	52 30	75.3		14.4		.191
.229	52 20	73.3		13.9		.190
.229	52 10	71.7		13.5		.188
.228	52 00	70.5		13.3		.189
.226	51 90	69.3		13.1		.189
.225	51 80	68.5		13.1		.191
.225	51 70	67.9		13.0		.191
.222	51 60	67.1		12.8		.191
.224	51 50	66.8		12.5		.187
.222						

Wavelength (Å)	Io Rec. (div)	Io Gain (db)	I Rec. (div)	I Gain (db)	I/Io
5140	65.8	-40 ↓	12.4	-40 ↓	.188
5130	65.0		12.2		.188
5120	64.5		12.1		.188
5110	63.8		12.0		.188
5100	63.3		11.9		.188
5090	62.6		11.7		.187
5080	62.2		11.6		.186
5070	61.9		11.5		.186
5060	61.2		11.4		.186
5050	60.8		11.3		.186
5040	60.2		11.1		.184
5030	59.8		11.0		.184
5020	59.2		10.9		.184
5010	58.7		10.8		.184
5000	58.2		10.8		.186
4990	58.1		10.8		.186
4980	57.8		10.7		.185
4970	57.4		10.6		.185
4960	56.4		10.5		.186
4950	55.9		10.5		.188
4940	55.3		10.3		.186
4930	55.1		10.2		.185
4920	54.5		10.1		.185
4910	54.1		10.0		.185
4900	53.8		10.0		.186
4890	53.3		10.0		.188
4880	52.7		9.9		.188
4870	52.5		9.8		.187
4860	51.5		—	-20 ↓	—
4850	51.0		91.5		.179
4840	50.4		90.3		.179
4830	50.0		90.0		.180
4820	49.5		89.2		.180
4810	49.3		88.5		.180
4800	48.7		87.3		.179
4790	48.2		86.3		.179
4780	47.8		85.5		.179
4770	47.2		85.0		.180
4760	46.7		84.1		.180
4750	46.1		82.8		.180

The following data is that taken yesterday on film #4.

Slit: 100 μ @ 6 mm
Scan: 500 Å/min
Source: W lamp (small)

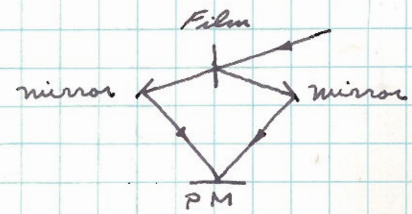
PM: 6256B @ 800 V (opt)
TC: 3
Amplifier: NB

Wavelength (Å)	I_o Rec. (div)	I_o Gain (db)	I Rec. (div)	I Gain (db)	I/I_o
7000	9.9	-20	3.8	0	.0384
6900	10.0	↓	5.1	↓	.0510
6800	11.0		6.5		.0591
6700	13.2		8.1		.0614
6600	16.6		9.0		.0542
6500	21.5		10.2		.0474
6400	29.0		12.3		.0424
6300	46.3		16.0		.0346
6200	97.0		26.3		.0271
6100	21.2	-40	34.7		.0164
6000	20.6	↓	26.6		.0129
5900	24.9		20.5		$8.23 \cdot 10^{-3}$
5800	29.5		16.4		$5.56 \cdot 10^{-3}$
5700	31.2		14.1		$4.52 \cdot 10^{-3}$
5600	34.1		14.8		$4.34 \cdot 10^{-3}$
5500	47.0		20.4		$4.34 \cdot 10^{-3}$
5400	71.0		31.1		$4.38 \cdot 10^{-3}$
5300	85.0		37.1		$4.36 \cdot 10^{-3}$
5200	77.2		34.1		$4.42 \cdot 10^{-3}$
5100	67.2		31.3		$4.66 \cdot 10^{-3}$
5000	61.6		30.0		$4.87 \cdot 10^{-3}$
4900	56.7		29.0		$5.11 \cdot 10^{-3}$
4800	51.7		27.4		$5.30 \cdot 10^{-3}$
4700	46.9		25.0		$5.33 \cdot 10^{-3}$
4600	42.5		22.2		$5.22 \cdot 10^{-3}$
4500	37.4		19.2		$5.13 \cdot 10^{-3}$
4400	32.5		15.9		$4.89 \cdot 10^{-3}$
4300	27.7		12.3		$4.44 \cdot 10^{-3}$
4200	23.0		9.4		$4.09 \cdot 10^{-3}$
4100	18.2		6.2		$3.41 \cdot 10^{-3}$
4000	13.4		4.0		$2.99 \cdot 10^{-3}$
3900	9.4		2.2		$2.34 \cdot 10^{-3}$
3800	—	-20	—		—
3700	58.0	↓	1.1		$1.89 \cdot 10^{-3}$
3600	45.0		1.0		$2.22 \cdot 10^{-3}$
3500	27.4		.4		$1.46 \cdot 10^{-3}$

10 June 1963 to 1 July 1963

This period was spent in the design and redesign of the sample optics and in the wiring of the photomultiplier assembly. The original design for the sample optics was discarded because of the difficulty in performing reflection measurements. However, this assembly is still intact and can be used for other transmission measurements.

The new design is as follows:



The angle of incidence of the principle ray of the beam is ~ 7°. One can see how transmission and reflection may be measured by blocking off first one mirror and then the other. The whole assembly was built by myself. The two mirrors were simultaneously evaporated in the Veeco evaporator of Bloembergen's group.

The photomultiplier divider chain was made up of 50K (14) 1% Daven wire-wound resistors. Also, a minibox unit was constructed to allow the switching of the PM anode resistor from values of 100K to 10K to 1K. Using the formula on page 18 we find that for an anode resistor of 1K and $A_{PA} = 38$:

$$A = 3.16 \text{ div}/\mu a$$

so that a 100 div deflection requires 31.6 μa. This appears to be much less than the saturation current. The dark current of the 6256B is about 1 mμa. For maximum A_{PA}, A = 40,000 div/μa, so that the dark current could give a deflection of 40 div.

Also during this time, Cardona's data was converted to conform with mine.

2 July 1963

The following is a calculation of thin film transmission characteristics from the data of Cardona, that is, a conversion of his graph to my form. See JAP 34, 813 (1963); Fig. 5.

Wavelength	Energy	log I_0/I			I/I_0		
		500 Å	1500 Å	3000 Å	500 Å	1500 Å	3000 Å
3500 Å	3.54 ev	.58	2.71		$2.63\cdot10^{-1}$	$1.95\cdot10^{-3}$	
3600	3.44	.57	2.71		$2.70\cdot10^{-1}$	1.95	
3700	3.35	.56	2.68		2.76	2.09	
3800	3.26	.54	2.59		2.89	2.57	
3900	3.18	.50	2.55		3.16	2.82	
4000	3.10	.47	2.50		3.40	3.16	
4100	3.02	.45	2.46		3.55	3.47	
4200	2.95	.45	2.42		3.55	3.81	
4300	2.88	.44	2.39		3.64	4.08	
4400	2.82	.43	2.36		3.72	4.37	
4500	2.76	.43	2.34		3.72	4.58	
4600	2.70	.43	2.33		3.72	4.68	
4700	2.64	.42	2.31		3.81	4.91	
4800	2.58	.41	2.29		3.90	5.14	
4900	2.53	.40	2.25		3.98	5.63	
5000	2.48	.39	2.18	4.25	4.08	6.46	$5.63\cdot10^{-5}$
5100	2.43	.38	2.10	4.25	4.17	7.95	$5.63\cdot10^{-5}$
5200	2.38	.37	2.01	4.24	4.27	9.80	$5.76\cdot10^{-5}$
5300	2.34	.35	1.94	4.22	4.48	$1.15\cdot10^{-2}$	$6.04\cdot10^{-5}$
5400	2.30	.34	1.81	4.17	4.58	1.55	$6.77\cdot10^{-5}$
5500	2.26	.32	1.72	4.18	4.80	1.91	$6.62\cdot10^{-5}$
5600	2.22	.30	1.61	4.20	5.02	2.46	$6.32\cdot10^{-5}$
5700	2.18	.28	1.50	4.18	5.25	3.16	$6.62\cdot10^{-5}$
5800	2.14	.25	1.39	4.05	5.63	4.08	$8.93\cdot10^{-5}$
5900	2.10	.23	1.31	3.50	5.90	4.90	$3.16\cdot10^{-4}$
6000	2.07	.21	1.25	3.10	6.18	5.63	$7.95\cdot10^{-4}$
6100	2.07	.19	1.20	2.73	6.46	6.31	$1.86\cdot10^{-3}$
6200	2.00	.16	1.10	2.45	6.93	7.95	$3.55\cdot10^{-3}$
6300	1.97	.14	1.05	2.25	7.25	8.93	$5.63\cdot10^{-3}$
6400	1.94	.13	.98	2.04	7.43	$1.05\cdot10^{-1}$	$9.14\cdot10^{-3}$
6500	1.91	.12	.93	1.90	7.60	1.18	$1.26\cdot10^{-2}$
6600	1.88	.11	.90	1.77	7.77	1.26	$1.52\cdot10^{-2}$
6700	1.85	.10	.88	1.65	7.95	1.32	$2.24\cdot10^{-2}$
6800	1.82	.10	.86		7.95	1.38	
6900	1.80	.10	.85		7.95	1.41	
7000	1.77	.09	.83		8.15	1.48	
7100	1.75	.08	.81		8.33	1.55	
7200	1.73	.08	.80		8.33	1.59	
7300	1.70	.08	.80		8.33	1.59	

3 July 1963

This morning I re-adjusted the sample optics so that the beam would be focused on each of the two mirrors (page 26) instead of the sample. In this way, I can contain all the light and prevent its spreading too much, while still having the area illuminated on the sample not too large. In fact, by having it larger, one averages out variations over the area of the film.

This afternoon, I checked for light-tightness and found generally that operation in a fully lighted room may be feasible for low PM voltages, but not high. Adjusted things to the point where my desk lamp and PM's desk lamp being on did not seem to make any difference at voltages of 2000 V. At 2500 V, dark current was high enough to give about previously calculated value (page 26). It seems that by using a long time constant, a fairly good dark current signal may be expected at 2500 V.

A check of the feasibility of using anode resistor variation to control the gain of the system proved to be successful to about .5% overall and less than this when switching between adjacent ranges.

Also today I finished plotting up Cardona's data. His data, taking his stated thicknesses, seems to indicate that the transmissivities of the films are consistently higher than one would expect from the curves computed from Tauc's data. Also, the edges of his thinner films seem to be quite broad.

8 July 1963

This morning I checked stability of the whole system. For no input, there seems to be present a small amount of "pulsing noise" due probably to small amounts of arc-over in the divider chain. When the signal is present, there seems to be source instability present. When the SR regulator is put back in and a long warmup allowed, the signal on stability is apparently improved. The no-signal, max. gain result seems to be pretty clean too. This is unusual when we regard that formerly the SR caused a great deal of interference. Probably now the Twin T is taking care of things. Overall stability of I_0 is probably about 1%. Will continue to check this. Also, this afternoon took transmission curves of filters CS3-73 and CS3-70 and a full set for film #6 in range 7000 Å - 4000 Å. Will do calculations later.

9 July 1963

Last night I finished the mount for the D_2 lamp (Hanau). This morning I tried it out for stability. Found that rapping the table caused the lamp to shift in its mount thereby causing the light output to change. When left alone, it appeared to be very stable in output. The test was made near λ 3188.

Also, a run was made to determine the transmissivity of Corning filter CS0-53.

In the afternoon, I ran R and T on film #6 in the range 4000Å - 2000Å. The peak and edge of the × transition is very evident even in the I_R and I_T tracings. It is now also apparent that the range 3500 - 4500 should be covered by the tungsten lamp. Thermal contraction of the D_2 lamp holder broke the lamp and we now have to wait for a new one. The new one should be wrapped with some "soft" substance like cloth.

Tonight I ran a transmission run on filter CS3-75. Had about a 4% drift in I_0, probably due to insufficient warmup of the W lamp.

Also, a "gap filler" run was made with the W lamp to fill in the range around 4000 Å for film #6. Good stability of I_0 was noted. It now appears that the following selection of sources will prove adequate:

Source	Filter	Range (Å)
W lamp	CS 3-73	7000 - 5000
W lamp	None	6000 - 3000
D_2 lamp	None	4000 - 2000

10 July 1963

This morning I wired up a Raytheon 1KW line stabilizer to use between all the equipment and the "mains" in the hope of further stabilizing I_0. There may be also some drift due to the Twin T in the preamplifier and someday perhaps wire wound Daven resistors should be used in that circuit.

In the afternoon I began writing the program library for the future computations to be done.

11 July 1963

Picnic.

12 July 1963

The day was spent preparing programs.

15 July 1963

This day was spent preparing programs.

16 July 1963

This day was spent preparing programs. A run was made on the 1401 pre-processor to detect obvious errors. The current 1401 rate is $35 per hour, or .35 per hundreth, or .59 per minute. The going rate on the 7090 is $285 per hour, or 2.85 per hundreth, or $4.75 per minute.

17 July 1963

The returns of last nights Fortran run were analyzed. The program GRAPH 1 was the only program that did not compile because of errors. The running time was 9 hundreths with a cost of $25.65. The runs will be denoted in the same way as the spectra, viz., by the data plus a sequence number. The re-compiling of GRAPH 1 took 2 hundreths with a cost of $5.70.

This afternoon I recorded the data from the run 8 July 1963 ② on Corning filter CS3-73 for the purpose of testing the programs already written and compiled. The data input consisted of:

Data Card
Div 2
Io, It, Io for CS3-73
Graph 1 and Graph 2
Title Card:
Scale Card:
Div 2
Io, It, Io for CS3-73
Graph 1
Title Card
Scale Card

18 July 1963 to 23 July 1963

Time spent in program debugging.

24 July 1963

Time spent in program debugging.

25 July 1963

Today the first useful results were received from the computer. The following programs now seem to be operating properly: DIV 1, DIV 3, GRAPH 1, GRAPH 2, and GRAPH 3.

The calculations for 8 July ③, 9 July ③ and 9 July ⑤ were completed today. On 8 July ③, there is a funny structure at 6300 and 6400 Å which appears in both R and T. This anamoly is unexplained and further measurements are necessary. The correlation between these three runs is not good and further study is definitely called for. The expected structure at the L and X edges is definitely observed as is the spin-orbit splitting at the L edge in both transmission and reflection. The following further steps seem to be in order:

(a) Study system stability for both W and D_2 sources.
(b) Check on attenuator values.
(c) Make runs on film 6 using polarized light.
(d) Find out effect of changing film position in the beam.

Note:

All measurements on Film #6 were taken with the sample holder set at:

Horizontal = 50
Vertical = 11

I have just designed a sample holder so that each specimen can be mounted in its own holder. It is hoped that this procedure will enable me to repeat measurements on the same spot on the film. Also, I have aligned a Polaroid HN32 polarizer. The transmitted E field is in the direction of the two staple holes.

26 July 1963

This day was spent preparing Opticon 1.

29 July 1963

Turned on system today at 5:25, to begin check on system stability.

The Io seemed to be highly unstable at all values of PM voltage and wavelengths and levels of light. Experimenting by knocking the table, lamp, and mirrors showed that this instability was due to minute motions of the source lamp. After adjusting position of lamp, several Io runs were made between 6000 Å and 5000 Å. The result was that about 1/2 % drift was noticed over a period of about an hour. Also, removing the cover from the lamp seemed to lend greater stability to the system. See 29 July ②.

30 July 1963

This morning I began some stability and resetability tests on film #6. Experienced the same initial high degree of Io instability as last night. Gently tapping the lamp with a piece of cardboard seemed to steady the output, that is, some sort of equilibrium was found.

Also, I tested the resetability of the sample holder under both reflection and transmission. Sample holder coordinates (50, 11) were used and the resetability was excellent within the limits imposed by the drift of Io which at times was as great as 4%. Also, there seemed to be some drift in the balance control setting. At this time, the Io is not holding as good as might be hoped and as good as it was last night. The following runs on #6 were taken:

30 July ②: 6000 – 5000 Å
30 July ③: 6000 – 5000 Å
30 July ④: 5500 – 4500 Å
30 July ⑤: 5000 – 4000 Å
30 July ⑥: 4500 – 3500 Å
30 July ⑦: 4000 – 3000 Å

30 July ⑧ : 6500 – 5500 Å
30 July ⑨ : 6000 – 5000 Å (polarization ⊥ plane of incidence)
(" ∥ " " ")

31 July 1963

At 2:00 AM, I stopped taking data. The last run was made with polarized light from a Polaroid Type HN32 linear polarizing sheet. This is to determine:
(1) The amount of polarization introduced by the monochromater,
(2) the effect of polarized light on the transmittance and reflectance of film 6.
All during the run, the I_0 stability was excellent, in most cases the variation was unoticable. The runs were made over intervals of 1000 Å, each overlapping, as can be seen from above.

1 August 1963

Today I ran the data of 30 July thru the computer. The results generally indicate reproducibility to within 2% as a conservative estimate. The error is probably introduced by the mechanical stage in that the film is probably not brought back to exactly the same space as before. A good set of data was obtained for 6500 Å to 3500 Å, the d spin-orbit splitting being consistently evident in all scans between 6000 Å and 5000 Å.
The runs under polarized light indicated that the direction of polarization made a difference of about 5%. However, the run on unpolarized light fell about ½ way between these, so it is probably safe to assume normal incidence to an accuracy of about 1 percent.

2 August 1963

Today I fixed the D_2 lamp holder by wrapping asbestos around the lamp and lining the lamp holder with neoprene. Also plotted up R and T for film 6. Noticed that the transmission seemed nearer the "theoretical" curve than did Cardona's.

5 August 1963

This morning I began the UV run on film 6. The D_2 lamp holder seemed to work satisfactorily. After a sufficient warmup period, the D_2 I_0 seemed quite stable and reproducible to within 1%. The following runs were made:

5 August	①	:	Preliminary measurements
"	②	:	4000 Å – 3000 Å
"	③	:	3500 Å – 2500 Å
"	④	:	3000 Å – 2000 Å
"	⑤	:	3500 Å – 2000 Å (different PM voltage)
"	⑥	:	3500 Å – 2000 Å (different settings on sample holder)

When different setting (48, 11) was used on the sample holder, about 8% difference in reflectivity over position (50, 11) was measured. This points definitely to the reproducibility of the sample holder setting as probably the largest error in the measurement.

Sometime I should investigate the possibility of experiments using lasers and thin films, notably, the effect of strong pumping on absorption.

6 August 1963

Spent the day preparing the data for computation.

7 August 1963

The results of 5 August seem to fit smoothly into the data of 30 July. This completes the data for film 6 for right now.

Tonight I tried measuring the reflectivity of Ge sample prepared by Dave MacLeod. It seems as if the reflectivity half of my Transmission – Reflection stage was not optimally alligned. This fact invalidates the reflectivity data of film 6. Also, there is quite a lot of "slop" in the mechanical stage movement. Will have to try re-adjusting to obtain optimum reflectivity.

During a run tonight, the I_0 stayed very constant after the equipment had been given several hours warm-up.

8-9 August 1963

It is clear that the present system of mounting the sample will be unsatisfactory. Therefore, a new mount will be built using micrometer adjustments following roughly a design by Kulicke and Soffa Manufacturing Co.

Also, testing of OPCON1 began.

12-13 August 1963

Most of OPCON1 seems to work, but I suspect trouble in subroutine TRANRE involving one of the derivatives.

14-16 August 1963

Vacation

19-21 August 1963

Vacation

22-23 August 1963

Trip to IBM. While there I began arrangements to obtain a Gaertner ellipsometer with its attachments.

26-30 August 1963

This week was spent in beginning the construction of the sample holder, checking out OPCON1, and THIFIL, building a jig to silver films and making arrangements to obtain the ellipsometer. There are many things the ellipsometer may be used for. I intend to make use of it possibly in the following ways:

(1) Measure the transmission of the films at three different angles of incidence and from this calculate the optical constants and the thickness.

(2) measure carefully the optical constants of semiconductors by ellipsometric measurements in order to observe the fine structure which was not seen by Archer.

(3) Make ellipsometric measurements on the films themselves.

3-6 September 1963

This week was spent working on the sample holder and cleaning up OPCON1. The trouble with this program was finally located. The writing of OPCON2 was begun. This is the program to solve for n, k, t given R, T, R'. Also, several subsidiary programs were started.

A run was made for testing the silvering jig and it seems to work all right at a current of 100 a. and an evaporation time of 1 min. Sometime some thought will have to be given to evaporating silicon films.

9-13 September 1963

This week was spent doing work on the sample holder and a shutter system to facilitate the measurement of I_o, I_R, and I_T. Also, OPCON2 was written and the conversion to the MIT FMS started. Attempts were made to catch up on the literature.

16-17 September 1963

These two days were spent principally in preparing programs, literature searches and reading, and keeping up with developments on the sample holder.

18 September 1963

Today began allignment of reflection - transmission system with new sample holder in place. Generally, the findings are as follows:

(1) The polished Ge mirror was used as the reflecting sample and allignments were made with a PM voltage of 500 V and an wavelength setting of 5300 Å or 5900 Å.

(2) First, the I_0 and I_T mirror was alligned to give maximum output. The region of maximum output seemed to peak rather sharply so that rotation of this mirror is quite critical.

(3) The I_R mirror was alligned with the Ge mirror in place. The maximum of this mirror allignment seemed to be much flatter than the I_0-I_T. Also, the image was slightly raised. The reflectivity at 5300 Å varied from .495 to .510 which is in the right ballpark.

(4) The reflectivity was very independent over a reasonably wide range of micrometer settings, a very good sign. In fact, the angle of incidence on the PM seems to be the only critical value.

(5) The 3 point mount enabled reproducibility and the frosted glass has been removed to increase sensitivity.

(6) A Ge mirror will be prepared according to the prescription of PDE(62) in order to see if we can match Fig. 2 of that paper.

19 September 1963

Today I built the sample in - sample out manipulator using an automotive choke cable. It takes some fooling around to get it to work right, but I finally obtained a good working fit. In raises the sample out of the way for I_0 and out puts it reproducibly in place for I_R and I_T. When in place, there is actually positive tension acting that tends to keep it in place.

Also, today I continued testing of OPCON2.

20 September 1963

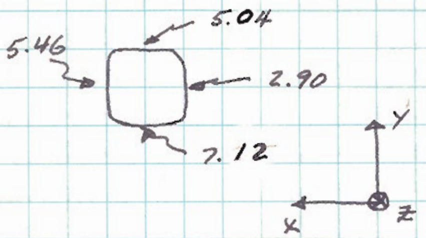
This morning I installed the I_R and I_T shutter and it seems to work OK, blocking out the light and yet giving room for the sample holder to move.

We now attempt to find the center of the available sample area in terms of micrometer settings. Consider the sample area as seen from the incident side:

$Z_0 = 5.00$

$Y_0 = 6.08$

$X_0 = 4.18$



The light is swept across the open area until it is blocked out thus giving the settings for the extremes.

This afternoon and tonight I fooled around trying to allign the system of the two mirrors. I used as a reflectance standard one of the Al mirrors I made some time ago. The measured reflectivity of this mirror was around 92%, in the right ballpark. Also, the two mirrors were realligned so that the peak output versus there rotation was flatter. This fact tends to reduce the critical factors of the allignment and instill confidence in the result. It was also found that the shutter leaks light and a better one will have to be found.

21 September 1963

This afternoon I began measuring the reflectivity of a sample of Ge prepared according to PDE (62).

21 Sept 1: F0 testing run

From now on we shall record a duplicate of the spectrum stamp in the log for convenience.

The sample Ge: PDE(62) was prepared on a variation of the prescription given in PDE(62) as follows:

(1) lap to smooth finish with #800 SiC and 5μ Al_2O_3

(2) Etch for 3 min in 3:1 HNO_3:HF

The surface was quite heavily etched but still gave quite specular reflection.

PURPOSE *Reflectivity of Ge: PDE (62)*
DATE *9/21/63* PAGE LOG BOOK *39* SPECTRUM # *2*
SAMPLE: MATERIAL *Ge* CODE *PDE (62)*
ORIENTATION *<111>* TEMP *RT*
THICKNESS ____ PREPARATION ____
STRESS: TYPE *—* MAGNITUDE ____ DIRECTION ____
SOURCE: TYPE *W lamp* STRENGTH *6 V*
MONOCHROMATOR: GRATING *30000* RANGE *6500-3500 Å*
SCAN RATE *250* SLIT WIDTH *100-5*
DETECTOR: TYPE *6256 B* TEMP *RT*
SETTING *1070 V*
POLARIZATION *—* FILTER ____
ELECTRONICS: PRE-AMP *Regular*
PSD *"*
TIME CONSTANT *3*
RECORDER: ____ A ____ B ____ C ____
SETTINGS ____
SPEED ____
REMARKS *(x, y, z) = 4.18, 6.08, 5.00*
OPERATOR *PMG*

21 Sept 2

PURPOSE *Reflectivity of Ge: PDE (62)*
DATE *9/21/63* PAGE LOG BOOK *39* SPECTRUM # *3*
SAMPLE: MATERIAL *Ge* CODE *PDE (62)*
ORIENTATION *<111>* TEMP *RT*
THICKNESS ____ PREPARATION ____
STRESS: TYPE *—* MAGNITUDE ____ DIRECTION ____
SOURCE: TYPE *D_2 lamp* STRENGTH *low (ccw)*
MONOCHROMATOR: GRATING *30000* RANGE *3500-2000 Å*
SCAN RATE *250* SLIT WIDTH *100-5*
DETECTOR: TYPE *6256B* TEMP *RT*
SETTING *1620 V*
POLARIZATION *—* FILTER *—*
ELECTRONICS: PRE-AMP *Regular*
PSD *"*
TIME CONSTANT *3*
RECORDER: ____ A ____ B ____ C ____
SETTINGS ____
SPEED ____
REMARKS *(x, y, z) = 4.18, 6.08, 5.00*
OPERATOR *PMG*

21 Sept 3

23 September 1963

Born today: One child, female, ~4 kg, ~50 cm, labelled Deborah Jean.

Today I am trying to make a reflectance run on sample Ge: MacLeod which was polished with as high degree of care as DM could muster.

PURPOSE: Reflectivity of Ge: MacLeod

DATE: 9/23/63 PAGE LOG BOOK: 40 SPECTRUM #: 1

SAMPLE: MATERIAL: Polished Ge CODE:

ORIENTATION: <111> TEMP: RT

THICKNESS: PREPARATION: Polish

STRESS: TYPE: — MAGNITUDE: DIRECTION:

SOURCE: TYPE: D_2 lamp STRENGTH: low

MONOCHROMATOR: GRATING: 30000 RANGE: 3500 - 2000 Å

SCAN RATE: 250 SLIT WIDTH: 100 - 5

DETECTOR: TYPE: 6256B TEMP: RT

SETTING: 1610 V

POLARIZATION: — FILTER: —

ELECTRONICS: PRE-AMP: Regular

PSD: "

TIME CONSTANT: 3

RECORDER: A B C

SETTINGS:

SPEED:

REMARKS: (x, y, z) = 4.18, 6.08, 5.00

OPERATOR: BMG

23 Sept 1

The finishing procedure followed by DM is as follows:

(1) Rough lap with Buehler #1200
(2) Fine lap with 3μ Al_2O_3
(3) Polished with Linde "A" on beeswax
(4) Final polish with Linde "B" on beeswax

It is hoped that this produced a highly reflecting flat surface with minimum damage and defect.

23 Sept 2

PURPOSE Reflectivity of Ge: MacLeod
DATE 9/23/63 PAGE LOG BOOK 41 SPECTRUM # 2
SAMPLE: MATERIAL Polished Ge CODE
ORIENTATION <111> TEMP RT
THICKNESS PREPARATION
STRESS: TYPE — MAGNITUDE DIRECTION
SOURCE: TYPE W lamp STRENGTH 6V
MONOCHROMATOR: GRATING 30000 RANGE 6500–3500Å
SCAN RATE 250 SLIT WIDTH 100–5
DETECTOR: TYPE 6256B TEMP RT
SETTING 1070V
POLARIZATION — FILTER —
ELECTRONICS: PRE-AMP Regular
PSD "
TIME CONSTANT 3
RECORDER: A B C
SETTINGS
SPEED
REMARKS (x, y, z) = 4.18, 6.08, 5.00
OPERATOR BMG

24 September 1963

Spent today processing the data of 21 Sept.

25 September 1963

Today I processed the data of 23 Sept. Also, tonight I installed the shutter in the system that is to block out I_R and I_T when needed. I made a measurement of the ratio of scattered light to incident light for the shutter in its two positions, using an aluminized mirror as a sample. The results are:

Shutter blocking I_0 ; $I_s/I_0 = 1.8 \cdot 10^{-4}$

Shutter blocking I_R ; $I_s/I_R = 1.15 \cdot 10^{-4}$

The situation is more serious in the I_R blocking position than in the I_0 blocking position as in the latter I_R will be incident on the PM and $I_S << I_R$ should be true at all times. However, in the former case, I_T is incident on the PM and there may be situations where $I_S \sim I_T$. We shall have to watch for these situations.

26 September 1963

Let us consider the consequences of the difference in linear thermal expansion coefficients of Ge and CaF_2. If we assume that the bulk of the CaF_2 substrate is so great that the Ge film does not stress it at all and that the expansion and contraction of the Ge film is governed by the CaF_2 substrate, and that the film-substrate system is unstressed when the film is being formed, we arrive at the following equations:

$$\Delta l_{CaF_2} = \Delta l_{Ge}$$

$$\Delta l_{CaF_2} = l\, \alpha_{CaF_2}\, \Delta T$$

$$\Delta l_{Ge} = l\, \alpha_{Ge}\, \Delta T - l\, F\, S_{11}$$

$$F = \frac{(\alpha_{Ge} - \alpha_{CaF_2})\, \Delta T}{S_{11}}$$

Here we use S_{11} without regard to crystal orientation.

Taking:

$\alpha_{Ge} = 5.75 \cdot 10^{-6}$ (300°K, TDC)
$\alpha_{CaF_2} = 19.5 \cdot 10^{-6}$ (CRC)
$\Delta T = -550°C$
$S_{11} = .98 \cdot 10^{-12}$ $cm^2/dyne$ (TDC)

Then:

$$F = 77 \cdot 10^{8}\ dyne/cm^2 = 7700\ atm.$$

Now, according to PDE (62), a uniaxial stress of about 4100 atm causes a shift (in compression) in the principal L reflectivity peak from about 5890 Å to about 5854 Å.

This is obviously a topic for investigation on the film and we shall begin to look for this by examining film 4 which appears to be a rather thick film.

PURPOSE Overall R and T of Film 4
DATE 9/26/63 PAGE LOG BOOK 43 SPECTRUM # 1
SAMPLE: MATERIAL Film 4 CODE Film log 45
ORIENTATION ___ TEMP ___
THICKNESS ___ PREPARATION ___
STRESS: TYPE — MAGNITUDE ___ DIRECTION ___
SOURCE: TYPE W lamp STRENGTH 6V
MONOCHROMATOR: GRATING 30000 RANGE 6500-3500Å
SCAN RATE 250 SLIT WIDTH 100-5
DETECTOR: TYPE 6256B TEMP RT
SETTING 1080 V
POLARIZATION — FILTER —
ELECTRONICS: PRE-AMP Regular
PSD "
TIME CONSTANT 3
RECORDER: A ___ B ___ C ___
SETTINGS ___
SPEED ___
REMARKS (x, y, z) = 3.81, 6.08, 5.00
OPERATOR PMG

26 Sept 1

27 September 1963

The reflectivity of Film 4 seemed to be too low for its apparent thickness so I checked the adjustment of the diagonal mirrors and found them to be OK so apparently this is not an artifact.

Also, the transmission in the vicinity of 5000Å - 6000Å seems to be oddly shaped and not at all like results given by calculation using bulk optical constants. The edge due to the 5900Å transition seems to be very sharp and goes much deeper than one would expect. It is interesting to speculate whether or not this is due to an exciton at the first L transition. Such a possibility has been suggested by Fox but it is hard to see this because of the short hole lifetime at this point in the Brillouin zone. Observations should be made on this film some time at low temperatures in order to see if this structure sharpens or is merely an artifact.

28 September 1963

Today I want to complete at least the run on one side of Film 4.

PURPOSE Overall R and T of Film 4
DATE 9/28/63 PAGE LOG BOOK 44 SPECTRUM # 1
SAMPLE: MATERIAL Film 4 CODE Film log 45
ORIENTATION ________ TEMP ________
THICKNESS ________ PREPARATION ________
STRESS: TYPE — MAGNITUDE ________ DIRECTION ________
SOURCE: TYPE W lamp STRENGTH 6V
MONOCHROMATOR: GRATING 30000 RANGE 6500-3500 Å
SCAN RATE 250 SLIT WIDTH 100-5
DETECTOR: TYPE 6256B TEMP RT
SETTING 1070 V
POLARIZATION — FILTER —
ELECTRONICS: PRE-AMP Regular
PSD "
TIME CONSTANT 3
RECORDER: ________ A ________ B ________ C ________
SETTINGS ________
SPEED ________
REMARKS (x, y, z) = 3.81, 6.08, 5.00
OPERATOR PMG

28 Sept 1

The purpose of 28 Sept 1 was to check reproducibility by comparing with 26 Sept 1. The I_0 seemed to wander quite badly during this run.

The purpose of 28 Sept 2 was to examine the L transition in transmission and reflection. In all, 5 scans were made in the following order:

(1) I_0
(2) I_T
(3) I_0
(4) I_R
(5) I_0

The third I_0 (3) will be used as the final I_0 for transmission and the initial I_0 for reflection.

28 Sept 3 is an overall scan of the UV for film 4.

PURPOSE Examination of L Transition: Film 4
DATE 9/28/63 PAGE LOG BOOK 45 SPECTRUM # 2
SAMPLE: MATERIAL Film 4 CODE FL 45
ORIENTATION ______ TEMP ______
THICKNESS ______ PREPARATION ______
STRESS: TYPE — MAGNITUDE ______ DIRECTION ______
SOURCE: TYPE 3W lamp STRENGTH 6V
MONOCHROMATOR: GRATING 30000 RANGE 6100 - 5100
SCAN RATE 125 SLIT WIDTH 100-5
DETECTOR: TYPE 6256B TEMP RT
SETTING 1070 V
POLARIZATION — FILTER —
ELECTRONICS: PRE-AMP Regular
PSD "
TIME CONSTANT 3
RECORDER: ______ A ______ B ______ C ______
SETTINGS ______
SPEED ______
REMARKS (x, y, z) = 3.81, 6.08, 5.00
OPERATOR PMG

28 Sept 2

PURPOSE R and T of Film 4
DATE 9/28/63 PAGE LOG BOOK 45 SPECTRUM # 3
SAMPLE: MATERIAL Film 4 CODE FL 45
ORIENTATION ______ TEMP ______
THICKNESS ______ PREPARATION ______
STRESS: TYPE — MAGNITUDE ______ DIRECTION ______
SOURCE: TYPE D_2 lamp STRENGTH Low
MONOCHROMATOR: GRATING 30000 RANGE 3500 - 2000Å
SCAN RATE 250 SLIT WIDTH 100 - 5
DETECTOR: TYPE 6256B TEMP RT
SETTING 1630 V
POLARIZATION — FILTER —
ELECTRONICS: PRE-AMP Regular
PSD "
TIME CONSTANT 3
RECORDER: ______ A ______ B ______ C ______
SETTINGS ______
SPEED ______
REMARKS (x, y, z) = 3.18, 6.08, 5.00
OPERATOR PMG

28 Sept 3

30 September 1963

Yesterday (Sunday) I prepared the data of 28 Sept. Today I made the first run on the reverse side of the film. This is 30 Sept 1, in the UV range.

A cursory review of todays results and those of 28 Sept reveals a very poorly developed X transition. This is as yet unexplained.

PURPOSE Reverse R and T of Film 4
DATE 9/30/63 PAGE LOG BOOK 46 SPECTRUM # 1
SAMPLE: MATERIAL Film 4 CODE FL 45
ORIENTATION ___ TEMP ___
THICKNESS ___ PREPARATION ___
STRESS: TYPE — MAGNITUDE ___ DIRECTION ___
SOURCE: TYPE D2 lamp STRENGTH Low
MONOCHROMATOR: GRATING 30000 RANGE 3500-2000Å
SCAN RATE 250 SLIT WIDTH 100-5
DETECTOR: TYPE 6256B TEMP RT
SETTING 1630 v
POLARIZATION — FILTER —
ELECTRONICS: PRE-AMP Regular
PSD "
TIME CONSTANT 3
RECORDER: A ___ B ___ C ___
SETTINGS ___
SPEED ___
REMARKS (x, y, z) = 3.18, 6.08, 5.00
OPERATOR PMG

30 Sept 1

1 October 1963

Today I ran the 6500-3500 run on the reverse side of film 4. The results to date are beginning to indicate that more range is needed on the amplifier gain control, say, steps of two instead of ten. Also, I began giving some thought to the problem of a mount for the Iodine Quartz Lamp.

PURPOSE Reverse R and T of Film 4

DATE 10/1/63 PAGE LOG BOOK 47 SPECTRUM # 1

SAMPLE: MATERIAL Film 4 CODE FL 45

ORIENTATION ______ TEMP ______

THICKNESS ______ PREPARATION ______

STRESS: TYPE — MAGNITUDE ______ DIRECTION ______

SOURCE: TYPE W lamp STRENGTH 6V

MONOCHROMATOR: GRATING 30000 RANGE 6500 - 3500

SCAN RATE 250 SLIT WIDTH 100 - 5

DETECTOR: TYPE 6256 B TEMP RT

SETTING 1070 V

POLARIZATION — FILTER —

ELECTRONICS: PRE-AMP Regular

PSD "

TIME CONSTANT 3

RECORDER: ______ A ______ B ______ C ______

SETTINGS ______

SPEED ______

REMARKS (x, y, z) = 3.18, 6.08, 5.00

OPERATOR PMG

1 Oct 1

PURPOSE (x, y, z) = 3.18, 6.08, 5.00

DATE 10/1/63 PAGE LOG BOOK 47 SPECTRUM # 2

SAMPLE: MATERIAL Film 4 CODE FL 45

ORIENTATION ______ TEMP ______

THICKNESS ______ PREPARATION ______

STRESS: TYPE — MAGNITUDE ______ DIRECTION ______

SOURCE: TYPE W lamp STRENGTH 6V

MONOCHROMATOR: GRATING 30000 RANGE 6100 - 5100

SCAN RATE 125 SLIT WIDTH 100 - 5

DETECTOR: TYPE 6256 B TEMP RT

SETTING 1070 V

POLARIZATION — FILTER —

ELECTRONICS: PRE-AMP Regular

PSD "

TIME CONSTANT 3

RECORDER: ______ A ______ B ______ C ______

SETTINGS ______

SPEED ______

REMARKS Reverse R and T for Film 4 in region of L transition.

OPERATOR PMG

1 Oct 2

2 October 1963

Last night I made a mount to hold the Sylvania Iodine Quartz Lamp 400T4Q/CL/F, 120 volt, 400 watt. I am now testing it. The variac setting for the GE instrument lamp was at 55.5.

The output of the Sylvania lamp was less than the GE ribbon lamp for the same PM voltage and slit width. This is because the filament width on the Sylvania is far greater than that of the GE. However, it did not seem to give appreciably more output at 3500 Å than the GE and this was the principle reason for trying it. Hence we will return to the GE lamp.

3 October 1963

Today was spent reducing data of 1 OCT.

5 October 1963

PURPOSE R and T of Film 6

DATE 10/5/63 PAGE LOG BOOK 48 SPECTRUM # 1

SAMPLE: MATERIAL Film 6 CODE FL50

ORIENTATION ______ TEMP ______

THICKNESS ______ PREPARATION ______

STRESS: TYPE - MAGNITUDE ______ DIRECTION ______

SOURCE: TYPE W lamp STRENGTH 6V

MONOCHROMATOR: GRATING 30000 RANGE 6500-5000

SCAN RATE 250 SLIT WIDTH 100-5

DETECTOR: TYPE 6256B TEMP RT

SETTING 1100V

POLARIZATION - FILTER CS 3-73

ELECTRONICS: PRE-AMP Regular

PSD "

TIME CONSTANT 3

RECORDER: ______ A ______ B ______ C ______

SETTINGS ______

SPEED ______

REMARKS (x, y, z) = 3.18, 6.08, 5.00

OPERATOR PMG

5 OCT 1

Today I began experiments on film 6. In order to minimize second order diffraction effects, I am using filter CS3-73 in the range 6500-5000 Å

PURPOSE R and T of Film 6

DATE 10/5/63 PAGE LOG BOOK 49 SPECTRUM # 2

5 OCT 2

SAMPLE: MATERIAL Film 6 CODE FL50

ORIENTATION ___ TEMP ___

THICKNESS ___ PREPARATION ___

STRESS: TYPE — MAGNITUDE ___ DIRECTION ___

SOURCE: TYPE W lamp STRENGTH 6 V

MONOCHROMATOR: GRATING 30000 RANGE 5000-3500

SCAN RATE 250 SLIT WIDTH 100-5

DETECTOR: TYPE 6256B TEMP RT

SETTING 1100 V

POLARIZATION — FILTER —

ELECTRONICS: PRE-AMP Regular

PSD "

TIME CONSTANT 3

RECORDER: ___ A ___ B ___ C ___

SETTINGS ___

SPEED ___

REMARKS (x, y, z) = 3.18, 6.08, 5.00

OPERATOR PMG

PURPOSE T of L structure in Film 6

DATE 10/5/63 PAGE LOG BOOK 49 SPECTRUM # 3

5 OCT 3

SAMPLE: MATERIAL Film 6 CODE FL50

ORIENTATION ___ TEMP ___

THICKNESS ___ PREPARATION ___

STRESS: TYPE — MAGNITUDE ___ DIRECTION ___

SOURCE: TYPE W lamp STRENGTH 6 V

MONOCHROMATOR: GRATING 30000 RANGE 6100-5100

SCAN RATE 125 SLIT WIDTH 100-5

DETECTOR: TYPE 6256B TEMP RT

SETTING 1040 V

POLARIZATION — FILTER CS 3-73

ELECTRONICS: PRE-AMP Regular

PSD "

TIME CONSTANT 3

RECORDER: ___ A ___ B ___ C ___

SETTINGS ___

SPEED ___

REMARKS (x, y, z) = 3.18, 6.08, 5.00

OPERATOR PMG

PURPOSE: R of L structure in Film 6

DATE: 10/5/63 PAGE LOG BOOK: 50 SPECTRUM #: 4

SAMPLE: MATERIAL: Film 6 CODE: FL 50

ORIENTATION: ______ TEMP: ______

THICKNESS: ______ PREPARATION: ______

STRESS: TYPE: — MAGNITUDE: ______ DIRECTION: ______

SOURCE: TYPE: W lamp STRENGTH: 6 v

MONOCHROMATOR: GRATING: 30000 RANGE: 6100 - 5100 Å

SCAN RATE: 125 SLIT WIDTH: 100 - 5

DETECTOR: TYPE: 6256 B TEMP: RT

SETTING: 960 v

POLARIZATION: — FILTER: CS 3 - 73

ELECTRONICS: PRE-AMP: Regular

PSD: "

TIME CONSTANT: 3

RECORDER: ______ A ______ B ______ C ______

SETTINGS: ______

SPEED: ______

REMARKS: (x, y, z) = 3.18, 6.08, 5.00

OPERATOR: PMG

5 OCT 4

7 October 1963

Today I processed the data of 5 Oct for computer reduction.
Let us consider some of the possible consequences of the thiness of the films on the band structure of Ge. We know that one of the size effects is the quantization of k space. For a film thickness of 500 Å, the division of k space in the direction of the film thickness is into about 100 parts. If we consider the ⟨111⟩ direction for Ge we see that two possible situations exist:

(1) $\nabla E_v = \nabla E_c = 0$

(2) $\nabla (E_v - E_c) = 0$

If (1) holds for a direct transition, then one expects to see little evidence of a discreet reciprocal space, while if (2) holds, which is believed to be the case in 2 ev structure in Ge, then one may expect to see some structure in the absorption spectrum around this energy. This would be a way of deciding whether or not (1) or (2) held for a particular transition.

Now in Ge, the Λ_3 line has a maximum slope of about 4 ev per πa^{-1}, so that if there were 100 divisions of k space in that direction, there should be an energy separation of about .04 ev for the states involved in the $\perp$ transition, which could be observed.

The ramifications and difficulties of identifying such an effect are not well understood right now, but one must point out that only one direction is affected (the direction of the thickness of the film) hence equivalent directions are left continuous thus tending to reduce the chance of observation.

A similar effect should be present around the X − Σ structure.

8 October 1963

Today I began examining some of the computed results of Film 6. There seemed to be some indication that the gain going from 33 to 32 was not 10 but a check showed it to be 9.9. This is critical for reflection. The Ω splitting was observed nicely in Film 6.

I am now beginning the UV run on Film 6.

PURPOSE: R and T of Film 6

DATE: 10/8/63 PAGE LOG BOOK: 51 SPECTRUM #: 1

SAMPLE: MATERIAL: Film 6 CODE: FL 50

ORIENTATION: TEMP:

THICKNESS: PREPARATION:

STRESS: TYPE: — MAGNITUDE: DIRECTION:

SOURCE: TYPE: W lamp STRENGTH: 6 V

MONOCHROMATOR: GRATING: 30000 RANGE: 3500 − 2000 Å

SCAN RATE: 250 SLIT WIDTH: 100 − 5

DETECTOR: TYPE: 6256B TEMP: RT

SETTING: 1690 V

POLARIZATION: — FILTER: —

ELECTRONICS: PRE-AMP: Regular

PSD: "

TIME CONSTANT: 3

RECORDER: A B C

SETTINGS:

SPEED:

REMARKS: (X, Y, Z) = 3.18, 6.08, 5.00

Erratum: D₂ lamp was used, of course.

OPERATOR: PMG

8 OCT 1

PURPOSE R and T at x transition for Film 6

DATE 10/8/63 PAGE LOG BOOK 52 SPECTRUM # 2

SAMPLE: MATERIAL Film 6 CODE FL50

ORIENTATION <111> TEMP

THICKNESS PREPARATION

STRESS: TYPE – MAGNITUDE DIRECTION

SOURCE: TYPE D_2 lamp STRENGTH Low

MONOCHROMATOR: GRATING 30000 RANGE 3300-2300 Å

SCAN RATE 125 SLIT WIDTH 100-5

DETECTOR: TYPE 6256B TEMP RT

SETTING 1690V

POLARIZATION – FILTER –

ELECTRONICS: PRE-AMP Regular

PSD "

TIME CONSTANT 3

RECORDER: A B C

SETTINGS

SPEED

REMARKS (x, y, z) = 3.18, 6.08, 5.00

OPERATOR PMG

8 OCT 2

PURPOSE Reverse R and T for Film 6

DATE 10/8/63 PAGE LOG BOOK 52 SPECTRUM # 3

SAMPLE: MATERIAL Film 6 CODE FL50

ORIENTATION <111> TEMP

THICKNESS PREPARATION

STRESS: TYPE – MAGNITUDE DIRECTION

SOURCE: TYPE D_2 lamp STRENGTH Low

MONOCHROMATOR: GRATING 30000 RANGE 3500-2000 Å

SCAN RATE 250 SLIT WIDTH 100-5

DETECTOR: TYPE 6256B TEMP RT

SETTING 1690V

POLARIZATION – FILTER –

ELECTRONICS: PRE-AMP Regular

PSD "

TIME CONSTANT 3

RECORDER: A B C

SETTINGS

SPEED

REMARKS (x, y, z) = 3.18, 6.08, 5.00

OPERATOR PMG

8 OCT 3

PURPOSE T for X transition on Film 6 (b)
DATE 10/8/63 PAGE LOG BOOK 53 SPECTRUM # 4

8 OCT 4

SAMPLE: MATERIAL Film 6 CODE FL 50
ORIENTATION (b) TEMP
THICKNESS PREPARATION
STRESS: TYPE – MAGNITUDE DIRECTION
SOURCE: TYPE D2 lamp STRENGTH low
MONOCHROMATOR: GRATING 30000 RANGE 3300-2300 Å
SCAN RATE 125 SLIT WIDTH 100-5
DETECTOR: TYPE 6256 B TEMP RT
SETTING 1690 V
POLARIZATION – FILTER –
ELECTRONICS: PRE-AMP Regular
PSD "
TIME CONSTANT 3
RECORDER: A B C
SETTINGS
SPEED
REMARKS (x, y, z) = 3.18, 6.08, 5.00
OPERATOR PMG

PURPOSE R for X transition on Film 6 (b)
DATE 10/8/63 PAGE LOG BOOK 53 SPECTRUM # 5

8 OCT 5

SAMPLE: MATERIAL Film 6 CODE FL50
ORIENTATION (b) TEMP
THICKNESS PREPARATION
STRESS: TYPE – MAGNITUDE DIRECTION
SOURCE: TYPE D2 lamp STRENGTH low
MONOCHROMATOR: GRATING 36000 RANGE 3300-2300 Å
SCAN RATE 125 SLIT WIDTH 100-5
DETECTOR: TYPE 6256 B TEMP RT
SETTING 1580 V
POLARIZATION – FILTER –
ELECTRONICS: PRE-AMP Regular
PSD "
TIME CONSTANT 3
RECORDER: A B C
SETTINGS
SPEED
REMARKS (x, y, z) = 3.18, 6.08, 5.00
OPERATOR PMG.

9 October 1963

PURPOSE R and T of Film 6 (b)

DATE 10/9/63 PAGE LOG BOOK 54 SPECTRUM # 1

SAMPLE: MATERIAL Film 6 CODE FL50

ORIENTATION (b) TEMP

THICKNESS PREPARATION

STRESS: TYPE — MAGNITUDE DIRECTION

SOURCE: TYPE W lamp STRENGTH 6V

MONOCHROMATOR: GRATING 30000 RANGE 6500 - 5000 Å

SCAN RATE 250 SLIT WIDTH 100 - 5

DETECTOR: TYPE 6256B TEMP RT

SETTING 1100V

POLARIZATION — FILTER CS3-73

ELECTRONICS: PRE-AMP Regular

PSD "

TIME CONSTANT 3

RECORDER: A B C

SETTINGS

SPEED

REMARKS (x, y, z) = 3.18, 6.08, 5.00

OPERATOR PMG

9 OCT 1

Today I began the W lamp run on the reverse side of Film 6.

PURPOSE R and T of Film 6 (b)

DATE 10/9/63 PAGE LOG BOOK 54 SPECTRUM # 2

SAMPLE: MATERIAL Film 6 CODE FL50

ORIENTATION (b) TEMP

THICKNESS PREPARATION

STRESS: TYPE — MAGNITUDE DIRECTION

SOURCE: TYPE W lamp STRENGTH 6V

MONOCHROMATOR: GRATING 30000 RANGE 5000 - 3500 Å

SCAN RATE 250 SLIT WIDTH 100 - 5

DETECTOR: TYPE 6256B TEMP RT

SETTING 1100V

POLARIZATION — FILTER —

ELECTRONICS: PRE-AMP Regular

PSD "

TIME CONSTANT 3

RECORDER: A B C

SETTINGS

SPEED

REMARKS (x, y, z) = 3.18, 6.08, 5.00

OPERATOR PMG

9 OCT 2

Because it has been observed that the amplifier gain control does not seem to give decade steps, some measurements were taken. This variation from 10 does not affect the transmission so much, but it raises hell with the reflection. The values below are mean values:

32/33 = 9.95

31/32 = 10.25

Since these are hard to measure, there may be considerable error.

PURPOSE Reverse T for film 6 on ⊥ transition
DATE 10/9/63 PAGE LOG BOOK 55 SPECTRUM # 3
SAMPLE: MATERIAL Film 6 CODE FL 50
ORIENTATION (b) TEMP
THICKNESS PREPARATION
STRESS: TYPE — MAGNITUDE DIRECTION
SOURCE: TYPE W lamp STRENGTH 6 V
MONOCHROMATOR: GRATING 30000 RANGE 6100 - 5100
SCAN RATE 125 SLIT WIDTH 100 - 5
DETECTOR: TYPE 6256B TEMP RT
SETTING 1040 V
POLARIZATION — FILTER CS 3-73
ELECTRONICS: PRE-AMP Regular
PSD "
TIME CONSTANT 3
RECORDER: A B C
SETTINGS
SPEED
REMARKS (x, y, z) = 3.18, 6.08, 5.00
OPERATOR PMG

9 OCT 3

PURPOSE Reverse R for ⊥ transition; Film 6
DATE 10/9/63 PAGE LOG BOOK 55 SPECTRUM # 4
SAMPLE: MATERIAL Film 6 CODE FL 50
ORIENTATION (b) TEMP
THICKNESS PREPARATION
STRESS: TYPE — MAGNITUDE DIRECTION
SOURCE: TYPE W lamp STRENGTH 6 V
MONOCHROMATOR: GRATING 30000 RANGE 6100 - 5100
SCAN RATE 125 SLIT WIDTH 100 - 5
DETECTOR: TYPE 6256 B TEMP RT
SETTING 1010 V
POLARIZATION — FILTER CS 3-73
ELECTRONICS: PRE-AMP Regular
PSD "
TIME CONSTANT 3
RECORDER: A B C
SETTINGS
SPEED
REMARKS (x, y, z) = 3.18, 6.08, 5.00
OPERATOR PMG

9 OCT 4

NB: After the runs were completed, it was found that the reflectance settings were not optimized. This will necessitate the application of a correction factor of 1.09 to the IR data of 8 OCT and 9 OCT.

This came about because of the offset of the reflecting face of the film when reversing. The z setting had to be changed from 5.00 to 6.20 to optimize the response. Adjusting the rotation of the IR mirror showed that it already had the correct angular position.

10 October 1963 to 16 October 1963

This time has been spent reducing data into graphical form. It has been found more convenient to do the elementary calculations by hand on the Monroe calculator than to use the 7094. There are several reasons for this. First, hand calculations provide more flexibility in technique so that system changes do not require extensive changes in the programming system. It was found that it is required to know the gain settings precisely as previously noted and minor changes such as these can be easily incorporated into the hand calculations. Also, graphing can be done simultaneously with calculation so that errors are discovered quickly and easily.

Several other new requirements were also noted during this period. It seems that gain intervals of 10 are too large because a great deal of inaccuracy occurs at low scale levels. Possibly intermediate gain steps can be had by using the PM power supply switches and this will have to be tried.

The following measurements have been taken on Film 6:

Overall: 6500 - 2000 Å, R, T, T', R'

Λ Transition: 6100 - 5100 Å, R, T, T', R'

Σ Transition: 3300 - 2300 Å, R, T, T', R'

In general the measurements confirm qualitatively the reflectivity measurements taken on bulk material, including the Λ spin-orbit splitting. However, quantitatively the Σ structure seems to be much weaker than indicated by the bulk measurements, at least in reflection. Calculations should be done using bulk optical constants for the transmission in order to do any comparisons here. Some consideration should be given to the position of the Σ peak in this film as it seems to be slightly displaced toward longer wavelengths than the bulk. Also there appears to be some sort of fine structure about the Λ edge that should be looked at.

I have had an idea about an experiment involving shear in Ge. It may be possible to measure the optical rotation due to twisting a bar of Ge in M. De Meis' equipment. I will have to do some preliminary calculations along this line. It may also be applicable to other materials. Also nobody has looked at the effects of strain on the reflectivity of Si, and the 3-5 compounds. Possibly in some of the 3-5's the 2 eV peak can be split.

We will now consider a method by which we can expand the eventual I/Io measurement:

$$R = \frac{M_f\,(B + D/G_f)}{M_{fo}\,(B_o + D_o/G_{fo})}$$

where $R = I/I_o$ = expanded reflection or transmission
M_f, M_{fo} = multiplying scale factors
B, B_o = Bucking signal in chart divisions
D, D_o = Deflection in chart divisions
G_f, G_{fo} = Gain factors

For further discussion, see the appropriate file paper.

17 October 1963

Today I began the investigation of whether or not there is fine structure in the Λ edge of Film 6. To do this, I tried to get both I_T and I_o as far up on the chart as possible in order to improve the accuracy. I have also found that the above equation holds only when one is able to do the bucking by feeding part of the signal back into the input, which presently I am not able to do.

PURPOSE: Structure of Λ Edge
DATE: 10/17/63 PAGE LOG BOOK: 57 SPECTRUM #: 1
SAMPLE: MATERIAL: Film 6 CODE: FL 50
ORIENTATION: (b) TEMP:
THICKNESS: PREPARATION:
STRESS: TYPE: — MAGNITUDE: DIRECTION:
SOURCE: TYPE: W lamp STRENGTH: 6 V
MONOCHROMATOR: GRATING: 30000 RANGE: 5700-5600
SCAN RATE: 50 SLIT WIDTH: 100-5
DETECTOR: TYPE: 6256B TEMP: RT
SETTING: 1540, 1220
POLARIZATION: — FILTER: CS 3-73
ELECTRONICS: PRE-AMP: Regular
PSD: "
TIME CONSTANT: 3
RECORDER: A B C
SETTINGS:
SPEED:
REMARKS: (x, y, z) = 3.18, 6.08, 5.00
PM Voltage used as gain
OPERATOR: PMG

17 OCT 1

PURPOSE: Structure of Λ Edge

DATE: 10/17/63 PAGE LOG BOOK: 58 SPECTRUM #: 2

17 OCT 2

SAMPLE: MATERIAL: Film 6 CODE: FL50

ORIENTATION: (b) TEMP:

THICKNESS: PREPARATION:

STRESS: TYPE: — MAGNITUDE: DIRECTION:

SOURCE: TYPE: W lamp STRENGTH: 6V

MONOCHROMATOR: GRATING: 30000 RANGE: 5900 - 5600

SCAN RATE: 50 SLIT WIDTH: 100 - 5

DETECTOR: TYPE: 6256B TEMP: RT

SETTING: 1220, 1450

POLARIZATION: — FILTER: CS 3-73

ELECTRONICS: PRE-AMP: Regular

PSD: "

TIME CONSTANT: 2

RECORDER: A B C

SETTINGS:

SPEED:

REMARKS: (x, y, z) = 3.12, 6.08, 5.00
PM voltage used as gain

OPERATOR: PMG

18 October 1963

The search for fine structure yesterday was not conclusive. 17 OCT 2 yielded some variation at 5660Å but 17 OCT 1 did not. Perhaps the search should be done at lower temps or with some sort of scale expansion.

Tests are still underway to debug OPCON2 so that the results on Film 6 can be processed.

21 October – 25 October 1963

This week was spent primarily in trying to get OPCON2 to run with no success. See CC Log. I am going to take a reflectivity run on Ge sample PDE(621) and then do a run on Film 3 which seems from the DK2 curves to have a Λ transition shift to higher energies. I should look into the possible effect of the difference in lattice constants. Also, thicknesses may have to be measured for OPCON1.

28 October 1963

PURPOSE	Reflectivity of PDE(62)
DATE	10/28/63
PAGE LOG BOOK	59
SPECTRUM #	1
SAMPLE: MATERIAL	PDE(62)
CODE	
ORIENTATION	
TEMP	
THICKNESS	
PREPARATION	
STRESS: TYPE	—
MAGNITUDE	
DIRECTION	
SOURCE: TYPE	W lamp
STRENGTH	6V
MONOCHROMATOR: GRATING	30000
RANGE	6500-5000
SCAN RATE	125
SLIT WIDTH	100-5
DETECTOR: TYPE	6256B
TEMP	RT
SETTING	see chart and Log
POLARIZATION	—
FILTER	CS3-73
ELECTRONICS: PRE-AMP	Regular
PSD	"
TIME CONSTANT	3
RECORDER: A / B / C	
SETTINGS	
SPEED	
REMARKS	(x, y, z) = 3.18, 6.08, 5.00
OPERATOR	PMG

28 OCT 1

Today I began a two-fold investigation: (1) the reflectivity of a Ge sample prepared according to PDE(62) to use as standard data; (2) the use of PM voltage settings as gain controls to allow a wider range of scale expansion.

PURPOSE	Reflectivity of PDE(62)
DATE	10/28
PAGE LOG BOOK	59
SPECTRUM #	2
SAMPLE: MATERIAL	PDE(62)
CODE	
ORIENTATION	
TEMP	
THICKNESS	
PREPARATION	
STRESS: TYPE	—
MAGNITUDE	
DIRECTION	
SOURCE: TYPE	W lamp
STRENGTH	6V
MONOCHROMATOR: GRATING	30000
RANGE	5000-3500
SCAN RATE	125
SLIT WIDTH	100-5
DETECTOR: TYPE	6256B
TEMP	RT
SETTING	see chart and Log
POLARIZATION	—
FILTER	None
ELECTRONICS: PRE-AMP	Regular
PSD	"
TIME CONSTANT	3
RECORDER: A / B / C	
SETTINGS	
SPEED	
REMARKS	(x, y, z) = 3.18, 6.08, 5.00
OPERATOR	PMG

28 OCT 2

29 OCT 1963

PURPOSE Reflectivity of PDE(62)

DATE 10/29 PAGE LOG BOOK 60 SPECTRUM # 1

28 OCT 1

SAMPLE: MATERIAL PDE(62) CODE

ORIENTATION TEMP

THICKNESS PREPARATION

STRESS: TYPE — MAGNITUDE DIRECTION

SOURCE: TYPE D_2 lamp STRENGTH low

MONOCHROMATOR: GRATING 30000 RANGE 3500-2000

SCAN RATE 125 SLIT WIDTH 100-5

DETECTOR: TYPE 6256B TEMP RT

SETTING see chart

POLARIZATION — FILTER —

ELECTRONICS: PRE-AMP Regular

PSD "

TIME CONSTANT 3

RECORDER: A B C

SETTINGS

SPEED

REMARKS (x, y, z) = 3.18, 6.08, 5.00

OPERATOR PMG

30 October - 1 November 1963

This time was spent in studying the data of 28 and 29 OCT. several observations were made:

(1) The region between 6500 Å and 6000 Å did not seem to decrease as it should. There has always been trouble here.

(2) The 5900 Å peak was at 5800 Å.

(3) There was a large discontinuity at 3500 Å when the sources were changed.

As for the (1) difficulty, this seems to arise from the fact that I_0 is changing rapidly in this region, hence there may be difficulty in scanning. As for (3), this effect was reproducible and mystifying. Further work must be done here; it may be due to scattered light. The most disturbing difficulty is (2). It was found that this effect has been appearing all along and was also a difficulty in PM's equipment!! This throws some suspicion on the photomultiplier as if the spectral response changes over the face of the PM, this could be a probable cause as neither I nor Io are incident on the same spot on the photomultiplier cathode. Changing the position of the beam seemed to restore the 5900Å peak to its proper position.

In light of the above, it has been decided to move the PM back from its present position so that a frosted glass can be inserted and used as a diffusing screen for the light. Also, an adapter will be made for the 7102 PM so that it can be used so that it can check the position of the 5900 peak.

4-16 November 1963

Most of this time was spent studying for the Russian language exam. The above-mentioned changes in the PM housing were made. This cut down the efficiency quite a bit but restored the 5900 peak to its proper place. The 7102 tube did not seem to give good results at all between 5000Å and 6000Å. Also, it now appears as though point-by-point with simultaneous calculation is much more accurate and faster than scanning.

18 November 1963 - 22 November 1963

Various attempts at point-by-point measurement of the reflectivity of etched and polished Ge were made. It seems that trouble (2) of 30 October was cleared up by diffusing the light, but troubles (1) and (3) remain. Several new troubles came to light; allignment difficulties giving the wrong magnitude of reflectivity, and non-linearity appearing when different magnitudes of anode resistor and PM voltage were used. It was then decided to place the PM further back, and remove the frosted glass. Then, allignment of Io and IR to exactly the same position on the PM is made by eye. This seemed to work satisfactorily, more satisfactory than anything yet. Note: The small W lamp burned out, or rather, began to fluctuate so badly that it was replaced with a new one. The GE part no. is 9A/T 8½/1.

In regard to the nonlinearity problem, the following data was collected:

3500 Å : W lamp : 100 μ : Ge

Anode Resistor	Voltage	R	Filter
100 K	870	.483, .485	
100 K	940	.485, .484, .481	CS 7-60
1 K	1490	.477, .476	CS 7-60
1 K	1380	.476, .476	

3500 Å : D_2 lamp : 100 μ : Ge

1 K	1470	.501, .500	
1 K	1590	.509, .509	CS-7-60
100 K	990	.517, .513, .527	CS 7-60
100 K	920	.520, .512, .518, .519	
1 K	1460	.518, .511, .511	

It was also noted that there is a line in the D_2 lamp at 4859 Å which is about 10 times the intensity at 3500 Å. The use of the filters demonstrates the nonlinearity and discrepancy at 3500 Å is not due to scattered light. It was decided that in order to investigate the non-linearity problem further, we would use Kravitz' filters with nominal 22%, 48% and 64% transmission. These filters were placed at the entrance hole of the entrance optics housing and the following results obtained:

3500 Å : D_2 lamp : 100 μ

Anode Resistor	Voltage	T		
1 K	1470	.649	.486	.213
100 K	930	.636	.478	.217

5300 Å : W lamp : 100 μ : CS 3-73

100 K	600	.639, .647	.484, .488	.212, .212
1 K	740	.652, .639	.478, .478	.213, .211

6500 Å : W lamp : 100 μ : CS 3-73

1 K	1380	.653, .637	.481, .480	.214, .211
100 K	850	.643, .652	.478, .476	.211, .218

3500 Å : W lamp : 100 μ

100 K	850	.641, .644	.485, .487	.211, .221
1 K	1350	.643, .651	.482, .486	.210, .221

these results seem to indicate that the non-linearity is something other than a dynamic effect in the PM or electronics.

I have also written letters to several people asking for samples. See copies.

The surroundings of the sample mount and photo-multiplier housing have been painted flat black and a light trap placed in front of the P.M. to cut down scattered light. However there still seems to be evidence of non-linearity in the operation of the PM with anode resistor. Very careful measurements were made and the results seem to be consistent.

26 - 27 November 1963

The following table presents the results of the previous week's work on the non-linearity problem and also these two days: the sample was Mac Load polished Ge.

		Voltage	R_A	R
3 days apart. Something happened	TC = 3, 3500 Å, 100 μ, W lamp	1330	1 K	.478
		840	100 K	.487
	TC = 2, 3500 Å 25 μ, W lamp	1150	100K	.466, .464
		1850	1K	.459, .460
	TC = 3, 3500 Å, 100 μ W lamp, 7-60 in	1430	1K	.458, .458
		900	100K	.465, .464
several hours apart	" 7-60 out	850	100K	.464, .465
		1320	1 K	.455, .454
	"	1320	1K	.456, .456
		830	100K	.464, .463
	" 5300 Å	590	100K	.513, .512
		930	1 K	.506, .506

We note that there is a consistent non-linearity. In principle the higher R should be the non-linear value and hence the 100K anode resistor seems to be allowing a space charge to build up between the anode and last dynode.

Thought: Would an incandescent Ge or Si filament have structure in its emission spectrum?

29-30 November 1963

In order to improve the equipment I have designed a backing circuit which should be capable of applying a bucking signal to the input signal so that scale expansion will be possible. Also, a stepping potentiometer was purchased from Shallcross in order to give the amplifier more ranges of gain. This will be calibrated when installed, but it is a 20 step job with about 4db per step, indentical to the PE system.

2-4 December 1963

I received from B.A. Joyce a small sample of a silicon film in response to my request. This film was evidently deposited on quartz by vapour means. The film itself seemed thick and had a brownish colour. Its texture was finely granulated and the back surface of the quartz substrate was rough ground. This made for somewhat difficult optical measurements. Also, it was noted that there were some pinholes in the film.

In an attempt to get the "big picture," the little sample was mounted on a piece of CaF_2 with Kravitz' GE cement. Unfortunately some of the cement ran under the back of the substrate, but a run was attempted anyway. As for the transmission, it was scattered light limited at about 4800Å. According to the reflectivity data of PT(60), structure should be seen in the region of 3800Å and 2800Å.

The reflectivity picture was pretty dismal. Relative reflectivity had to be studied due to the length of the optical path from sample to PM and the diffusion of light from the sample so that the difference between I_o and I_R was fairly large. The reflectivity does not behave at all like the bulk material, but rather decreases steadily with decreasing wavelength. There appears to be no structure at 3800Å but there is a suggestion of something at 2800Å, and this should be looked at again.

Perhaps a better arrangement can be found for looking at the transmission after the sample has been remounted.

PURPOSE Transmission of Silicon sample
DATE 12/4/63 PAGE LOG BOOK 65 SPECTRUM # 1
SAMPLE: MATERIAL Joyce Silicon 1 CODE
ORIENTATION ? TEMP
THICKNESS ? PREPARATION
STRESS: TYPE — MAGNITUDE DIRECTION
SOURCE: TYPE W lamp STRENGTH 6 V
MONOCHROMATOR: GRATING 30000 RANGE 6500 - 3500 Å
SCAN RATE PBP SLIT WIDTH 200 - 2.5
DETECTOR: TYPE 6256B TEMP RT
SETTING See Chart
POLARIZATION — FILTER CS3-73, none
ELECTRONICS: PRE-AMP Regular
PSD "
TIME CONSTANT 2
RECORDER: A B C
SETTINGS
SPEED
REMARKS Measurements made point-by-point
OPERATOR PMG

4 December ①

PURPOSE Reflection of Si film sample
DATE 12/4/63 PAGE LOG BOOK 65 SPECTRUM # 2
SAMPLE: MATERIAL Joyce Silicon 1 CODE
ORIENTATION ? TEMP
THICKNESS ? PREPARATION
STRESS: TYPE — MAGNITUDE DIRECTION
SOURCE: TYPE W lamp STRENGTH 6 V
MONOCHROMATOR: GRATING 30000 RANGE 6500 - 3500 Å
SCAN RATE PBP SLIT WIDTH 200 - 2.5
DETECTOR: TYPE 6256B TEMP RT
SETTING See Chart
POLARIZATION — FILTER CS3-73, none
ELECTRONICS: PRE-AMP Regular
PSD "
TIME CONSTANT 2
RECORDER: A B C
SETTINGS
SPEED
REMARKS
OPERATOR PMG

4 December ②

PURPOSE Reflection of Se Film sample

DATE 12/4/63 PAGE LOG BOOK 66 SPECTRUM # 3

SAMPLE: MATERIAL Joyce Sample 1 CODE

ORIENTATION ? TEMP

THICKNESS ? PREPARATION

STRESS: TYPE – MAGNITUDE DIRECTION

SOURCE: TYPE D2 lamp STRENGTH low

MONOCHROMATOR: GRATING 30000 RANGE 3500-2000 Å

SCAN RATE PBP SLIT WIDTH 200-2.5

DETECTOR: TYPE 6256 B TEMP RT

SETTING see chart

POLARIZATION – FILTER –

ELECTRONICS: PRE-AMP Regular

PSD "

TIME CONSTANT 2

RECORDER: A B C

SETTINGS

SPEED

REMARKS

OPERATOR DMG

4 December ③

5-6 December 1963

In these two days I finished the unit providing a bucking signal at the input. It seems to work well except that there is capacitative feedthru on the toggle switch so that the reference signal input cable should be disconnected when not in use as a bucking source.

On Friday Manuel Cardona was here and we discussed his II-VI and thin film work. As regards the film work he claims to have "bulk polished" films of Ge and Se 1000 Å thick in small places. He also reports seeing exiton structure at the Λ transition in the Ge. This is also what I have expected as being present in Film 4 as early as 6 June. We also discussed certain possible experiments with III-V and II-VI compounds epitaxially deposited on CaF_2, including GaAs - GaP alloys. All previous work on these films has been done on quartz substrates. He seemed to have the opinion that strain effects in the films were rather unimportant and indicated mistrust of the results of PDE(62). We also talked some of the Γ (assumed) transition at about 3900 Å which I have also observed in my Ge films. The talk about excitons was most interesting and I should look at Film 4 at low temperatures to confirm my feelings about this.

9 December 1963

The following is an extension of the conversion of Cardona's results. See 2 July. This is the 500 Å film (and 1500 Å).

Wavelength	Energy	log I_0/I 500 Å	log I_0/I 1500 Å	I/I_0 500 Å	I/I_0 1500 Å
3500 Å	3.54 ev	.58	2.71	$2.63 \cdot 10^{-1}$	$1.95 \cdot 10^{-3}$
3400	3.65	.59	2.71	2.57	$1.95 \cdot 10^{-3}$
3300	3.76	.60	2.70	2.51	1.99
3200	3.88	.60	2.67	2.51	2.14
3100	4.00	.63	2.64	2.34	2.29
3000	4.13	.77	2.80	1.70	1.58
2900	4.27	1.90		$1.26 \cdot 10^{-2}$	
2800	4.43	4.28		$5.24 \cdot 10^{-5}$	
2700	4.59	4.30		5.00	
2600	4.77	4.20		6.30	
2500	4.96	4.25		5.62	
2400	5.16	4.66		2.18	

10 December 1963

The following is the position of the UV peak and dip at the Σ transition in Ge Film 6; at 300°K:

Dip in Transmission: 2760 ± 20 Å or 4.49 ± .03 ev

Peak in Reflection: 2800 ± 20 Å or 4.40 ± .03 ev

According to the data of Lukes and Schmidt, LS(62), the reflectivity peak is just about where it should be within the above error.

However, the absorption edge at the Λ transition in Film 6 is about 2.17 ev which is about .07 ev higher in energy than the usually reported value of the reflectivity peak.

11 December 1963

Today I installed a stepping potentiometer in the amplifier. This potentiometer is a Daven SPEC 2208-3, 500K, 20 steps, 4 db/step and is the same one as used in the Perkin-Elmer 107 amplifier and was ordered from them. The inclusion of this component made it necessary to reevaluate the linearity of the amplifier. This was done by trying to keep the output within the range that drives the recorder full scale, usually 1.2 volts. The input signal was obtained from the calibrator of a Tektronix 543a scope. Note that the gain setting is, and will be, reported in terms of twice the dial plate reading.

Input	Δ In	Output	Δ Out	Gain Setting	Gain
.5 mv	.4	1.9 v	.4	21	3800
.2		.75			
1	.5	1.5	.5	18	1500
.5		.75			
2	.5	1.2	.5	16	600
1		.6			
5	.4	1.2	.4	14	240
2		.5			
10	.5	1.5	.5	13	150
5		.75			
20	.5	1.2	.5	11	60
10		.6			
50	.4	1.2	.4	9	24
20		.5			
100	.5	1.4	.5	8	14
50		.7			
200	.5	1.4	.65	7	7
100		.9			9
500	.4	1.7	.8	7	3.4
200		1.4			2.8

It seems as if the "danger point" for non-linearity is gain setting 9 and under no circumstances should this be exceeded. If further attenuation is needed, the anode resistors can be switched.

12-13 December 1963

These two days I began planning for the installation of a liquid N_2 cryostat and took the following data on the new gain control. There are two sets of data, one taken on each of these days with a final figure taken nearest the theoretical figure of 4 db = 1.59. These figures were taken with a slit = 100μ @ 5mm at 5300Å with a 1K anode resistor:

Gain Control Ratios	Step Change in Gain			Final Values	
6/5	1.60	1.58		1.59	6/5
7/6	1.61	1.58		1.59	7/6
8/7	1.60	1.58		1.59	8/7
9/8	1.59	1.58		1.59	9/8
10/9	1.59	1.59		1.59	10/9
11/10	1.55	1.55		1.55	11/10
12/11	1.60	1.60		1.60	12/11
13/12	1.58	1.57		1.58	13/12
14/13	1.59	1.59		1.59	14/13
15/14	1.60	1.61		1.60	15/14
16/15	1.58	1.58		1.58	16/15
17/16	1.57	1.58		1.58	17/16
18/17	1.60	1.61		1.60	18/17
19/18	1.58	1.60		1.59	19/18
20/19	1.60	1.62		1.60	20/19
21/20	1.56*	1.56*	1.59	1.59	21/20

* The noise at this setting required re-zeroing. These numbers are for re-zeroed measurements. All others are not.

A reading on the Anode Resistors was also made for calibration purposes. The Gain Control was set at 12.

Ratio	Slit	Voltage	Gain
10K/1K	100μ	890	10.03
	25μ	1250	10.06
100K/10K	100μ	700	8.32
	25μ	990	8.68

It is seen that the 100K setting probably produces non-linear results.

I also installed a Hewlett - Packard 120AR scope. It appears as though the load on the 110 AC circuitry is beginning to tell and this is probably the last piece of equipment it will be able to take. A measurement of the line voltage inside the cabinet shows it to be 110V. I also had built and installed a filter holder.

Had a talk with WP Wednesday and he stressed professional development over priority of work. Also pointed out that I should stress the vast improvement in my optical constants over previous ones.

The new bucking circuit was tried out and worked fair. There seems to be some phase difficulty as one attempts very large bucking signals, but what we have will serve its purpose as we were able to expand to the point where the source noise was intolerable. Also, bucking was tried at the output with the balance control and seems at first glance to operate linearly. More will have to be done on this later.

We took up the reflectivity measurements on Film 4 again to get a proper value for these quantities.

PURPOSE R: Film 4
DATE 12/13/63 PAGE LOG BOOK 70 SPECTRUM # 1
SAMPLE: MATERIAL Film 4 CODE
ORIENTATION TEMP
THICKNESS PREPARATION
STRESS: TYPE — MAGNITUDE DIRECTION
SOURCE: TYPE W lamp STRENGTH 6V
MONOCHROMATOR: GRATING 30000 RANGE 6500 - 3500 Å
SCAN RATE PBP SLIT WIDTH 100 μ @ 5 mm
DETECTOR: TYPE 6256B TEMP RT
SETTING 1260V
POLARIZATION — FILTER see chart
ELECTRONICS: PRE AMP Regular
PSD "
TIME CONSTANT 3
RECORDER: A B C
SETTINGS
SPEED
REMARKS (x, y, z) = 3.180, 6.08, 5.00
OPERATOR PMG

13 December 1

13 December 2

PURPOSE R(λ): Film 4

DATE 12/13/63 PAGE LOG BOOK 71 SPECTRUM # 2

SAMPLE: MATERIAL Film 4 CODE

ORIENTATION TEMP

THICKNESS PREPARATION

STRESS: TYPE — MAGNITUDE DIRECTION

SOURCE: TYPE W lamp STRENGTH 6 V

MONOCHROMATOR: GRATING 30000 RANGE 6100-5100

SCAN RATE 125 SLIT WIDTH 100-5

DETECTOR: TYPE 6256B TEMP RT

SETTING 1270 V

POLARIZATION — FILTER CS3-73

ELECTRONICS: PRE-AMP Regular

PSD "

TIME CONSTANT 3

RECORDER: A B C

SETTINGS

SPEED

REMARKS (x, y, z) = 3180, 6.08, 5.00

OPERATOR PMG

14 December 1963

Today I reduced the data of yesterday. The R(λ) curve seems to show a very broad 5900 Å peak and a barely discernible 5400 Å peak at about 5280 Å (2.35 ev). I am also now taking data in the UV reflection of Film 4. This film has, or seems to have, some sort of film (oil?) on the Ge-air surface and this seems to ruin the UV reflectivity qualitatively. Also, there is still some anomaly in the 6000-6500 Å range. This <u>must</u> be due to the PM as almost everything else has been eliminated.

PURPOSE R: Film 4

DATE 12/14/63 PAGE LOG BOOK 72 SPECTRUM # 1

SAMPLE: MATERIAL Film 4 CODE

ORIENTATION TEMP

THICKNESS PREPARATION

STRESS: TYPE MAGNITUDE DIRECTION

SOURCE: TYPE D_2 lamp STRENGTH low

MONOCHROMATOR: GRATING 30000 RANGE 3500 - 3000

SCAN RATE PBP SLIT WIDTH 100 - 5

DETECTOR: TYPE 6256B TEMP RT

SETTING 1500 V

POLARIZATION — FILTER —

ELECTRONICS: PRE-AMP Regular

PSD "

TIME CONSTANT 3

RECORDER: A B C

SETTINGS

SPEED

REMARKS 3180, 6.08, 5.00

OPERATOR PMG

14 December 1

PURPOSE R(&) : Film

DATE 12/14/63 PAGE LOG BOOK 72 SPECTRUM # 2

SAMPLE: MATERIAL Film 4 CODE

ORIENTATION TEMP

THICKNESS PREPARATION

STRESS: TYPE MAGNITUDE DIRECTION

SOURCE: TYPE D_2 lamp STRENGTH low

MONOCHROMATOR: GRATING 30000 RANGE 3000 - 2000

SCAN RATE 125 SLIT WIDTH 100 - 5

DETECTOR: TYPE 6256B TEMP RT

SETTING 1900 V

POLARIZATION — FILTER —

ELECTRONICS: PRE-AMP Regular

PSD "

TIME CONSTANT 3

RECORDER: A B C

SETTINGS

SPEED

REMARKS 3180, 6.08, 5.00

OPERATOR PMG

14 December 2

16 - 20 December 1963

This week was spent primarily on renovating the nitrogen cryostat so that it could be used with my equipment. A new base was built using a Cenco Vacuum coupling. A trial run was made with B.K.'s new pumping system and it seemed to have no leaks at all. It took quite a lot of liquid N_2 to cool it to the point where the dewar part would hold it without excessive boil off, but once this was accomplished, the temperature on the sample block dropped rapidly to 79°K as recorded by a copper-constantan TC soldered to it. The outside got cold but not so cold that condensation took place. The temperature held at 79°K until the very last drop of N_2 was gone. It then rose to 120°K after 15 min. (2.7°K/min) and to 250°K (-23°C, -9°F) in 200 min (.85°K/min). All in all, the whole device seems to work well. Also this week J.I. finished the sample holders for me with the teflon holding tabs.

This week I also reduced the data of 14 Dec 2 pertaining to R(Σ) of film 4. Because of the marked indistinctness of the 4.4 ev peak in the reflectivity of this side, it is hard to pin it down exactly. The results for R'(Σ) should be much better.

The quarterly progress report was written this week and we had a talk with W.P. The talk revolved mainly around the effect of the built-in stress due to the thermal contraction of the film from its formation temperature. W.P. seemed to believe that the ultimate stress would be the same whether or not the film was formed at 700°C or 500°C due to a high surface mobility of atoms and a subsequent "annealing" effect. My opinion was that at such temperatures where the mobility was so high one would probably not observe a distinct Laue pattern as one did in the case of Ge at the epitaxial temperature so that in this case one could use the concept of thermal contraction from the epitaxial temperature. However, there is probably a region near the melting point of Ge in which the phenomenon described by W.P. exists.

Work was started on OPCON3, a program to take R, T, R' and make a guess at the thickness through the use of a combination of a two-dimensional Newton's method and the reguli falsi method.

In view of the failure of OPCONZ, not too much hope is held out for its success.

New ideas of the week:

(1) The measurement of the optical properties of Wurtzite materials under hydrostatic pressure through the use of an ellipsometer. Such measurements could help identify certain transitions by relating their pressure coefficients to the ZnS structures from which they should not be too different.

(2) By preparing a careful series of Ge - Si alloys, one might possibly study the effects of a cross-over of the <111> and <100> conduction band minima and so test some of Peterson's theory. Perhaps if one gets the minima close enough, one might use hydrostatic pressure to effect the switchover.

(3) We have evidence of seeing the $\Gamma_{25'} - \Gamma_{15}$ transition at around 3800 Å in our films. One wonders if the S.O. split-off state of $\Gamma_{25'} - \Gamma_{15}$ is allowed. If it is we should check for it. Also, can one explain the fact that Λ is an edge and Σ a peak by the curvature of the bands in their vicinity? It seems that a peak in absorption should arise from rather flat bands, while an edge from sharp ones.

22 December 1963

PURPOSE: R of Film 4 in 6500-5000 w/7102
DATE: 12/22/63 PAGE LOG BOOK: 74 SPECTRUM #: 1
SAMPLE: MATERIAL: Film 4 CODE:
ORIENTATION: TEMP:
THICKNESS: PREPARATION:
STRESS: TYPE: — MAGNITUDE: DIRECTION:
SOURCE: TYPE: W lamp STRENGTH: 6V
MONOCHROMATOR: GRATING: 30000 RANGE: 6500-5000
SCAN RATE: PBIP SLIT WIDTH: 100-5
DETECTOR: TYPE: 7102 TEMP: RT
SETTING: 1220V @ 10K
POLARIZATION: — FILTER: CS3-73
ELECTRONICS: PRE-AMP: Regular
PSD: ::
TIME CONSTANT: 2
RECORDER: A B C
SETTINGS:
SPEED:
REMARKS: (XYZ) = 3.180, 6.08, 5.00
OPERATOR: PMG

A run is being taken of the 6500 - 5000 Å region using the 7102 PM.

22 December 1

There was quite a lot of PM noise. Also, the reflectivity was generally too high. A try was made with RA = 100 K, but this did not change things much so there is probably not a non-linearity here. Also, RA is probably in parallel with a 100K built-in RA. Should try widening slit.

23 - 27 December 1963

The first part of this week was spent taking R' data on Film 4. Then I discovered an article by Donovan, Ashley, and Bennett in this month's JOSA 53, on reflectivity of germanium and germanium films. On the suggestion of WP, I am writing them a letter and for further details, see letter and article. In their article they mention new structure at around 5000Å (WP doesn't take it seriously); therefore, I set up to examine the reflectivity in this region on sample PDE(62). What I got I will send to DAB to see what they think of it.

I also set up Film 3 for measurements. R and T of this film showed the Λ splitting the best of any so far, with the Λ peaks in reflection being shifted to higher energies by about 100Å. This is in accordance with my theory that the built-in strain is high enough to shift these peaks. The Σ peak was at 2800Å ± 10Å, unchanged from bulk and other film values, as one would expect from the insensitivity of this peak to strain. The $L_3' - L_3$ peak was also observed at 2140 ± 10Å (5.79 ± .03 ev). This may be shifted and a measurement on PDE(62) should be made to find out. The reflectivity of this sample again seems to be very weak in magnitude. I will have to try some way of cleaning the surface and see if this makes any difference. I can't think of any other reason for this. Also, in transmission I saw the very sharp edge again and the dip in the Λ region as I saw in Film 4, although not quite as sharp as Film 4, not sharp enough to pull the SO split off edge with it.

In conjunction with this, I completed the mechanical arrangements for liquid N_2 work and this will definitely have to be done as soon as possible.

Also this week I examined the possibility of a transition from the split off valence band to the Γ_{15} conduction band. Group theoretically, such a transition is possible and a search should be made for it.

The talk with WP on Friday again centered mostly around the discussion of strain in the film and how to get an independent check on the shift of the Λ peaks. It was decided to write another letter to Sloope and ask if he had any information on the subject and also to ask around and find an instrument capable of reflection electron diffraction.

We also talked about the DAB (63) paper and I have his comments on it.

New Ideas:

(1) Uniaxial strain may be a way of determining whether or not the 4.4 peak has X or Σ symmetry.

(2) In view of the recent theoretical discussions on the effect of the Darwin term on the band structure of semiconductors, it might be well to consider the effect of high electric fields, although all they may do is shift all the bands the same amount.

What now follows is the data on each of the runs taken this week.

PURPOSE R': Film 4 w/ 7102

DATE 12/23/63 PAGE LOG BOOK 76 SPECTRUM # 1

SAMPLE: MATERIAL Film 4 CODE

ORIENTATION TEMP

THICKNESS PREPARATION

STRESS: TYPE MAGNITUDE DIRECTION

SOURCE: TYPE W lamp STRENGTH 6V

MONOCHROMATOR: GRATING 30000 RANGE 6500-5000

SCAN RATE PBP SLIT WIDTH 200-5 mm

DETECTOR: TYPE 7102 TEMP RT

SETTING 1010V, 10K

POLARIZATION – FILTER CS 3-73

ELECTRONICS: PRE-AMP Reg.

PSD "

TIME CONSTANT 3

RECORDER: A B C

SETTINGS

SPEED

REMARKS (3.18, 6.08, 5.00)

This data not plotted

OPERATOR PMG

23 December 1

PURPOSE: R': Film 4 w/7102
DATE: 12/23/63 PAGE LOG BOOK: 77 SPECTRUM #: 2
SAMPLE: MATERIAL: Film 4 CODE:
ORIENTATION: TEMP:
THICKNESS: PREPARATION:
STRESS: TYPE: MAGNITUDE: DIRECTION:
SOURCE: TYPE: W lamp STRENGTH: 6 V
MONOCHROMATOR: GRATING: 30000 RANGE: 6500 - 5000
SCAN RATE: 125 SLIT WIDTH: 200 - 5
DETECTOR: TYPE: 7102 TEMP: RT
SETTING: 1010 10K
POLARIZATION: — FILTER: CS3-73
ELECTRONICS: PRE-AMP: Reg
PSD: "
TIME CONSTANT: 3
RECORDER: A B C
SETTINGS:
SPEED:
REMARKS: (3.18, 6.08, 500)
OPERATOR: PMG

23 December 2

PURPOSE: R: PDE(62); 5400Å – 4400Å
DATE: 12/24/63 PAGE LOG BOOK: 77 SPECTRUM #: 1
SAMPLE: MATERIAL: PDE(62) CODE:
ORIENTATION: TEMP:
THICKNESS: PREPARATION:
STRESS: TYPE: MAGNITUDE: DIRECTION:
SOURCE: TYPE: W lamp STRENGTH: 6 V
MONOCHROMATOR: GRATING: 30000 RANGE: 5400 - 4400
SCAN RATE: 125 SLIT WIDTH: 100 - 5
DETECTOR: TYPE: 6256B TEMP: RT
SETTING: 1280 V
POLARIZATION: — FILTER: —
ELECTRONICS: PRE-AMP: Reg
PSD: "
TIME CONSTANT: 3
RECORDER: A B C
SETTINGS:
SPEED:
REMARKS: (3.18, 6.08, 5.00)
OPERATOR: PMG

24 December 1

PURPOSE T: Film 3; 5400 - 4400 Å
DATE 12/24/63 PAGE LOG BOOK 78 SPECTRUM # 2
SAMPLE: MATERIAL Film 3 CODE
ORIENTATION TEMP
THICKNESS PREPARATION
STRESS: TYPE MAGNITUDE DIRECTION
SOURCE: TYPE W lamp STRENGTH 6V
MONOCHROMATOR: GRATING 30000 RANGE 5400-4400
SCAN RATE 125 SLIT WIDTH 100 - 5
DETECTOR: TYPE 6256B TEMP RT
SETTING 1280V
POLARIZATION — FILTER —
ELECTRONICS: PRE-AMP Reg.
PSD "
TIME CONSTANT 3
RECORDER: A B C
SETTINGS
SPEED
REMARKS (3.18, 6.08, 5.00)
OPERATOR PMg

24 December 2

PURPOSE T: Film 3; 6000 - 5000 Å
DATE 12/24/63 PAGE LOG BOOK 78 SPECTRUM # 3
SAMPLE: MATERIAL Film 3 CODE
ORIENTATION TEMP
THICKNESS PREPARATION
STRESS: TYPE MAGNITUDE DIRECTION
SOURCE: TYPE W lamp STRENGTH 6V
MONOCHROMATOR: GRATING 30000 RANGE 6000 - 5000
SCAN RATE 125 SLIT WIDTH 100 - 5
DETECTOR: TYPE 6256B TEMP RT
SETTING 1280V
POLARIZATION — FILTER —
ELECTRONICS: PRE-AMP Reg
PSD "
TIME CONSTANT 3
RECORDER: A B C
SETTINGS
SPEED
REMARKS (3.18, 6.08, 5.00)
OPERATOR PMg

24 December 3

PURPOSE R: Film 3

DATE 12/26/63 PAGE LOG BOOK 79 SPECTRUM # 1

26 December 1

SAMPLE: MATERIAL Film 3 CODE

ORIENTATION TEMP

THICKNESS PREPARATION

STRESS: TYPE MAGNITUDE DIRECTION

SOURCE: TYPE W lamp STRENGTH 6 v

MONOCHROMATOR: GRATING 30000 RANGE 6000-3500

SCAN RATE 125 SLIT WIDTH 100-5

DETECTOR: TYPE 6256B TEMP RT

SETTING 1250V, 1K

POLARIZATION — FILTER —

ELECTRONICS: PRE-AMP Reg.

PSD "

TIME CONSTANT 3

RECORDER: A B C

SETTINGS

SPEED

REMARKS (3.18, 6.08, 5.00)

OPERATOR PMG

PURPOSE R: Film 3.

DATE 12/27/63 PAGE LOG BOOK 79 SPECTRUM # 1

27 December 1

SAMPLE: MATERIAL Film 3 CODE

ORIENTATION TEMP

THICKNESS PREPARATION

STRESS: TYPE MAGNITUDE DIRECTION

SOURCE: TYPE D₂ lamp STRENGTH 20w

MONOCHROMATOR: GRATING 30000 RANGE 3900-2000

SCAN RATE 125 SLIT WIDTH 100-5

DETECTOR: TYPE 6256B TEMP RT

SETTING 1910 V

POLARIZATION — FILTER —

ELECTRONICS: PRE-AMP Reg.

PSD "

TIME CONSTANT 3

RECORDER: A B C

SETTINGS

SPEED

REMARKS (3.18, 6.08, 5.00)

OPERATOR PMG

30 - 31 December 1963

Monday I investigated cleaning the surface of of my films by trying several experiments on Ge and CaF_2 surfaces. I applied diffusion pump oil to the surface of a piece of each. I then tried cleaning in boiling benzene with an ethyl alcohol rinse and then I prepared two more pieces and tried cleaning in Fisher RBS 25 cleaning solution followed by an ethyl alcohol rinse. Both methods seemed to remove the oil while attacking neither the CaF_2 nor the Ge.

On Tuesday I ran some reflectivity runs on Ge samples MacLeod and PDE(62), both previously cleaned with ethyl alcohol. The run on PDE(62) was an effort to locate the Λ peaks as close as possible. However, the results were generally disappoint because of what I think was a mal-functioning of the Hofman reference signal generating diode which was found later, so this experiment will have to be redone.

PURPOSE: Ge Reflectivity: MacLeod
DATE: 12/31/63 PAGE LOG BOOK: 80 SPECTRUM #: 1
SAMPLE: MATERIAL: Ge CODE:
ORIENTATION: TEMP:
THICKNESS: PREPARATION:
STRESS: TYPE: MAGNITUDE: DIRECTION:
SOURCE: TYPE: W lamp STRENGTH: 6V
MONOCHROMATOR: GRATING: 30000 RANGE: 6000-3500
SCAN RATE: 125 SLIT WIDTH: 100-5
DETECTOR: TYPE: 6256B TEMP: RT
SETTING: 1320v
POLARIZATION: — FILTER: CS0-53
ELECTRONICS: PRE-AMP: Reg
PSD: "
TIME CONSTANT: 3
RECORDER: A: B: C:
SETTINGS:
SPEED:
REMARKS:
OPERATOR: PMG

31 December 1

PURPOSE R of PDE(62) : 5900Å

DATE 12/31/63 PAGE LOG BOOK 81 SPECTRUM # 2

31 December 2

SAMPLE: MATERIAL Ge CODE

ORIENTATION TEMP

THICKNESS PREPARATION

STRESS: TYPE MAGNITUDE DIRECTION

SOURCE: TYPE W lamp STRENGTH 6v

MONOCHROMATOR: GRATING 30000 RANGE 6000-5700

SCAN RATE 125 SLIT WIDTH 100-5

DETECTOR: TYPE 6256B TEMP RT

SETTING 1470 V

POLARIZATION FILTER CS0-53

ELECTRONICS: PRE-AMP Reg

PSD "

TIME CONSTANT 3

RECORDER: A B C

SETTINGS

SPEED

REMARKS

OPERATOR DMG

PURPOSE R of PDE(62) : 5400Å

DATE 12/31/63 PAGE LOG BOOK 81 SPECTRUM # 3

31 December 3

SAMPLE: MATERIAL Ge CODE

ORIENTATION TEMP

THICKNESS PREPARATION

STRESS: TYPE MAGNITUDE DIRECTION

SOURCE: TYPE W lamp STRENGTH 6v

MONOCHROMATOR: GRATING 30000 RANGE 5500-6200

SCAN RATE 125 SLIT WIDTH 100-5

DETECTOR: TYPE 6256B TEMP RT

SETTING 1340 V

POLARIZATION FILTER CS0-53

ELECTRONICS: PRE-AMP Reg

PSD "

TIME CONSTANT 3

RECORDER: A B C

SETTINGS

SPEED

REMARKS

OPERATOR DMG

2-4 January 1964

On Thursday a liquid N_2 run was made on Film 4 and on Friday a run was made on Film 3. The transmission of these two films at room temperature had shown an interesting dip in transmission in the vicinity of the L transition. This dip looked suggestive of exciton behaviour, so it was decided to go to liquid N_2 temperatures. Some simple modifications were made to Cardona's old LN_2 cryostat in order to do the experiment. This was mounted on a table made to straddle the existing transmission - reflection setup.

There is a peculiarity in the position of the dip between films 4 and 3. In film 4 the dip seems to be associated with the first L transition (5900 Å) and in film 3 with the second L transition. The difference in energies between the dips in both films is:

$$\Delta E_L^{300} = (2.46\ ev)_3 - (2.20\ ev)_4 = .26\ ev$$

$$\Delta E_L^{79} = (2.56\ ev)_3 - (2.25\ ev)_4 = .31\ ev$$

It is seen that this difference is roughly that of the so splitting measured in reflectivity. However, the sharpening of the peaks at LN_2 temperatures was quite noticable, particularly in film 4 where the width of the dip appears to be about 200 Å. This is interesting enough to justify going to LHe temps and this is going to be done.

The temperature coefficients of the edges and dips in the two films was measured and found to be:

Film 4: dip: $-2.3 \cdot 10^{-4}$ ev/K°
edge: $-3.18 \cdot 10^{-4}$ ev/K°

Film 3: dip: $-4.5 \cdot 10^{-4}$ ev/K°
edge: $-4.1 \cdot 10^{-4}$ ev/K°

The coefficient in film 3 seems to correspond to the value reported by Cardona ($4.15 \cdot 10^{-4}$) while right now the deviation of film 4 is unexplained. However, this might have something to do with its exitonic behavour. Ehrenriech has suggested that this structure might be due to the formation of an exciton at the L point.

Saturday a run was made on film 2. This film is on a cleaved surface and is quite thick.

PURPOSE LN_2 on Film 4 at R : T'
DATE 1/2/64 PAGE LOG BOOK 83 SPECTRUM # 1
SAMPLE: MATERIAL Film 4 CODE
ORIENTATION TEMP RT & 79°K
THICKNESS PREPARATION
STRESS: TYPE MAGNITUDE DIRECTION
SOURCE: TYPE W lamp STRENGTH 6V
MONOCHROMATOR: GRATING 30000 RANGE 6000-5000
SCAN RATE 50 SLIT WIDTH 100-5
DETECTOR: TYPE 6256B TEMP RT
SETTING 1190 V
POLARIZATION – FILTER CS0-53
ELECTRONICS: PRE-AMP Reg.
PSD Reg.
TIME CONSTANT 3
RECORDER: A B C
SETTINGS
SPEED
REMARKS Time between I_0 and I_T about 40 min
OPERATOR DMG

2 January 1

PURPOSE LN_2 on Film 3 at R : T'
DATE 1/3/64 PAGE LOG BOOK 83 SPECTRUM # 1
SAMPLE: MATERIAL Film 3 CODE
ORIENTATION TEMP RT & 79°K
THICKNESS PREPARATION
STRESS: TYPE MAGNITUDE DIRECTION
SOURCE: TYPE W lamp STRENGTH 6V
MONOCHROMATOR: GRATING 30000 RANGE 6000 - 4500
SCAN RATE 50 SLIT WIDTH 100 - 5
DETECTOR: TYPE 6256B TEMP RT
SETTING 1190
POLARIZATION FILTER CS0-53
ELECTRONICS: PRE-AMP Reg
PSD "
TIME CONSTANT 3
RECORDER: A B C
SETTINGS
SPEED
REMARKS
OPERATOR DMG

3 January 1

Today I had my weekly talk with WP. We discussed again the strain problem at length and tentatively decided the followed:

(1) Evidence exists that thermal strain has shifted the reflectivity peaks and is in qualitative agreement with expected values.
(2) This evidence means that the shift in transmission edge is due in part to strain.

I also showed him the LN_2 data and he suggested going to LHe.

PURPOSE R & T of Film 2

DATE 1/4/64 PAGE LOG BOOK 84 SPECTRUM # 1

SAMPLE: MATERIAL Film 2 CODE

ORIENTATION TEMP

THICKNESS PREPARATION

STRESS: TYPE MAGNITUDE DIRECTION

SOURCE: TYPE W lamp STRENGTH 6 v

MONOCHROMATOR: GRATING 30000 RANGE 6000-3500

SCAN RATE 125 SLIT WIDTH 100-5

DETECTOR: TYPE 6256 B TEMP RT

SETTING 1250 v

POLARIZATION – FILTER CS0-53

ELECTRONICS: PRE-AMP Ray

PSD Ray

TIME CONSTANT 2

RECORDER: A B C

SETTINGS

SPEED

REMARKS (2.85, 5.66, 5.00)

OPERATOR PMG

4 January 1

PURPOSE R & T: Film 2

DATE 1/4/64 PAGE LOG BOOK 84 SPECTRUM # 2

SAMPLE: MATERIAL Film 2 CODE

ORIENTATION TEMP

THICKNESS PREPARATION

STRESS: TYPE MAGNITUDE DIRECTION

SOURCE: TYPE D_2 lamp STRENGTH low

MONOCHROMATOR: GRATING 30000 RANGE 3500-2000

SCAN RATE 125 SLIT WIDTH 100-5

DETECTOR: TYPE 6256 B TEMP RT

SETTING 1870 v

POLARIZATION FILTER CS0-53 out

ELECTRONICS: PRE-AMP Ray

PSD "

TIME CONSTANT 3

RECORDER: A B C

SETTINGS

SPEED

REMARKS (2.85, 5.66, 5.00)

OPERATOR PMG

4 January 2

6-10 January 1964

The better part of this week was spent investigating the procurement of a LHe cryostat.

Some of the data taken on Film 2 was plotted up. The transmission was very strong, much stronger than the thickness of the film as measured at IBM. The curve shows a dip which bottoms out at about 5100Å, the same as film 3. However, after this the data keeps rising. This may be due to scattered light due to the extremely low light transmission. More work should be done here. The overall reflectivity was very similar to films 3 and 4 with a much reduced reflectivity in the UV. The curves of these films seem to be similar in the geometric sense. The Σ peak was at 2800 ± 10 Å, the same position as in the other films. However, no distinct $L_3 - L_3$ transition could be observed.

This week's talk with W.P. was very short and centered mostly around the peaks seen at LN_2. One disturbing feature is that the dip in film 4 is at a different place than in 2 or 3. We will see what happens at LHe.

13 January 1964

Today I plotted up the data on Film 2. The transmission showed no SO splitting. I am suspicious of this data because of the extremely low light levels involved. The R(λ) curve showed the SO splitting along with a shift to higher energies. The position of the peaks are as follows:

5750 Å ± 50 Å	⟷	2.16 ev ± .02 ev	FILM 2
5250 Å ± 25 Å	⟷	2.36 ev ± .01 ev	

Compare with:

5800 Å ± 50 Å	⟷	2.14 ev ± .02 ev	FILM 3
5275 Å ± 25 Å	⟷	2.35 ev ± .01 ev	

14-17 January 1964

The final decision on the procurement of the LHe optical cryostat was made during this period and it was decided to give the job to Janis Research to build an optical cryostat along the lines of a design by T. Deutsch.

In order to gain further knowledge concerning the poor UV reflectivity of the films, a study was made on the surfaces of films 2, 3, and 4 using the Vickers microscope in the Metallurgy Group. This study revealed a granular structure whose particle size was < 1μ. The study was made under dark field illumination using a catoptric condenser. The granularity seemed to be due to the film itself and not due to irregularities in the substrate surface. My results seem to agree well with Hoope's electron microscope studies which show a grain size of .5 to 1μ. This is probably caused by the nucleation of the film at different points on the substrate and the consequent growing together of these nucleations as the film thickens. The microstructure of films on both cleaved and polished surfaces seems to be the same. Now it is very possible that this granular surface could be the cause of the poor UV reflectivity and this will be explored. The letter of Hoope of 16 January 1964 should be referred to in connection with the above.

Last week I went to a talk by Zemel of NORL on epitaxial lead salt films. The part interesting to me was that on the strain effect. It appears that NaCl has funny stress-strain properties which make his results substantially different than mine as regards the effect of thermal strain on the optical properties.

This weeks talk with W.P. centered around the effect of the poor UV reflectivity on the optical constants. He seemed to indicate that some change of emphasis in the interpretation of the results was permissible in that one did not have to claim that the optical constants of the films were "truer" than those obtained by a KK analysis of the bulk reflectivity but rather indicated the present state of the art insofar as the films are concerned.

Also, this week I attempted to measure the fundamental edge in film 2. The first attempt was made on DeMeis' equipment was not very successful. A second run was made on the Cary Model 14 in the Chemistry Dept. and the results are now being analyzed.

PURPOSE: IR Transmission of Film 2

DATE: 1/14/64 PAGE LOG BOOK: 87 SPECTRUM #: 1

SAMPLE: MATERIAL: Film 2 CODE:

ORIENTATION: TEMP:

THICKNESS: PREPARATION:

STRESS: TYPE: MAGNITUDE: DIRECTION:

SOURCE: TYPE: Globar STRENGTH:

MONOCHROMATOR: GRATING: CaF_2 Prism RANGE: 2μ – 1μ

SCAN RATE: 4 SLIT WIDTH: 100μ

DETECTOR: TYPE: TC TEMP: RT

SETTING: –

POLARIZATION: – FILTER: –

ELECTRONICS: PRE-AMP: Regular

PSD: "

TIME CONSTANT: 2

RECORDER: A B C

SETTINGS:

SPEED:

REMARKS: This data was taken on the equipment of M. Demeis

OPERATOR: PMG

14 January 1

PURPOSE: IR Transmission of Film 2

DATE: 1/17/64 PAGE LOG BOOK: 87 SPECTRUM #: 1

SAMPLE: MATERIAL: Film 2 CODE:

ORIENTATION: TEMP:

THICKNESS: PREPARATION:

STRESS: TYPE: MAGNITUDE: DIRECTION:

SOURCE: TYPE: STRENGTH:

MONOCHROMATOR: GRATING: RANGE:

SCAN RATE: SLIT WIDTH:

DETECTOR: TYPE: TEMP:

SETTING:

POLARIZATION: FILTER:

ELECTRONICS: PRE-AMP:

PSD:

TIME CONSTANT:

RECORDER: A B C

SETTINGS:

SPEED:

REMARKS: This data taken on the Cary 14 in Chem. Dept.

OPERATOR: PMG

17 January 1

20 - 24 January 1964

Most of this week was spent designing parts for the LHe dewar and purchasing other parts.

I analyzed the data of 17 January I and found that there was a big dip in an interference fringe right where the direct gap should appear. There are some other curves which suggest a transition from the split-off valence band and these are being looked at.

Also I took some more pictures of the film surfaces, this time doing all the films I have. The results seem inconclusive in that I cannot decide whether or not the granularity is inherent in the epitaxial growth or in the CaF_2 substrate. I have found a paper by Bennett and Porteus on reflection from a rough surface. If we consider the reflectivity of the E_1 peak to be 50% lower in the films than in the bulk, then their theory indicates an RMS roughness of about 180 Å. From the photographs the grain size of the films is about 5000 Å. It is hard to tell if these two numbers are consistent.

Also, Film 1, which is polycrystalline, appears to be quite flat. This film was deposited on a cleaved CaF_2 surface. However, film 10, which is also polycrystalline, was deposited on a polished surface and is granular, while Film 2 was epitaxially grown on a cleaved surface and is granular also. This is all confusing.

My investigations this week also included taking R and T of film 1. Preliminary results indicate poor UV reflectivity. The transmission of this film may not be too good as there seems to be a large number of pinholes.

This week I built another lamp holder for the W lamps. This means that interchangeability of the W and D_2 lamp will be easier in the future.

PURPOSE R and T : Film 1
DATE 1/26/64 PAGE LOG BOOK 89 SPECTRUM # 1
SAMPLE: MATERIAL Film 1 CODE
ORIENTATION TEMP
THICKNESS PREPARATION
STRESS: TYPE MAGNITUDE DIRECTION
SOURCE: TYPE W lamp STRENGTH 6v
MONOCHROMATOR: GRATING 30000 RANGE 6000 - 3500
SCAN RATE 125 SLIT WIDTH 100 - 5
DETECTOR: TYPE 6256B TEMP RT
SETTING 1220v
POLARIZATION — FILTER CS0-53
ELECTRONICS: PRE-AMP Regular
PSD "
TIME CONSTANT 3
RECORDER: A B C
SETTINGS
SPEED
REMARKS I₀ stability ~ 5%
OPERATOR PMG

26 January 1

PURPOSE R and T : Film 1
DATE 1/26/64 PAGE LOG BOOK 89 SPECTRUM # 2
SAMPLE: MATERIAL Film 2 CODE
ORIENTATION TEMP
THICKNESS PREPARATION
STRESS: TYPE MAGNITUDE DIRECTION
SOURCE: TYPE D_2 lamp STRENGTH low
MONOCHROMATOR: GRATING 30000 RANGE 4000 - 2000
SCAN RATE 125 SLIT WIDTH 100 - 5
DETECTOR: TYPE 6256B TEMP RT
SETTING 1850v
POLARIZATION — FILTER —
ELECTRONICS: PRE-AMP Regular
PSD "
TIME CONSTANT 3
RECORDER: A B C
SETTINGS
SPEED
REMARKS I_0 stability ~ 5%
OPERATOR PMG

26 January 2

27 January 1964

Today I talked with W.P. and we discussed mainly the effect of a rough surface on the reflectivity and agreed that this could be the reason for the poor UV reflectivity of the films. We also discussed the setting up of an effort in thin films and the equipment required.

28 January – 3 February 1964

This time was spent working on the auxiliary parts to the LHe cryostat and on a trip to IBM at their request. While at IBM Yorktown I talked about my work with Keyes, Turner and Stern about my work in an effort to initiate professional contacts with the people there.

4 February – 7 February 1964

This week was spent making runs on Films 5, 7, and 8. Also more work was done in conjunction with setting up the LHe dewar which was delivered. It holds LN_2 for about 5 hours.

My talk with W.P. this week centered around a new group effort in the thin film area. Also, we discussed my trip to IBM.

PURPOSE Film 5: R&T

DATE 2/5/64 PAGE LOG BOOK 91 SPECTRUM # 1

SAMPLE: MATERIAL Film 5 CODE

ORIENTATION TEMP

THICKNESS PREPARATION

STRESS: TYPE MAGNITUDE DIRECTION

SOURCE: TYPE W lamp STRENGTH 6 V

MONOCHROMATOR: GRATING 30000 RANGE 6000 - 3500

SCAN RATE 125 SLIT WIDTH 100 - 5

DETECTOR: TYPE 6256 B TEMP RT

SETTING 1200 V

POLARIZATION — FILTER —

ELECTRONICS: PRE-AMP Reg

PSD "

TIME CONSTANT 3

RECORDER: A B C

SETTINGS

SPEED

REMARKS .613, .372, .500

OPERATOR PMG

5 February 1

PURPOSE Film 5: R&T

DATE 2/5/64 PAGE LOG BOOK 91 SPECTRUM # 2

SAMPLE: MATERIAL Film 5 CODE

ORIENTATION TEMP

THICKNESS PREPARATION

STRESS: TYPE MAGNITUDE DIRECTION

SOURCE: TYPE D_2 lamp STRENGTH low

MONOCHROMATOR: GRATING 30000 RANGE 4000 - 2000

SCAN RATE 125 SLIT WIDTH 100 - 5

DETECTOR: TYPE 6256 B TEMP RT

SETTING 1890 V

POLARIZATION — FILTER —

ELECTRONICS: PRE-AMP Reg

PSD "

TIME CONSTANT 2

RECORDER: A B C

SETTINGS

SPEED

REMARKS .613, .372, .500

OPERATOR PMG

5 February 2

PURPOSE Film 7 : R&T
DATE 2/6/64 PAGE LOG BOOK 92 SPECTRUM # 1
SAMPLE: MATERIAL Film 7 CODE
ORIENTATION TEMP
THICKNESS PREPARATION
STRESS: TYPE MAGNITUDE DIRECTION
SOURCE: TYPE W lamp STRENGTH 6 V
MONOCHROMATOR: GRATING 30000 RANGE 6000 - 3500
SCAN RATE 125 SLIT WIDTH 100 - 5
DETECTOR: TYPE 6256 B TEMP RT
SETTING 1200
POLARIZATION — FILTER —
ELECTRONICS: PRE-AMP Regular
PSD "
TIME CONSTANT 3
RECORDER: A B C
SETTINGS
SPEED
REMARKS .613, .372, .500
OPERATOR PMG

6 February 1

PURPOSE Film 7 : R&T
DATE 2/6/64 PAGE LOG BOOK 92 SPECTRUM # 2
SAMPLE: MATERIAL Film 7 CODE
ORIENTATION TEMP
THICKNESS PREPARATION
STRESS: TYPE MAGNITUDE DIRECTION
SOURCE: TYPE D_2 lamp STRENGTH low
MONOCHROMATOR: GRATING 30000 RANGE 4000 - 2000
SCAN RATE 125 SLIT WIDTH 100 - 5
DETECTOR: TYPE 6256 B TEMP RT
SETTING 1830
POLARIZATION — FILTER —
ELECTRONICS: PRE-AMP Regular
PSD "
TIME CONSTANT 3
RECORDER: A B C
SETTINGS
SPEED
REMARKS .613, .372, .500
OPERATOR PMG

6 February 2

PURPOSE *Film 8: R&T*
DATE *2/7/64* PAGE LOG BOOK *93* SPECTRUM # *1*
SAMPLE: MATERIAL *Film 8* CODE
ORIENTATION TEMP
THICKNESS PREPARATION
STRESS: TYPE MAGNITUDE DIRECTION
SOURCE: TYPE *W lamp* STRENGTH *6V*
MONOCHROMATOR: GRATING *30000* RANGE *6000-3500*
SCAN RATE *125* SLIT WIDTH *100-5*
DETECTOR: TYPE *6256B* TEMP *RT*
SETTING *1200 v*
POLARIZATION *—* FILTER *—*
ELECTRONICS: PRE-AMP *Regular*
PSD *"*
TIME CONSTANT *3*
RECORDER: A B C
SETTINGS
SPEED
REMARKS *.613, .372, .500*
OPERATOR *PMG*

7 February 1

PURPOSE *Film 8: R&T*
DATE *2/7/64* PAGE LOG BOOK *93* SPECTRUM # *2*
SAMPLE: MATERIAL *Film 8* CODE
ORIENTATION TEMP
THICKNESS PREPARATION
STRESS: TYPE MAGNITUDE DIRECTION
SOURCE: TYPE *D_2 lamp* STRENGTH
MONOCHROMATOR: GRATING *30000* RANGE *4000-2000*
SCAN RATE *125* SLIT WIDTH *100-5*
DETECTOR: TYPE *6256B* TEMP *RT*
SETTING *1840*
POLARIZATION *—* FILTER *—*
ELECTRONICS: PRE-AMP *Regular*
PSD *"*
TIME CONSTANT *3*
RECORDER: A B C
SETTINGS
SPEED
REMARKS *.613, .372, .500*
OPERATOR *PMG*

7 February 2

10 February - 22 February 1964

During this period I calculated and plotted the overall results for films 5, 7, and 8. I also plotted up composite curves for most of the films measured to date. The most interesting fact about the transmissivity curves is that as the thickness increases, the L-1 dip becomes more pronounced. More measurements need to be taken to see how the other films fit into this picture.

All the reflectivity curves show the decrease in amplitude as λ decreases. However, very interestingly, the thinner films display less of a decrease than the thicker ones. This is very likely because a thinner film will have a smaller rms roughness than the thicker films because the aggregate size will not have become as great as in the thicker ones. A correction to some of the films according to the relation for reduced specular reflectance due to a rough surface (BP61), viz:

$$R = R_0 \exp\{-(4\pi\sigma/\lambda)^2\}$$

and the results show that very nearly bulk reflectivity curves result, except below the X-Σ peak where the wavelength may be too short for the above formula to hold. Here the exponential relation tends to overcorrect and this is seen to be true for films 4 and 8. However, for films 6 the exponential seems to work well even here and the reason for this may lie in the fact that film 6 has a very high X-Σ reflectivity compared to the other films and therefore probably has a smaller σ so that the exponential law is extended into short wavelength regions. In these calculations σ was found by taking the ratio of the reflectivity of the film X-Σ peak to that of the bulk X-Σ peak.

In relation to this problem, another letter was written to Sloope in which I enclosed film 6 and its microstructure microphotographs and asked him his views and opinions on the microstructure granularity and the possibility of getting rid of it by post-annealing. I also asked whether or not he had observed such structure in his films.

In conjunction with this roughness problem, a photomicrograph of a film of PbS sent to V. Prakash by Zemel of NOL was taken. This showed that granular structure was present in these films too, the grain size being about the same as for my Ge films although the roughness appeared less, possibly because this film was grown off the <100> face of NaCl.

In order to study the effect if any of the preparation of the CaF_2 substrate on the Ge film, an experiment was proposed to D. MacLeod to prepare several CaF_2 surfaces by various methods and then overcoat them with a reflecting surface so they could be studied by dark-field illumination. The results will be considered later.

Finally a good look was had at the reflectivity spectrum of an etched piece of Ge. The purpose of this was to demonstrate the quality of my equipment and to look very closely at some of the important structure points. The results were compared against those of DAB(63). The sample was polished and etched in CP-4 according to the procedure outlined in D. MacLeod's log, page 17, 2/12/64. This sample has been named MacLeod 2. While making the measurements, several equipment and measurement-taking observations were made considering the difference in results between the W and D_2 lamps at the 3500 Å crossover point. The difference in reflectivity is perhaps caused by misallignment between the two lamps while also being due to I_0 drift difference between the sources, whereas any difference in transmission is likely to be due to differences in I_0 drift. That any differences are not likely to be due to non-linear effects is to be seen in the fact that sometimes there is a sign change in the difference at 3500 Å. For this sample, however, there turned out to be negligible difference in the overlap region. The results show good agreement in structure and amplitude with those of DAB(63). The agreement in amplitude is to within 2% which I consider excellent. The following gives the correspondence of the reflectivity peaks.

Peak	MacLeod 2	DAB(63)
Λ {	5840 ± 10 Å (2.123 ev)	5850 Å (2.119 ev)
	5400 ± 20 Å (2.296 ev)	5400 Å (2.296 ev)
X, Σ	2780 ± 20 Å (4.460 ev)	2804 Å (4.422 ev)

In addition to this data, there appears to be some additional structure near the X, Σ peak. This takes the appearance of a bump at or near 2540 Å (4.881), a distance of .421 ev from the sharper peak. This may be due to the fact that the X and Σ are close together in energy as concerns their critical points in the joint density of states, so close that they cannot presently be resolved in the band structure calculations. Here may be experimental evidence of the X and Σ transitions appearing separately by themselves. However, according to BPB (62), the difference between these two saddle points is only .1 ev.

It is also interesting to speculate as to whether or not there is some detail of the band structure in the <111> direction which makes the 5400 Å peak much broader than the 5850 Å peak. This may be due to a dip in the valence band near L_3 which gives a greater density of states for low energy acoustical phonons causing scattering of holes more expeditiously from the lower split-off L_3 band. However, such a dip is not indicated in the band structure of BPB(62).

Also, a photomicrograph was made of the surface of MacLeod 2 and it appeared locally very flat. This is why even a mottled etched surface can give such good reflectivity in the UV.

During this time some calculations were made with THIFIL and KRAKRO. The THIFIL calculations were made to examine what the transmissivity of thicker films would be. Up to 1μ, the interference fringes tend to mask any useful study of the direct fundamental edge, and more calculations will be done for higher thicknesses. The KRAKRO calculations were done on the data of DAB(63) modified by Ehrenreich's higher energy data. There seems to be some minor errors in the program that will have to be corrected.

My talks with W.P. in this period revolved around preparing the letter to Hoope and discussing the reflectivity results on MacLeod 2. He is looking for some sort of definitive answer to the feasibility of finding the optical constants of the films.

Also, I wrote a letter to Reynolds covering my conclusions on my recent trip to Kingston, Poughkeepsie, and Yorktown.

12 February 1

PURPOSE Ge Reflectivity : MacLeod 2

DATE 2/12/64 PAGE LOG BOOK 97 SPECTRUM # 1

SAMPLE: MATERIAL MacLeod 2 CODE

ORIENTATION TEMP

THICKNESS PREPARATION

STRESS: TYPE MAGNITUDE DIRECTION

SOURCE: TYPE W lamp STRENGTH 6V

MONOCHROMATOR: GRATING 30000 RANGE 6000 - 3500

SCAN RATE 125 SLIT WIDTH 100 - 5

DETECTOR: TYPE 6256 B TEMP RT

SETTING 1210 V

POLARIZATION — FILTER —

ELECTRONICS: PRE-AMP Regular

PSD "

TIME CONSTANT 3

RECORDER: A B C

SETTINGS

SPEED

REMARKS .613, .372, .500

OPERATOR PMS

12 February 2

PURPOSE Ge Reflectivity : MacLeod 2

DATE 2/12/64 PAGE LOG BOOK 97 SPECTRUM # 2

SAMPLE: MATERIAL Mac 2 CODE

ORIENTATION TEMP

THICKNESS PREPARATION

STRESS: TYPE MAGNITUDE DIRECTION

SOURCE: TYPE D_2 lamp STRENGTH Low

MONOCHROMATOR: GRATING 30000 RANGE 4000 - 2000

SCAN RATE 125 SLIT WIDTH 100 - 5

DETECTOR: TYPE 6256 B TEMP RT

SETTING 1360 V

POLARIZATION — FILTER —

ELECTRONICS: PRE-AMP Regular

PSD "

TIME CONSTANT 3

RECORDER: A B C

SETTINGS

SPEED

REMARKS .613, .372, .500

OPERATOR PMS

24-28 February 1964

This week I went skiing.

29 February - 4 March 1964

During this period I set up and performed a LHe experiment on Film 4. The equipment worked fine but apparently I was working at a thin or unusual point on the film because the transmission was not as great as during the original LN_2 experiment nor was the effect of the sharpening as great, although it was quite noticible. I plan to continue the LHe work to other films and also look at the behaviour of the Σ-X dip in some of the thinner films, as well as possibly another look at Film 4. We also had a visit from Cardona and we discussed the possible excitonic nature of the L structure. There are apparently two views of the curvature of the L_3 valence band, one leading to a parabolic density of states and the other to a hyperbolic. The bearing of this on the above structure should be investigated.

I recieved an answer from Sloope and in general he corroborates all my general suspicions about the rougness of epitaxial films of Ge on CaF_2. However, it appears that polycrystalline films will be much smoother and may possibly have as much structure in there optical response as the epitaxial ones.

We are going to start a thin film effort in the group with the two new students, and we will start with Ge on CaF_2 so I will be able to get some new films to work with.

My talk with W.P. involved discussing the results of the LHe experiment and Sloope's letter. He suggested making polycrystalline films in order to find the optical constants. He seems so fixed on the optical constants that I am going to calculate them in the L range anyway where the roughness error is not too large for some of my epitaxial films.

PURPOSE Film 4 : T(λ) : L He
DATE 3/2/64 PAGE LOG BOOK 99 SPECTRUM # 1
SAMPLE: MATERIAL Film 4 CODE
ORIENTATION TEMP L He
THICKNESS PREPARATION
STRESS: TYPE MAGNITUDE DIRECTION
SOURCE: TYPE W lamp STRENGTH 6V
MONOCHROMATOR: GRATING 30000 RANGE 6000-4500
SCAN RATE 125 SLIT WIDTH 100-5
DETECTOR: TYPE 6256 B TEMP RT
SETTING 1150V
POLARIZATION — FILTER —
ELECTRONICS: PRE-AMP Regular
PSD "
TIME CONSTANT TC3
RECORDER: A B C
SETTINGS
SPEED
REMARKS
OPERATOR PMG

2 March 1

PURPOSE Film 4 : T(λ) : L N₂
DATE 3/2/64 PAGE LOG BOOK 99 SPECTRUM # 2
SAMPLE: MATERIAL Film 4 CODE
ORIENTATION TEMP L N_2
THICKNESS PREPARATION
STRESS: TYPE MAGNITUDE DIRECTION
SOURCE: TYPE W lamp STRENGTH 6V
MONOCHROMATOR: GRATING 30000 RANGE 6000-4500
SCAN RATE 125 SLIT WIDTH 100-5
DETECTOR: TYPE 6256 B TEMP RT
SETTING 1150
POLARIZATION — FILTER —
ELECTRONICS: PRE-AMP Regular
PSD "
TIME CONSTANT TC3
RECORDER: A B C
SETTINGS
SPEED
REMARKS
OPERATOR PMG

2 March 2

3 March 1

PURPOSE: Film 4; T(λ): RT

DATE: 3/3/64 PAGE LOG BOOK: 100 SPECTRUM #: 1

SAMPLE: MATERIAL: Film 4 CODE:

ORIENTATION: TEMP: RT

THICKNESS: PREPARATION:

STRESS: TYPE: MAGNITUDE: DIRECTION:

SOURCE: TYPE: W lamp STRENGTH: 6 V

MONOCHROMATOR: GRATING: 30000 RANGE: 6000 - 4500

SCAN RATE: 125 SLIT WIDTH: 100 - 5

DETECTOR: TYPE: 6256 B TEMP: RT

SETTING: 1150

POLARIZATION: — FILTER: —

ELECTRONICS: PRE-AMP: Regular

PSD: "

TIME CONSTANT: TC3

RECORDER: A B C

SETTINGS:

SPEED:

REMARKS:

OPERATOR: PMG

PURPOSE: Transmission of Empty Dewar

DATE: 3/2/64 PAGE LOG BOOK: 100 SPECTRUM #:

SAMPLE: MATERIAL: — CODE:

ORIENTATION: TEMP:

THICKNESS: PREPARATION:

STRESS: TYPE: MAGNITUDE: DIRECTION:

SOURCE: TYPE: W lamp STRENGTH: 6 V

MONOCHROMATOR: GRATING: 30000 RANGE: 5300 Å

SCAN RATE: — SLIT WIDTH: 100 - 5

DETECTOR: TYPE: 6256 B TEMP: RT

SETTING: 1150

POLARIZATION: — FILTER: —

ELECTRONICS: PRE-AMP: Reg

PSD: "

TIME CONSTANT:

RECORDER: A B C

SETTINGS:

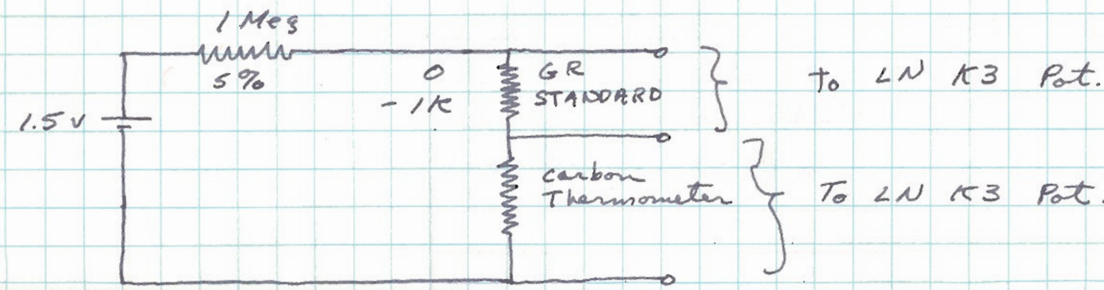
SPEED:

REMARKS: Transmission = .917 with CF both in and out.

OPERATOR: PMG

5-15 March 1964

Most of this period was spent studying Russian. T. Shankland did some LHe work during this period and I was able to select a resistor thermometer. This is one of S. Groves Allen-Bradley 47 Ω, 1/10 watt carbon resistors for which he has a calibration curve for a 556 Ω one. I found one that I will use that is 45.4 Ω at RT and 552 at LHe. This will enable me to use his curve to a fair degree of accuracy. Also, the boil-off rate with the present tail unit is about 120 ml/hr. The resistance of the thermometer is being measured by the following circuit:



The voltage drop across a GR resistance box set somewhere near the expected resistance of the carbon thermometer is measured to determine the current which will be about 1.5 μa. The voltage drop across the carbon resistor is then measured and the resistance determined

Also, the beginning of an effort in the production of thin films was started this week by E. Rossi and R. Ludeke. This will initially involve the production of some more germanium films for optical constant investigation and for the investigation of the L structure. Also, use will be made of the electron microscope.

I have instructed D. MacLeod in the performance of some experiments on the surface of prepared CaF_2 (prepared by polishing, etching, and cleaving). This is to determine if the roughness of the epitaxial films is due to replication of the substrate surface, but since recieving the latest letter from Sloope I rather doubt that the CaF_2 surface is the cause of the observed roughness.

16 March – 5 April 1964

PURPOSE T(Ω) : Film 3 (RT)

DATE 3/16/64 PAGE LOG BOOK ______ SPECTRUM # 1

SAMPLE: MATERIAL Film 3 CODE ______

ORIENTATION ______ TEMP RT

THICKNESS ______ PREPARATION ______

STRESS: TYPE ______ MAGNITUDE ______ DIRECTION ______

SOURCE: TYPE W lamp STRENGTH 6 V

MONOCHROMATOR: GRATING 30000 RANGE 6000 – 4000

SCAN RATE 125 SLIT WIDTH 100 – 5

DETECTOR: TYPE 6256B TEMP RT

SETTING 1150 V

POLARIZATION – FILTER –

ELECTRONICS: PRE-AMP Rey.

PSD TC3

TIME CONSTANT 3

RECORDER: ______ A ______ B ______ C ______

SETTINGS ______

SPEED ______

REMARKS ______

OPERATOR PMS

16 March 1

PURPOSE T(Ω) : Film 3 (LHe)

DATE 3/16/64 PAGE LOG BOOK ______ SPECTRUM # 2

SAMPLE: MATERIAL Film 3 CODE ______

ORIENTATION ______ TEMP LHe

THICKNESS ______ PREPARATION ______

STRESS: TYPE ______ MAGNITUDE ______ DIRECTION ______

SOURCE: TYPE W lamp STRENGTH 6 V

MONOCHROMATOR: GRATING 30000 RANGE 6000 – 4000

SCAN RATE 125 SLIT WIDTH 100 – 5

DETECTOR: TYPE 6256B TEMP RT

SETTING 1150 V

POLARIZATION – FILTER –

ELECTRONICS: PRE-AMP Rey

PSD TC3

TIME CONSTANT 3

RECORDER: ______ A ______ B ______ C ______

SETTINGS ______

SPEED ______

REMARKS ______

OPERATOR PMS

16 March 2

3 April 1

PURPOSE T, R: Film 9
DATE 4/3/64 PAGE LOG BOOK SPECTRUM # 1
SAMPLE: MATERIAL Film 9 CODE
ORIENTATION TEMP RT
THICKNESS PREPARATION
STRESS: TYPE MAGNITUDE DIRECTION
SOURCE: TYPE W lamp STRENGTH 6v
MONOCHROMATOR: GRATING 30000 RANGE 6000-3500
SCAN RATE 125 SLIT WIDTH 100 - 5
DETECTOR: TYPE 6256B TEMP RT
SETTING 1210 v
POLARIZATION — FILTER —
ELECTRONICS: PRE-AMP Reg
PSD "
TIME CONSTANT 3
RECORDER: A B C
SETTINGS
SPEED
REMARKS 3.71, 5.57, 5.00
OPERATOR PMG

3 April 2

PURPOSE T, R: Film 9
DATE 4/3/64 PAGE LOG BOOK SPECTRUM # 2
SAMPLE: MATERIAL Film 9 CODE
ORIENTATION TEMP RT
THICKNESS PREPARATION
STRESS: TYPE MAGNITUDE DIRECTION
SOURCE: TYPE D_2 lamp STRENGTH Low
MONOCHROMATOR: GRATING 30000 RANGE 4000 - 2000
SCAN RATE 125 SLIT WIDTH 100 - 5
DETECTOR: TYPE 6256B TEMP RT
SETTING 1890 v
POLARIZATION — FILTER —
ELECTRONICS: PRE-AMP Reg.
PSD "
TIME CONSTANT 3
RECORDER: A B C
SETTINGS
SPEED
REMARKS 3.71, 5.57, 5.00
OPERATOR PMG

The LHe low temperature runs have seemed to add nothing new to the LN_2 data. The results for films 3 and 4 are certainly different, and $\partial E/\partial T$ is different for different identifiable structure. A recent paper by Donovan and Bennett reveals that this may be due to L transitions and Λ transitions appearing separately when the crystal structure is not perfect. The dip in film 4 occurs at a lower energy than in 5, 3, or 2 (the L energy is supposed to be lower than the Λ energy) and has a temperature coefficient half that of 5, 3, or 2. This is a topic suitable for further pursuit.

The results for film 9 indicate that its thickness must be very close to that of 6 but with a rougher surface. Otherwise no new results are obtained.

I prepared a schedule of what I think remains to be done for a thesis package. This consists of 3 main topics:

(1) Optical constants of Ge films
(2) L, Λ structure
(3) Σ, X structure

I have attempted to calculate the optical constants of film 6 in the region 5100 – 6100 Å using the thickness measured by Sloope, but I do not think this is going to work out but I will still keep trying. I think the trouble is due to a wrong thickness.

As pertains to the examination of the Σ, X structure, I am going to see if I can find what I did in Ge in InSb and possibly GaSb. I am sure that a similar broadening is occuring in films 6 and 8, but there may be too much noise in 7, at least it seems as if it is not there. I think some low temperature work might be called for here

I spent a good deal of this time helping Zudeke and Rossi, setting up the Gaertner ellipsometer, and fooling with my Kramers-Kronig program.

6 April - 5 May 1964

This period was spent engaged in several activities.
1) An electron diffraction goniometer was constructed and tested for doing reflection electron diffraction on the Hitachi. This arrangement seems to work OK when the intermediate and projection lens are turned off and the projection aperture opened wide. The beam is first focused to a small spot with the condenser and objective lens. The sample is then moved into the beam and the ED pattern observed. Poor photographs are obtained because the camera only photographs a portion of the phosphor screen.
2) Various methods of thickness measurements were tried on the Reichert microscope. These were Nomarski, and multiple beam using some Reichert attachments. Neither of these were very satisfactory because of the broadness of the fringes. Several silvered microscope slides were used and sodium and mercury light sources employed. These give reasonably good fringes but the technique may not be too useful on cleaved surfaces. Aluminum and chromium matter slides will also be tried.
3) The production of some new germanium films was initiated during this period under the efforts of E. Rossi. A suitable substrate heater has been constructed and apparently works well. Trouble has occured in the use and construction of a reliable source heater and a commercial one (R.D. Mathis) has been purchased and awaits trial. Several quite thin Ge films have been produced at substrate temperatures of 600°C, 500°C, and 400°C and await optical measurements.
4) One of the principle reasons for making new films is to determine whether or not the roughness problem can be solved or not. It is thought that the making of polycrystalline films would aid in this. Also, the arrangement of the reflectometer-densitometer optics was changed to allow for collecting more of the scattered light. The new set-up was checked out with MacLoed 2, and was found to give approximately the right values at 5300Å and 2800Å. However, all of the new films still give very low values of the reflectivity at 2800Å, in spite of the fact that they were deposited on cleaved CaF_2. Even allowing for a constant error due to macroroughness

did not improve matters because the ratio of the X peak to the Λ peaks was about unity for all the films. These films were spot-checked at various d's and no continuous scan was made on them.

5) Surface Roughness. Photographs of the surfaces of the new Ge films were taken and very small microstructure was observed on the epitaxial films and none on the polycrystalline films. It has been shown by Ludeke that all the films made at IBM have extreme surface roughness introduced by the polishing operation on the CaF_2 substrates. An attempt was made to correct for the surface roughness of Film 9 and Film 4/24/64 Ge#1 by simultaneously overcoating them and a flat microscope slide with aluminum and then comparing their reflectivities in the hope of correcting the original reflectivity data. Unfortunately, this did not turn out to be so as the correction actually over corrected in far ultraviolet for both films and did not follow a $\exp[-(4\pi\sigma/\lambda)^2]$ law but actually decreased at a much more rapid rate. I am at present totally at loss for the reason or explanation. Thus it appears impossible to correct for the roughness by this method.

6) Programs and Calculations: I attempted to calculate some optical constants from reflectivity data corrected by the roughness formula, particularly for Film 6. These were only partially successful as there seemed to be a divergence around 3000 Å with improper behaviour of n and k around this value. The values most consistent with PT(59) KK values were obtained for a film of 140 Å thick, very near the thickness of Film 6 as determined by OPCON 3 from transmission and bulk optical constants. Some of the troubles at short wavelengths are perhaps due to the transcendental nature of the equations used and perhaps better convergence can be obtained with approximate formulae. Also, I will have to rewrite my KK program to automatically fit an extrapolation curve to the high energy reflectivity in accordance with Stern's article in SSP15. Bad extrapolations have been the cause of the failure so far to calculate n and k for MacLeod 2 and DAB(63).

7) My
co
the

7) My talks with W.P. centered around the optical constants and the experimental difficulties with the reflectivity.

24 April 1

PURPOSE R & T: 4/24/64 Ge #1
DATE 4/24/64 PAGE LOG BOOK 107 SPECTRUM # 1
SAMPLE: MATERIAL 4/24/64 Ge #1 CODE
ORIENTATION TEMP
THICKNESS PREPARATION
STRESS: TYPE MAGNITUDE DIRECTION
SOURCE: TYPE W lamp STRENGTH 6 v
MONOCHROMATOR: GRATING 30000 RANGE 6000-3500
SCAN RATE 125 SLIT WIDTH 100-5
DETECTOR: TYPE 6256 B TEMP RT
SETTING 1230 v
POLARIZATION — FILTER —
ELECTRONICS: PRE-AMP Reg.
PSD "
TIME CONSTANT 3
RECORDER: A B C
SETTINGS
SPEED
REMARKS 6.03, 4.12, 5.00
OPERATOR PMG

24 April 2

PURPOSE R & T: 4/24/64 Ge #1
DATE 4/24/64 PAGE LOG BOOK 107 SPECTRUM # 2
SAMPLE: MATERIAL 4/24/64 Ge #1 CODE
ORIENTATION TEMP
THICKNESS PREPARATION
STRESS: TYPE MAGNITUDE DIRECTION
SOURCE: TYPE D_2 lamp STRENGTH Low
MONOCHROMATOR: GRATING 30000 RANGE 4000-2000
SCAN RATE 125 SLIT WIDTH 100-5
DETECTOR: TYPE 6256 B TEMP RT
SETTING 1880 v
POLARIZATION — FILTER —
ELECTRONICS: PRE-AMP Reg.
PSD "
TIME CONSTANT 3
RECORDER: A B C
SETTINGS
SPEED
REMARKS 6.03, 4.12, 5.00
OPERATOR PMG

PURPOSE RT of FILM 6
DATE 4/25/64 PAGE LOG BOOK 108 SPECTRUM # 1
SAMPLE: MATERIAL FILM6 CODE
ORIENTATION TEMP
THICKNESS PREPARATION
STRESS: TYPE MAGNITUDE DIRECTION
SOURCE: TYPE W lamp STRENGTH 6V
MONOCHROMATOR: GRATING 30000 RANGE 6000-3500
SCAN RATE 125 SLIT WIDTH 100-5
DETECTOR: TYPE 6256B TEMP RT
SETTING 1210V
POLARIZATION — FILTER —
ELECTRONICS: PRE-AMP Reg
PSD "
TIME CONSTANT 3
RECORDER: A B C
SETTINGS
SPEED
REMARKS 6.03, 4.12, 5.00
OPERATOR PMG

25 April 1

PURPOSE R T of FILM6
DATE 4/26/64 PAGE LOG BOOK 108 SPECTRUM # 1
SAMPLE: MATERIAL FILM 6 CODE
ORIENTATION TEMP
THICKNESS PREPARATION
STRESS: TYPE MAGNITUDE DIRECTION
SOURCE: TYPE D2 lamp STRENGTH low
MONOCHROMATOR: GRATING 30000 RANGE 4000-2000
SCAN RATE 125 SLIT WIDTH 100-5
DETECTOR: TYPE 6256B TEMP RT
SETTING 1880V
POLARIZATION — FILTER —
ELECTRONICS: PRE-AMP Reg.
PSD "
TIME CONSTANT 3
RECORDER: A B C
SETTINGS
SPEED
REMARKS 6.03, 4.12, 5.00
OPERATOR PMG

26 April 1

29 April 1

PURPOSE R correction: 4/24/64 Ge#1
DATE 4/29/64 PAGE LOG BOOK 109 SPECTRUM # 1
SAMPLE: MATERIAL 4/24/64 Ge#1 CODE
ORIENTATION TEMP
THICKNESS PREPARATION Al coat
STRESS: TYPE MAGNITUDE DIRECTION
SOURCE: TYPE W lamp STRENGTH 6v
MONOCHROMATOR: GRATING 30000 RANGE 6000-3500
SCAN RATE 125 SLIT WIDTH 100-5
DETECTOR: TYPE 6256B TEMP RT
SETTING 1220v
POLARIZATION — FILTER —
ELECTRONICS: PRE-AMP Reg
PSD "
TIME CONSTANT 3
RECORDER: A B C
SETTINGS
SPEED
REMARKS 6.03, 4.12, 5.00
OPERATOR PMG

29 April 2

PURPOSE R correction: 4/24/64 Ge#1
DATE 4/29/64 PAGE LOG BOOK 109 SPECTRUM # 2
SAMPLE: MATERIAL 4/24/64 Ge#1 CODE
ORIENTATION TEMP
THICKNESS PREPARATION Al coat
STRESS: TYPE MAGNITUDE DIRECTION
SOURCE: TYPE D₂ lamp STRENGTH low
MONOCHROMATOR: GRATING 30000 RANGE 4000-2000
SCAN RATE 125 SLIT WIDTH 100-5
DETECTOR: TYPE 6256B TEMP RT
SETTING 1870v
POLARIZATION — FILTER —
ELECTRONICS: PRE-AMP Reg.
PSD "
TIME CONSTANT 3
RECORDER: A B C
SETTINGS
SPEED
REMARKS 6.03, 4.12, 5.00
OPERATOR PMG.

PURPOSE R Correction: Film 9
DATE 4/30/64 PAGE LOG BOOK 110 SPECTRUM # 1
SAMPLE: MATERIAL Film 9 CODE
ORIENTATION TEMP
THICKNESS PREPARATION Al coat
STRESS: TYPE MAGNITUDE DIRECTION
SOURCE: TYPE W lamp STRENGTH 6v
MONOCHROMATOR: GRATING 30000 RANGE 6000-3500
SCAN RATE 125 SLIT WIDTH 100-5
DETECTOR: TYPE 6256B TEMP RT
SETTING 1220V
POLARIZATION — FILTER —
ELECTRONICS: PRE-AMP Reg.
PSD "
TIME CONSTANT 3
RECORDER: A B C
SETTINGS
SPEED
REMARKS 3.71, 5.57, 5.00
OPERATOR PMG

30 april 1

PURPOSE R Correction: Film 9
DATE 4/30/64 PAGE LOG BOOK 110 SPECTRUM # 2
SAMPLE: MATERIAL Film 9 CODE
ORIENTATION TEMP
THICKNESS PREPARATION Al Coat
STRESS: TYPE MAGNITUDE DIRECTION
SOURCE: TYPE D_2 lamp STRENGTH low
MONOCHROMATOR: GRATING 30000 RANGE 4000-2000
SCAN RATE 125 SLIT WIDTH 100-5
DETECTOR: TYPE 6256B TEMP RT
SETTING 1870
POLARIZATION — FILTER —
ELECTRONICS: PRE-AMP Reg
PSD "
TIME CONSTANT 3
RECORDER: A B C
SETTINGS
SPEED
REMARKS 3.71, 5.57, 5.00
OPERATOR PMG

6 Ma
scat
Refl
form
ve
as
How
im
me
po
of
the
epi
no
refl
fil
The
and
was
to
deg
that
effe
stru
the
wit
any
off
of
4/24
5/2

6 May – 11 May 1964

In order to attempt to capture as much of the scattered light as possible, a rearrangement of the Reflectometer – Densitometer optics to one of the original forms was made. That is, the 6256B PM was moved very close to the mirrors and the light was focused as sharply as possible on the sample position. However, as it turned out, this did not seem to improve the UV reflectivity of the films appreciably. Spot measurements were made on both epitaxial and polycrystalline samples of new Ge films. The amplitude of the X-Σ peaks seemed to be about the same as the Λ peaks. This is an improvement over the epitaxial Ge films on "polished" CaF_2 but is still no where near that expected by the bulk material.

In order to gain some perspective on our film work, reflectivity measurements were made on an epitaxial film of PbS on NaCl <100> and on a cleaved PbS surface. The results compared excellently with each other and with those of Cardona on cleaved PbS. There was a slight tailing off at 2200Å due probably to a roughness effect. Microphotographs showed a degree of structure in the PbS film about like that in the Ge films but apparently here the effect is smaller. The cleaved PbS surface showed no structure under microscopic examination. Apparently the ionic solids are going to be easier to work with. I wonder if the effect of roughness has anything to do with whether or not one is working off a <111> face or a <100> face.

The following is a compilation of the formation data of some of the thin films that have been made to date.

4/24/64 Ge #1

Source temp: unknown due to poor thermal contact to BN boat
Substrate temp: 600 °C
Exposure time: 4 min.
Result: red film, probably epitaxial,

5/2/64 Ge #1

Source – Substrate: 13.5 cm
Substrate temp: 600 °C
Source temp: 1300 °C
Exposure time: 5 min.
Result: red, probably epitaxial, quite thick

5/2/64 Ge # 2
Result: no film

5/2/64 Ge # 3
Source - Substrate: 13.5 cm
Substrate Temp: 400 °C
Source Temp: 1300 °C
Exposure Time: 5 min
Result: Orange Film, probably polycrystalline

5/2/64 Ge # 4
Source - Substrate: 13.5 cm
Substrate Temp: 500 °C
Source Temp: 1300 °C
Exposure Time: 5 min
Result: Orange Film, probably polycrystalline

5/3/64 Ge # 1
Source - Substrate: 13.5 cm
Substrate Temp: 600 °C
Source: 1300 °C
Exposure time: 8 min
Result: Red film, probably epitaxial, quite thin

5/11/64 Ge # 1
Source - Substrate: 19.5 cm
Substrate Temp: 500 °C
Source: 1050 °C
Exposure Time: 5 min
Result: Very thin, red or pink

6 May 1

PURPOSE R: 5/3/64 Ge#1
DATE 5/6/64 PAGE LOG BOOK 113 SPECTRUM # 1
SAMPLE: MATERIAL 5/3/64 Ge#1 CODE
ORIENTATION TEMP
THICKNESS PREPARATION
STRESS: TYPE MAGNITUDE DIRECTION
SOURCE: TYPE W lamp STRENGTH 6v
MONOCHROMATOR: GRATING 30000 RANGE 6000-3500
SCAN RATE 125 SLIT WIDTH 100-3
DETECTOR: TYPE 6256B TEMP RT
SETTING 1210v
POLARIZATION — FILTER —
ELECTRONICS: PRE-AMP Reg
PSD "
TIME CONSTANT 3
RECORDER: A B C
SETTINGS
SPEED
REMARKS 6.33, 4.00, 4.64
OPERATOR PMG

6 May 2

PURPOSE R: 5/3/64 Ge#1
DATE 5/6/64 PAGE LOG BOOK 113 SPECTRUM # 2
SAMPLE: MATERIAL 5/3/64 Ge#1 CODE
ORIENTATION TEMP
THICKNESS PREPARATION
STRESS: TYPE MAGNITUDE DIRECTION
SOURCE: TYPE D_2 lamp STRENGTH 1
MONOCHROMATOR: GRATING 30000 RANGE 4000-2000
SCAN RATE 125 SLIT WIDTH 100-3
DETECTOR: TYPE 6256B TEMP RT
SETTING 1850v
POLARIZATION — FILTER —
ELECTRONICS: PRE-AMP Reg
PSD "
TIME CONSTANT 3
RECORDER: A B C
SETTINGS
SPEED
REMARKS 6.33, 4.00, 4.64
OPERATOR PMG

PURPOSE T: 5/3/64 Ge #1
DATE 5/6/64 PAGE LOG BOOK 114 SPECTRUM # 3
SAMPLE: MATERIAL 5/3/64 Ge #1 CODE
ORIENTATION TEMP
THICKNESS PREPARATION
STRESS: TYPE MAGNITUDE DIRECTION
SOURCE: TYPE W lamp STRENGTH 6V
MONOCHROMATOR: GRATING 30000 RANGE 6000-3500
SCAN RATE 125 SLIT WIDTH 100-3
DETECTOR: TYPE 6256B TEMP RT
SETTING 1200
POLARIZATION — FILTER —
ELECTRONICS: PRE-AMP Reg
PSD "
TIME CONSTANT 3
RECORDER: A B C
SETTINGS
SPEED
REMARKS ?, 4.00, 4.64
OPERATOR PMG

6 May 3

PURPOSE T: 5/3/64 Ge #1
DATE 5/6/64 PAGE LOG BOOK 114 SPECTRUM # 4
SAMPLE: MATERIAL 5/3/64 Ge #1 CODE
ORIENTATION TEMP
THICKNESS PREPARATION
STRESS: TYPE MAGNITUDE DIRECTION
SOURCE: TYPE D_2 lamp STRENGTH 1
MONOCHROMATOR: GRATING 30000 RANGE 4000-2000
SCAN RATE 125 SLIT WIDTH 100-3
DETECTOR: TYPE 6256B TEMP RT
SETTING 1830V
POLARIZATION — FILTER —
ELECTRONICS: PRE-AMP Reg
PSD "
TIME CONSTANT 2
RECORDER: A B C
SETTINGS
SPEED
REMARKS ?, 4.00, 4.64
OPERATOR PMG

6 May 4

8 May 1

PURPOSE R: NOR PbS Film
DATE 5/8/64 PAGE LOG BOOK 115 SPECTRUM # 1
SAMPLE: MATERIAL NOR PbS Film CODE
ORIENTATION TEMP
THICKNESS PREPARATION
STRESS: TYPE MAGNITUDE DIRECTION
SOURCE: TYPE W lamp STRENGTH 6 v
MONOCHROMATOR: GRATING 30000 RANGE 6000 - 3500
SCAN RATE 125 SLIT WIDTH 100 - 3
DETECTOR: TYPE 6256 B TEMP RT
SETTING 1210 v
POLARIZATION — FILTER —
ELECTRONICS: PRE-AMP Reg
PSD "
TIME CONSTANT 3
RECORDER: A B C
SETTINGS
SPEED
REMARKS 6.89, 4.44, 3.51
OPERATOR PMS

8 May 2

PURPOSE R: NOR PbS Film
DATE 5/8/64 PAGE LOG BOOK 115 SPECTRUM # 2
SAMPLE: MATERIAL NOR PbS Film CODE
ORIENTATION TEMP
THICKNESS PREPARATION
STRESS: TYPE MAGNITUDE DIRECTION
SOURCE: TYPE D_2 lamp STRENGTH 1
MONOCHROMATOR: GRATING 30000 RANGE 4000 - 2000
SCAN RATE 125 SLIT WIDTH 100 - 3
DETECTOR: TYPE 6256 B TEMP RT
SETTING 1860 v
POLARIZATION — FILTER —
ELECTRONICS: PRE-AMP Reg
PSD "
TIME CONSTANT 3
RECORDER: A B C
SETTINGS
SPEED
REMARKS 6.89, 4.44, 3.51
OPERATOR PMS

PURPOSE R: NOR PbS Crystal
DATE 5/9/64 PAGE LOG BOOK 116 SPECTRUM # 1

9 May 1

SAMPLE: MATERIAL NOR PbS Crystal CODE
ORIENTATION TEMP
THICKNESS PREPARATION
STRESS: TYPE MAGNITUDE DIRECTION
SOURCE: TYPE W lamp STRENGTH 6V
MONOCHROMATOR: GRATING 30000 RANGE 6000-3500
SCAN RATE 125 SLIT WIDTH 100-3
DETECTOR: TYPE 6256B TEMP RT
SETTING 1210V
POLARIZATION — FILTER —
ELECTRONICS: PRE-AMP Reg
PSD "
TIME CONSTANT 3
RECORDER: A B C
SETTINGS
SPEED
REMARKS 6.89, 3.95, 4.28
OPERATOR PMG

PURPOSE R: NOR PbS Crystal
DATE 5/9/64 PAGE LOG BOOK 116 SPECTRUM # 2

9 May 2

SAMPLE: MATERIAL NOR PbS Crystal CODE
ORIENTATION TEMP
THICKNESS 0 PREPARATION
STRESS: TYPE MAGNITUDE DIRECTION
SOURCE: TYPE D_2 lamp STRENGTH 1
MONOCHROMATOR: GRATING 30000 RANGE 4000-2000
SCAN RATE 125 SLIT WIDTH 100-3
DETECTOR: TYPE 6256B TEMP RT
SETTING 1850V
POLARIZATION — FILTER —
ELECTRONICS: PRE-AMP Reg
PSD "
TIME CONSTANT 3
RECORDER: A B C
SETTINGS
SPEED
REMARKS 6.89, 3.95, 4.28
OPERATOR PMG

12 May – 18 May 1964

During this period several experiments were performed with the object of finding the cause of the decline of the UV reflectivity of the Ge films. This entailed depositions on substrates of different materials, chemical examination of the films, and a determination of the oxidation rate of germanium under medium vacuum conditions as studied by reflectivity methods. One of the films, 5/3/64 Ge #1, was placed in an HF bath to see what would happen. The film immediately broke loose from the substrate and floated to the surface of the HF, but no further disolving took place and there were several large pieces floating around. Various attempts to pick these pieces up intact failed but if a well-studied attack were made, it could probably be done. Some of the film pieces were put in CP-4 where they dissolved upon agitation of the etch (rather strange, as one would expect them to be dissolved by themselves with no outside agitation). The object of this was to determine crudely the amount of GeO_2 present. The result indicates that it cannot be present in extremely large quantities.

An experiment was performed to find out if there is any oxidation of a germanium surface under high temperatures in a medium vacuum. The following are the results:

Surface Treatments	Reflectivity 5300Å	Reflectivity 2800Å
Ge polished by .1 μ Linde "B"	46.2%	57.0%
1 min. etch in fresh CP-4	48.3%	68.0%
After heating to 600°C in $5\cdot10^{-6}$ mm Hg vacuum for ½ hr., then cooling for 1½ hr. before taking out.	49.0%	69.0%
After HF rinse for 1 min.	49.4%	69.0%

This material then became the substrate for 5/18/64 Ge #1.

Film	Substrate Parameters	Source Parameters	Run Time	Reflectivity 5300 Å	Reflectivity 2800 Å
5/3/64 Ge #1	CaF_2, 600 °C, Cl.	IBM Ge, 1300 °C (54)	8 min.	42.5 %	36.3 %
5/2/64 Ge #1	CaF_2, 600 °C, cl.	IBM Ge, 1300 °C (54)	5 min.	33.6 %	40.8 %
5/15/64 Ge #1	Glass, 500 °C	IBM Ge, ~1300 °C (60)	5 min.	37.0 % 33.1 % R	47.5 % (glass opaque)
5/15/64 Ge #2	Fuzed Quartz, 600 °C (42)	IBM Ge, ~1300 °C (55)	5 min.	37.5 % 33.9 % R	47.5 % 51.5 % R
5/17/64 Ge #1	Polished MIT Ge substrate			46.7 %	65.0 %
5/17/64 Ge #1	Pol. Ge, ~600 °C (42)	IBM Ge, ~1300 °C (55)	10 min.	39.6 %	30.0 %
5/18/64 Ge #1	Etched Ge, ~600 °C (42)	IBM Ge, ~1300 °C (55)	10 min.	41.2 %	41.2 %
5/18/64 Ge #2	CaF_2, ~600 °C (42)	MIT Ge, ~1300 °C (55)	2 min.	46.0 %	61.7 %
5/18/64 Ge #3	Substrate, etched (PDE(62)) Ge with HF rinse			44.8 %	65.0 %
5/18/64 Ge #3	Etched Ge, ~600 °C (42)	MIT Ge, ~1300 °C (55)	3 min.	43.7 %	57.0 %

The conclusion to be drawn from the table on page 118 is that the situation improved markedly when we changed sources over to MacLeod 2 type source material which we know to be intrinsic. The only thing constant between films made at IBM and here is the source material and it now appears that this is contaminated. The 2800Å reflectivity of film 5/18/64 #2 Ge is the best I have seen and it was the first try with the new material. The results of 5/18/64 Ge #3 are a bit disappointing, but is much better than before. Certainly more work must be done. One could even see the difference in the monitor slides where the MIT material gave a "light" shade and the IBM a "dark" shade. One could actually see the film on 5/18/64 Ge #1 but not on 5/18/64 Ge #3. The source of the contamination must be neutral in its action because none of the structure energies in the old films is changed at all. This suggests either GeO_2 or dissolved carbon in the IBM germanium coming from the carbon crucibles.

This week I wrote a letter to Donovan, et al., generally outlining my results to date.

19 May – 23 June 1964

This period saw intensive activity in the production and measurement of Ge films on CaF_2, fuzed quartz, and Ge substrates under high and low deposition rates, and with different source holders. Generally, a 2800Å reflectivity of about 58% was the best that we were able to obtain on both fuzed quartz and germanium and CaF_2 substrates. Donovan reports a value of about 65% for fuzed quartz substrates at temperatures below 625 °C. I believe that the primary cause of this decrease in reflectivity is surface roughness.

Electron diffraction studies were made on the Hitachi electron microscope and the results were pretty much as expected, that is, the high substrate temperature films were epitaxial with varying amounts of twinning while the low temperature and the ones deposited on fuzed quartz were polycrystalline. The fuzed quartz samples showed especially broken Debye-Scherrer rings. Photomicrographic studies of the film surfaces indicate various degrees of roughness, the films on germanium substrates being especially susceptible to roughness.

A much better idea has been obtained of the effect of strain on the reflectivity of the films by studying in detail film 5/18/64 Ge#2 (CaF_2). It appears as though the strain in the films produce a stress of 8800 atm. as determined by the shift of the Λ peaks. However, the $\Sigma - X$ peak seems to be shifted anomalously too much but this may be due to the envelope of the roughness effect, or perhaps to some unknown effect because the plane of the film contains the <110> direction.

In relation to this effect, it is expected that there will be a shift to longer wavelengths of the reflectivity peaks because of the differential thermal expansion in the case of when the substrate is fuzed quartz (see page 42). In this case:

$$\alpha_{FQ} = .546 \cdot 10^{-6}/°C \quad (0 - 800°C)$$
$$\alpha_{Ge} = 5.75 \cdot 10^{-6}/°C$$

Differential stress = 2900 atm in uniaxial tension

SUMMARY OF FILM RESULTS FROM 5/15/64 TO 6/11/64

PG. 121	FILM NUMBER	SUBSTRATE TEMPERATURE	SOURCE CONFIGURATION	SOURCE MATERIAL	SOURCE POWER	SOURCE - SUBSTRATE DISTANCE	VACUUM SYSTEM - PRESSURE
	5/3/64 Ge#1 (CaF_2)	600°C (38)	BN BOAT	IBM Ge	1300°C (54-5)	5.3"	NRC <1·1
a	5/2/64 Ge#1 (CaF_2)	600°C (38)			1300°C (54-5)		
	5/15/64 Ge#1 (Glass)	500°C			(60-5)		
	5/15/64 Ge#2 (FQ)	>600°C (42)			(55-5)		
	5/17/64 Ge#1 (PGe)	>600°C (42)			(55-5)		
	5/18/64 Ge#1 (EGe)	>600°C (42)			(55-5)		
a	5/18/64 Ge#2 (CaF_2)	>600°C (42)		OLD MIT Ge	(55-5)		
	5/18/64 Ge#3 (EGe)	>600°C (42)			(55-5)		
a	5/20/64 Ge#1 (CaF_2)	>600°C (42)			(55-5)		
b	5/21/64 Ge#1 (CaF_2)	>600°C (42)			(50-5)		
d	5/23/64 Ge#1 (CaF_2)	>600°C (42)			(45-5)		
	5/23/64 Ge#2 (EGe)	>600°C (42)			(45-5)		
	5/25/64 Ge#1 (EGe)	>600°C (42)			(50-5)		
c	5/30/64 Ge#1 (CaF_2)	>600°C (47)		NEW LINCOLN Ge	(60-5)		
c	5/31/64 Ge#1 (CaF_2)	>600°C (47)			(60-5)		
a	6/1/64 Ge#1 (CaF_2)	>600°C (56)			(65-5)		
	6/2/64 Ge#1 (FQ)	>600°C (73)			(65-5)		
	6/3/64 Ge#1 (EGe)	>600°C (770) (75)			(65-5)		
b	6/3/64 Ge#2 (CaF_2)	625°C (40)	W Basket		(60-10)		
d	6/4/64 Ge#1 (CaF_2)	620°C (40)			(90-10)		
a	6/4/64 Ge#2 (CaF_2)	610°C (40)	W Boat		(49-10)		
	6/5/64 Ge#1 (FQ)	700°C (50)			(50-10)		
	6/6/64 Ge#1 (EGe)	750°C (55)			(53-10)		
	6/8/64 Ge#1 (FQ)	750°C (55)			(50-10)		
	6/10/64 Ge#1 (FQ)	780°C (55)			(50-10)	11"	
	6/11/64 Ge#1 (FQ)	585°C (37)			(50-10)		

ABBREVIATIONS: RO = RAN OUT; PU = PM UP; FS = FOCUS ON SAMPLE
(-) = VARIAC SETTING; PB = PM BACK; FM = FOCOS ON MIRROR

…E	TIME OF RUN — THICKNESS	DEPOSITION RATE	OPTICAL REFLECTIVITY RESULTS CONFIGURATION	5300 Å	3500 Å	2800 Å	SURFACE TEXTURE	ELECTRON DIFFRACTION RESULTS
10^{-5}	8 min		PU-FS	42.5%		36.3%	? (FILM REMOVED BY HF)	
	5 min		PU-FS	33.6%		40.8%	VR MR P	
	5 min		PU-FS	37.0% 33.1%R		47.5%	VR	
	5 min		PU-FS	37.5% 33.9%R		47.5% 51.5%R	VR	
	10 min		PU-FS	39.6% 46.7%S		30.0% 65.0%S	VR	
	10 min		PU-FS	41.2%		41.2%	VR	
	2 min		PU-FS	46.0%	41.6%	56.5%	VS MS P	LP
	3 min		PU-FS	43.7% 44.8%S		57.0% 65.0%S	VR	
	30 s		PU-FS	43.2%	39.2%	52.0%	VS MS(?) P	LP: DS
	20 s (300 Å)	(15 Å/s) (900 Å/m)	PU-FS	52.7%	41.6%	54.6%	VS MS P	LP
	60 s		PU-FS	35.4%	37.4%W 38.6%D_2	50.0%	VS	LP
	5 min		PU-FS	42.2% 47.0%S	35.7% 45.0%S	43.6% 63.3%S	VR MR (Extremely) P	LP: KL
	60 s		PU-FS	42.6% 43.3%S	37.7% 41.2%S	48.5% 57.6%S	VR MR P	
	11.5 s		PB-FM	42.7%	40.0%	53.4%	VS	
	11.5 s		PU-FM	40.8%	42.5%	56.6%	VS MS P	LP: FAINT DS
	13 s		PU-FM	37.3%	26.1%	23.4%	Very Rough P	LP
	30 s						Very Rough	
	1 min						Very Rough	
	47 s		PU-FM	39.8%	40.6%	51.5%	VS	
	25 s (ro) (10 s)		PU-FM	34.9%	36.6%	47.5%	VS	
	25 s (ro) (10 s)		PU-FM	44.1%	44.8%	58.5%	VS (FILM BREAKING) (VR)	
	14 s		PU-FM	44.5%	44.9%	56.8%	VS (SUB. DIRTY)	
	20 s (ro)		PU-FM	45.5%	43.6%	57.8%	VR (SUB. DIRTY)	
	15 s (?)		PU-FM	42.2%	38.4%	44.7%	VR (SUBSTRATE DIRTY)	
	18 s (?)		PU-FM	43.6% 35.3%R	40.1% 35.6%R	46.3% 50.8%R	VR	DS(T)
			PB-FM	47.0%	40.6%	48.2%		
	(?) 20 s		PU-FM	42.2% 31.6%R	47.6% 35.8%R	58.6% 49.0%R	VS	DS(T)
			PB-FM	45.2%	48.8%	63.5%		

VR = VISIBLY ROUGH MR = MICROSCOPICALLY ROUGH P = PHOTOGRAPH
VS = VISIBLY SMOOTH MS = " SMOOTH

a. Very thick
b. Thickness ≅ 5/21/64 Ge#1 (CaF_2)
c. Thickness > "
d. Thickness < "

Optical Arrangement	Sample	Reflectivity 5300 Å	Reflectivity 3500 Å	Reflectivity 2800 Å
PU-FS ; 100-3	MacLeod 2	47.0	45.8 W 46.5 D_2	65.7 (64.8)
PB-FS ; 100-3	MacLeod 2	49.9	45.0 W 53.4 D_2	72.4 (61.1)
PB-FS ; 100-5	MacLeod 2	49.2	44.5 W 47.0 D_2	64.5 (61.1)
PB-FM ; 100-5	MacLeod 2	51.2	47.0 W 49.0 D_2	67.7 (65.0)
PU-FM ; 100-5	MacLeod 2	47.0	47.5 W 47.2 D_2	64.5
PB-FM ; 100-5	MacLeod 2 (after HF)	51.4	48.7 W 51.0 D_2	72.6 (69.5)

Effect of Optical Arrangement on the Reflectivity

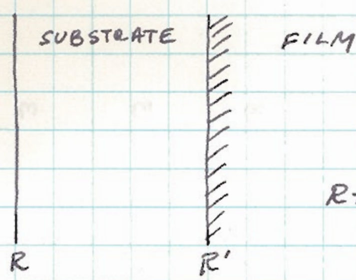
PU = Photomultiplier Up
PB = " Back

FS = Focus on sample
FM = Focus on mirror

100-5 = 100μ slit width, 5 mm height
100-3 = " , 3 " "

measurements were made using MacLeod 2 as a standard under different optical configurations. The results are on page 122. It is seen that generally the reflectivity is better when the light is focused on the mirrors rather than on the sample. This is very likely because of the spherical abberation of the mirrors which, when in FS position, caused some light to miss the diagonal mirrors. However, a considerable difference in reflectivity is noted between the PV and PB positions at 5300Å. The reason for this is at present unexplained but it may be tied into the fact that in the PV position, the large angle of incidence of the light causes a peculiar response in the photomultiplier. The PB position not only gives the right answer but is also esthetically more pleasing because the light covers the whole PM cathode thus assuring a more uniform response to both I_R and I_O.

In order to investigate the effect of the surface roughness a little more thoroughly, I computed what the theoretical reverse reflectivity should be based on the following model.



$$R_T = R + (1-R)R'(1-R) + (1-R)R'RR'(1-R) + (1-R)R'RR'RR'(1-R) + \cdots$$

$$R_T = R + \frac{T^2 R'}{1 - RR'}$$

Take for Ge: $n = 2.50$; $k = 4.25$; $R(\text{air}) = 67.0\%$
Take for FQ: $n = 1.50$

$R = .040$; $T^2 = .92$
$R' = .559$

$R_T = 56.4\%$

Let us consider two films on FQ; and Reflectivity at 2800Å:

Film	Front Reflectivity	% Difference	Back Reflectivity	% Difference
6/10/64 Ge#1 (FQ)	46.3 (M) 67.0 (C)	30.9%	50.8 (M) 56.4 (C)	9.9%
6/11/64 Ge#1 (FQ)	58.6 (M) 67.0 (C)	12.5%	49.0 (M) 56.4 (C)	13.1%

Summary of Optical Measurements: 5/19 - 6/23

Run No	Sample No	Measurement	Time Const.	PM Voltage	Optics	Range	Scan
20 MAY 1	5/20/64 Ge#1 (CaF_2)	R	3	1240	PV-FS: 100-3	6000 - 3500	125
20 MAY 2		R	3	1850		4000 - 2000	
20 MAY 3		T	2	1240		6000 - 3500	
21 MAY 1	5/21/64 Ge#1 (CaF_2)	R&T	3	1230	PV-FS: 100-3	6000 - 3500	125
21 MAY 2				1850		4000 - 2000	
23 MAY 1	5/23/64 (EGe)	R	3	1230	PV-FS: 100-3	6000 - 3500	125
23 MAY 2				1850		4000 - 2000	
26 MAY 1	5/25/64 Ge#1 (EGe)	R	3	1230	PV-FS: 100-3	6000 - 3500	125
26 MAY 2				1850		4000 - 2000	
26 MAY 3	5/25/64 (Substrate)			1230		6000 - 3500	
26 MAY 4				1850		4000 - 2000	
27 MAY 1	5/18/64 Ge#2 (CaF_2)	R	3	1230	PV-FS: 100-3	6000 - 3500	125
27 MAY 2				1850		4000 - 2000	
28 MAY 1	5/23/64 Ge#2 (EGe)	R	3	1230	PV-FS: 100-3	6000 - 3500	125
28 MAY 2				1850		4000 - 2000	
5 JUNE 1	6/5/64 Ge#1 (FQ)	R	3	1100	PV-FM: 100-5	6000 - 3500	125
5 JUNE 2				1720		4000 - 2000	
6 JUNE 1	MacLeod 2	R	3	1100	PV-FM: 100-5	6000 - 5000	125

A letter was recieved during this time from T.M. Donovan of the NOL group at China Lake. There is a program in thin semiconductor films in this group. He has gotten 65% reflectivity at the 2800 Å group, but not for a film in which both 2 peaks appear. I still feel that the reduction in amplitude of this peak is due to a texture effect such as roughness, but I plan a program on FQ substrates anyway.

Also, during this time I made a trip to IBM and spoke with many people at Yorktown. I have communicated with Nowick of Yorktown concerning the possibility of obtaining epitaxial films of silicon on silicon substrates and possibly substrates of other materials.

24 June - 22 July 1964

During this period a study was made of germanium films deposited on FQ substrates at various deposition rates and substrate temperatures in that their optical reflectivity in the region 6000 Å to 2000 Å as a function of these parameters was measured with particular attention being paid to the amplitude of the $\Sigma_1 X$ peak.

The following is the experimental procedure used to fabricate the films:

Experimental Procedure for Ge Films on FQ Substrates

(1) Do two sets of experiments:
  (a) 4 films - same deposition rate, different substrate temperature.
  (b) 4 films - same ST, different DR
  all FQ slides to be cut from the same big slide.

(2) Substrate Cleaning:
  (a) Wash in detergent
  (b) Wash in HNO_3
  (c) Wash in two baths of fresh acetone
  (d) Dry in N_2 stream
  (e) Wipe with Ross Optical Lens Tissue

(3) Source Preparation and Procedure:
  (a) Use W (.005) boats. Weigh before use.
  (b) Use Etched Ge (CP-4) from Rediker. Weigh before use.
  (c) Hopefully evaporation rates will not be such as to require the changing of source material from run to run during the different substrate temperature experiment.

(4) Evaporation Procedure:
  (a) Rough out slowly.
  (b) Keep LN_2 in cold trap at all times.
  (c) Put DP on at 25 microns and let pump steadily for 15 min. Record Pressure.
  (d) Bake out substrate at about 750 °C for 20 min. and then reduce to operating temperature and record.
  (e) Bring up source heater to prescribed level and record Variac setting and meters.
  (f) Open shutter for prescribed time and record.
  (g) Leave substrate at Temp for 5 min., then reduce slowly.
  (h) Open bell jar when ST is about 50°C

(5) Jig Parameters:
(a) Source - Substrate distance = 10 5/8."
(b) Jig cleaned of PbS by HNO_3 bath.
(c) Substrate TC spot welded to Ta substrate holder plate.
(d) Use Rossi's original jig in NRC system.

In the carrying out of the above procedure, it was not immediately known what the deposition rates were. As it turned out, one of the runs had such a low rate that a film was hardly formed at all. Also, the run at high substrate temperature turned out to be almost useless for optical measurements as it was very rough and discontinuous. Therefore, two previous FQ runs were used to "fill in" the data. The final film disposition turned out to be:

Variable ST, Constant DR		Variable DR, Constant ST
7/2/64 Ge #1 (FQ)	··· 450°C	7/2/64 Ge #3 (FQ)
7/2/64 Ge #2 (FQ)	··· 300°C	7/3/64 Ge #1 (FQ)
7/1/64 Ge #3 (FQ)	··· 600°C	7/3/64 Ge #2 (FQ)
6/10/64 Ge #1 (FQ)	··· 780°C	6/11/64 Ge #1 (FQ)
10 JULY 1 & 2	··· 25°C	

The film listed as 10 JULY 1 & 2 is a measurement made on an opaque amorphous film obtained from a monitor slide used during one of the runs. The DR was probably quite high.

A chart has been made which gives the gain for various gain switch ratios over the linear range of the amplifiers in order to expedite the reduction of data. Also a new program written by myself and B. Kosicki has been used to calculate I/I_0, but I think it will prove seldom efficient for me to use it. The gain chart is on page 128.

As regards the results: There is apparently no meaningful dependence of the Σ, X peak on DR. However, there is the expected dependence on ST, with a really high ST giving good structure but poor Σ, X amplitude due to roughness. Note that several Σ, X peaks are of the order 63 - 64% in amplitude.

GAIN CHART 13 DECEMBER 1963

SWITCH SETTINGS	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
5		1.59															
6			1.59														
7				1.59													
8					1.59												
9						1.59											
10							1.55	2.48	3.92	6.23	9.97	15.75	24.9	39.8	63.3	101.3	161.1
11								1.60	2.53	4.02	6.43	10.16	16.05	25.7	40.8	65.3	103.9
12									1.58	2.51	4.02	6.35	10.03	16.05	25.5	40.8	64.9
13										1.59	2.54	4.02	6.35	10.16	16.16	25.9	41.1
14											1.60	2.53	3.99	6.39	10.16	16.26	25.9
15												1.58	2.50	3.99	6.35	10.16	16.16
16													1.58	2.53	4.02	6.43	10.23
17														1.60	2.54	4.07	6.47
18															1.59	2.54	4.04
19																1.60	2.54
20																	1.59

SUMMARY OF RESY TO 7/3/64
ALSO OTHER MISC.

PG 121 FILM NUMBER	SUBSTRATE TEMPERATURE	REFLECTIVITY RESULTS 3500 Å	2800 Å	SURFACE TEXTURE	ELECTRON DIFFRACTION RESULTS
7/1/64 Ge#2 (FQ)	730°C BO: 730°C, 75m			VR (BROKEN)	DS: FINE LINES
7/1/64 Ge#3 (FQ)	600°C BO: 780°C, 35m	48.8%	63.7%	VS	DS: BROKEN
7/2/64 Ge#1 (FQ)	450°C BO: 780°C, 22m	(55.6%	59.8%	VS	DS: BROAD
7/2/64 Ge#2 (FQ)	300°C BO: 780°C, 30m	52.3%	57.8%	VS	DS: BROAD
7/2/64 Ge#3 (FQ)	610°C BO: 800°C, 20m	(47.8%	60.0%	VS	DS: BROKEN
7/2/64 Ge#4 (FQ)	600°C BO: 780°C, 20m	17.0%	26.5%	TOO THIN TO BE VISIBLE	DS: (BROAD LINES)
7/3/64 Ge#1 (FQ)	600°C BO: 780°C, 23m	48.5%	63.8%	VS	DS: VERY BROKEN
7/3/64 Ge#2 (FQ)	600°C BO: 780°C, 20m	45.3%	56.3%	VS	DS: VERY BROKEN
7/1/64 Ge#1 (CaF₂)	600°C BO: 720°C, 30	43.7%	53.2%	VS	DS: FINE LINES
10 JULY 1&2	25°C	47.3%	46.7%	VS	DS: VERY BROAD
d 4/18/64 Ge#1 (CaF_2)	596°C				
d 4/23/64 Ge#3 (CaF_2)	600°C				
d 4/24/64 Ge#1 (CaF_2)	600°C	ED TO STUDY ITS ROUGHNESS			
b 5/1/64 Ge#1 (CaF_2)	550°C				
d 5/2/64 Ge#2 (CaF_2)	500°C				
d 5/11/64 Ge#1 (CaF_2)	510°C				
d 10/13/64 Ge#1 (CaF_2)	600°C (PA				
a 10/15/64 Ge#2 (CaF_2)	580°C (PA				
12/2/64 Ge#1 (CaF_2)					
12/4/64 Ge#1 (CaF_2)					

SWITCH SETTING

GAIN CHART 13 DECEMBER 1963

PG 121

SUMMARY OF RESULTS ON Ge FILMS DEPOSITED ON FUZED QUARTZ AND ALSO OTHER MISCELLANEOUS DEPOSITIONS ON CaF_2

	FILM NUMBER	SUBSTRATE TEMPERATURE	SOURCE CONFIGURATION	SOURCE MATERIAL	SOURCE POWER	SOURCE – SUBSTRATE DISTANCE	VACUUM SYSTEM – PRESSURE	TIME OF RUN – THICKNESS	D
	7/1/64 Ge#2 (FQ)	730 °C (55) BO: 730°C, 35m (55)	3.545 g W(.005)	New Lincoln Ge .3204 g	(25-5)	10 5/8"	NRC $1\cdot10^{-6}$	121 s	
	7/1/64 Ge#3 (FQ)	600 °C (38) BO: 780°C, 35m (55)			(25-5, 6)		$<1\cdot10^{-6}$	121 s	
	7/2/64 Ge#1 (FQ)	450 °C (22.5) BO: 780°C, 22m (55)		.3242 g added	(25-5, 6.2)		$5\cdot10^{-7}$	121 s	
	7/2/64 Ge#2 (FQ)	300 °C (12) BO: 780°C, 30m (55)			(25-5, 6.3)		$8\cdot10^{-7}$	121 s	
	7/2/64 Ge#3 (FQ)	610 °C (35) BO: 800°C, 20m (55)			(25-5, 6)		$8\cdot10^{-7}$	121 s	
	7/2/64 Ge#4 (FQ)	600 °C BO: 780°C, 20m (52)	4.4439 g W(.005)	New Lincoln Ge .3160 g	(18.5-5, 52)		$8\cdot10^{-7}$	360 s	
	7/3/64 Ge#1 (FQ)	600 °C (33) BO: 780°C, 23m (52)			(30-5, 6.6)		$8\cdot10^{-7}$	90 s	
	7/3/64 Ge#2 (FQ)	600 °C (33) BO: 780°C, 20m (53)		.3243 g added	(35-5)		$5\cdot10^{-7}$	14 s	
	7/1/64 Ge#1 (CaF_2)	600 °C (38) BO: 720°C, 30m (53)	3.545 g W(.005)	New Lincoln Ge .3204 g	(25-5, 6.1)		$2\cdot10^{-6}$	92 s	
	10 JULY 1&2	25 °C	?	?	?		?	?	
d	4/18/64 Ge#1 (CaF_2)	596 °C	Ta Boat	IBM Ge	1525 °C	15 cm	VEECO $<1\cdot10^{-5}$	10 min	
d	4/23/64 Ge#3 (CaF_2)	600 °C			1050-1110 °C			10 min	
d	4/24/64 Ge#1 (CaF_2)	600 °C	BN Boat		?			4 min	
b	5/1/64 Ge#1 (CaF_2)	550 °C	W Boat		1300 °C		NRC $<1\cdot10^{-5}$	5 min	
d	5/2/64 Ge#2 (CaF_2)	500 °C	BN Boat		1315 °C	13.5 cm		5 min	
d	5/11/64 Ge#1 (CaF_2)	510 °C	BN Boat		1040 °C			5 min	
d	10/13/64 Ge#1 (CaF_2)	600 °C (PA 7m)	W Boat	Rediker Ge	VAR 45, I 38, V 1.7	7"	Little NRC $<1\cdot10^{-5}$	2 min	
a	10/15/64 Ge#2 (CaF_2)	580 °C (PA 5m)	W Boat	Rediker Ge	VAR 50, I 136, V 1.85	2 3/4"	Little NRC $<1\cdot10^{-5}$	62 sec	
	12/2/64 Ge#1 (CaF_2)								
	12/4/64 Ge#1 (CaF_2)								

UARTZ AND CaF₂ SUBSTRATES FROM 7/1/64 TO 7/3/64

	TIME OF RUN — THICKNESS	DEPOSITION RATE	OPTICAL REFLECTIVITY RESULTS CONFIGURATION	5300 Å	3500 Å	2800 Å	SURFACE TEXTURE	ELECTRON DIFFRACTION RESULTS
10^{-6}	121s		NO MEASUREMENT				VR (BROKEN)	DS: FINE LINES
10^{-6}	121s		PB-FM	50.2%	48.8%	63.7%	VS	DS: BROKEN
0^{-7}	121s		PB-FM	62.1%	55.6%	59.8%	VS	DS: BROAD
10^{-7}	121s		PB-FM	60.5%	62.3%	57.8%	VS	DS: BROAD
10^{-7}	121s		PB-FM	57.0%	47.8%	60.0%	VS	DS: BROKEN
$\cdot 10^{-7}$	360s		PU-FM	12.1%	17.0%	26.5%	TOO THIN TO BE VISIBLE	DS: (BROAD LINES)
$3\cdot 10^{-7}$	90s		PB-FM	50.0%	48.5%	63.8%	VS	DS: VERY BROKEN
10^{-7}	14s		PB-FM	48.1%	45.3%	56.3%	VS	DS: VERY BROKEN
10^{-6}	92s		PU-FM	45.4%	43.7%	53.2%	VS	DS: FINE LINES
?	?		PB-FM	45.6%	47.3%	46.7%	VS	DS: VERY BROAD
$\cdot 10^{-5}$	10 min							
	10 min							
	4 min		THIS FILM WAS ALUMINIZED TO STUDY ITS ROUGHNESS					
10^{-5}	5 min							
	5 min							
	5 min							
$< 1\cdot 10^{-5}$	2 min							
$< 1\cdot 10^{-5}$	62 sec							

Summary of Optical Measurements: 7/6 – 7/14

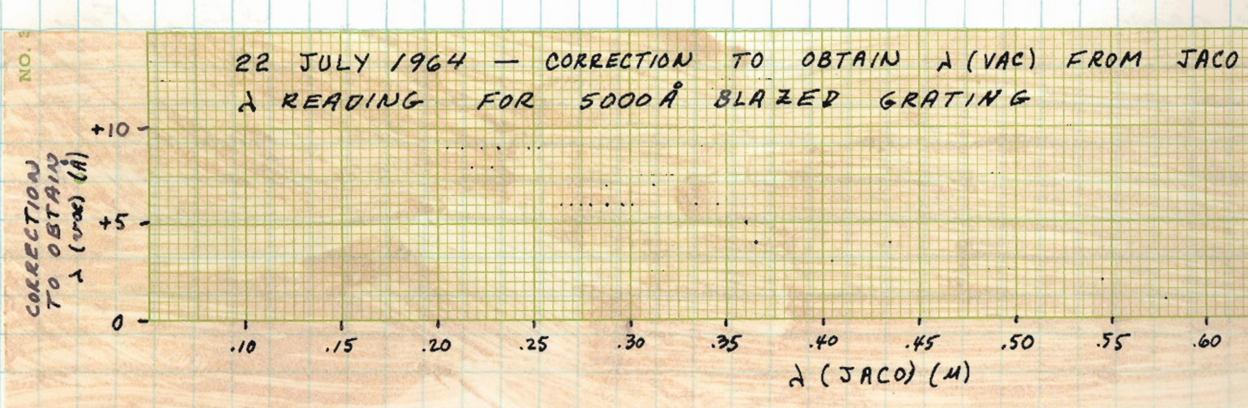
Run No.	Sample No	Measurement	Time Const	PM Voltage	Optics	Range	Scan
6 JULY 1	7/3/64 Ge#2 (FQ)	R	3	1230 v	PB-FS:100-5	6000-3500	125
6 JULY 2				1930 v		4000-2000	
6 JULY 3	7/3/64 Ge#1 (FQ)			1240 v		6000-3500	
6 JULY 4				1940 v		4000-2000	
6 JULY 5	7/2/64 Ge#3 (FQ)			1240 v		6000-3500	
6 JULY 6				1940 v		4000-2000	
6 JULY 7	7/1/64 Ge#3 (FQ)			1240 v		6000-3500	
6 JULY 8				1940 v		4000-2000	
7 JULY 1	7/2/64 Ge#1 (FQ)			1240 v		6000-3500	
7 JULY 2				1940 v		4000-2000	
7 JULY 3	7/2/64 Ge#2 (FQ)			1240 v		6000-3500	
7 JULY 4				1930 v		4000-2000	
9 JULY 1	6/11/64 Ge#1 (FQ)			1230 v		6000-3500	
9 JULY 2				1950 v		4000-2000	
9 JULY 3	6/10/64 Ge#1 (FQ)			1240 v		6000-3500	
9 JULY 4				1970 v		4000-2000	
10 JULY 1	Amorphous Ge			1230 v		6000-3500	
10 JULY 2				1950 v		4000-2000	
14 JULY 1	RT: Bulk Ge: $R^4(\Sigma X)$	R^4		1820 v		3000-2000	
14 JULY 2	LHe: Bulk Ge: $R^4(\Sigma, X)$						

The following table represents a calibration of the JACO .5 meter monochromator with respect to standard vacuum wavelengths of the Hg, Cd, and Zn emission line spectrum, taken from the article by Zwerdling and Theriault, Spectrochimica Acta, Vol 17, No. 8, pp 819-856. The appropriate conversion factor to electron volts is:

$$\lambda\,(vac)\;E\,(ev) = 1.23977\ ev\cdot\mu$$

The following calibration is for the 5000 Å blaze grating and all wavelengths have been rounded to the nearest Å.

λ(vac) (Å)	Source	λ (JACO) (Å)	Deviation (Å)
2289	Cd	2281	-8
2145	Cd	2137	-8
2139	Zn	2130	-9
2063	Zn	2054	-9
2241	Cd	2232	-9
2330	Cd	2321	-9
2484	Hg	2475	-9
2537	Hg	2528	-9
2653	Hg	2647	-6
2700	Hg	2694	-6
2754	Hg	2748	-6
2805	Hg	2799	-6
2882	Cd	2875	-7
2894	Hg	2888	-6
2968	Hg	2962	-6
3022	Hg	3016	-6
3127	Hg	3120	-7
3342	Hg	3338	-6
3468	Cd	3462	-6
3612	Cd	3607	-5
3651	Hg	3647	-4
4048	Hg	4045	-3
4360	Hg	4356	-4
5462	Hg	5460	-2
5792	Hg	5791	-1



In order to further investigate a shoulder found near the Σ, X peak when examining the reflectivity of bulk germanium (see MacLeod 2 and log page 96), I measured carefully the reflectivity of the bulk Ge in the region 3000Å – 2000Å with a 10 Å resolution using Zallen's R^4 reflectivity capsule and performing the experiment at room and liquid helium temperatures. Four pieces of germanium were etched and mounted in the sample holder (etchant = CP4). The etched surfaces were rather rough and due to this and other probable optical inefficiencies (windows, etc) the actually reflectivity at 2800Å was about 54% instead of the expected 72%; however, this was sufficient to do the experiment.

A nominal 47Ω, 1/10 watt carbon resistor was mounted on the cold finger near the sample. Earlier measurements showed that the actual room temperature resistance was 44Ω while that at 4.2°K was 525Ω. The calibration curve used was that of Groves-Holland for Grove's Carbon "D" resistor thermometer. The LHe resistance of this resistor was 568Ω at 4.2°K. However, the approximate inverse slope in the region 4–6°K is: $dT/dR = -6.56 \cdot 10^{-3}$ °K/Ω. Assuming that this inverse slope does not change much from resistor to resistor, the temperature error at about LHe due to the difference in temperature resistors at LHe is only about .3°K. Hence we should get accuracy to well within a degree without having to calibrate each resistor separately. Our resistor was cemented to the cold finger with GE low temperature cement and, using the circuit shown on page 101, the equilibrium resistance with 1.2 liters of He in the dewar was 437Ω or a temperature very close to 5°K.

The resultant curves were plotted up and the data analyzed in the following way: The Σ, X peaks were so sharp that they could be located ± 5Å. This was done (the peaks were also quite symmetrical for a considerable portion of their height), the result corrected according to page 131 and converted to electron-volts. For the shoulders, an asymptotic continuation of the Σ, X peak was made, at each temperature, under the shoulder and then subtracted out. The resulting peaks were quite asymmetric so that the position of the "half power" point was arbitrarily chosen to be measured. It was guessed that the position could be determined exact to within ± 10Å. The results were as follows:

Σ, X Peak Positions:

293 °K : 4.452 ± .008 ev

5 °K : 4.517 ± .008 ev

$dE/dT = -(2.26 \pm .56)\cdot 10^{-4}$ ev/°K

Shoulder "Half Peak Power" Positions:

293 °K : 4.893 ± .020 ev

5 °K : 4.963 ± .020 ev

$dE/dT = -(2.43 \pm 1.39)\cdot 10^{-4}$ ev/K°

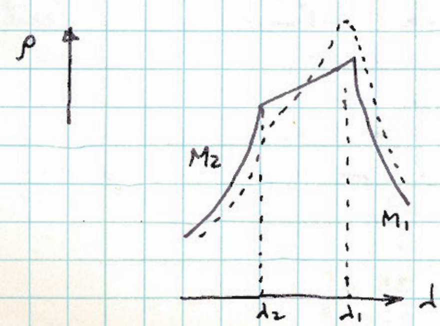
The two previously reported temperature coefficients for the Σ, X peak are those of Cardona and Somers $\{-(1.8 \pm .5)\cdot 10^{-4}\}$ and Jules and Schmidt $\{-(2.5 \pm .5)\cdot 10^{-4}\}$. I feel that mine is more accurate than either of these because of the R^4 sharpening and the much greater energy resolution.

With regard to an explanation of the origin of the shoulder, the picture is still unclear. A theoretical discussion of the structure in the joint density of states for bands 4-5 and bands 4-6 is contained in Beusts paper on band structure of Ge and Si in PR 134, A1337, {B(64)}. It seems to me that there are two possible explanations of this shoulder:

(1) The finite energy difference between the following two 4-5 transitions:

Singularity Type	Transition	Theoretical Energy
M_1 (100)	$X_4 - X_1$	3.6 ev
M_2 $(\frac{3}{3}\frac{2}{3}0)$	$\Sigma_4 - \Sigma_1$	3.8 ev

A possible way in which these two singularities could combine to give the observed structure is sketched below:



However, the theoretical separation for Ge is about .2ev while the observed difference between the peak and the shoulder is:

293 °K : .441 ± .028 ev

5 °K : .446 ± .028 ev

This is more than twice the theoretical prediction, although it is unknown at this time whether or not the resolution (not absolute values) of the theoretical calculation is sufficient to decide this assignment negatively. Also, if a transition occurs at a different symmetry point than another transition, one might expect, although not necessarily so, that the temperature coefficients might be different. Here we see that this is probably not the case.

(2) In the III-V compounds the conduction band degeneracy at X is removed and one observes a secondary peak neak the Σ, X peak. Although in germanium (the above splitting is observed by Greenaway, PRL 9, 97) there is no splitting, there could possibly be a 4-6 transition from $\Delta_5 - \Delta_2'$ a short distance away from X_1 which would be analogous to the III-V's. In the III-V's the energy separation between $X_5 - X_1$ and $X_5 - X_3$ is about .4 ev, the amount observed here. The principle difficulty with this interpretation is that Brust gives no evidence of a critical point in the 4-6 transitions that could be assigned to $\Delta_5 - \Delta_2'$. However, the closeness of the two temperature coefficients would tend to substantiate this interpretation.

It would be interesting to follow this work up with a similar measurement on GaSb or InAs to see if this shoulder exists independently of $X_5 - X_3$. If so, this may favor interpretation (1) above, and, if not, favour interpretation (2).

There may be a reason for the frequency-dependent nature of the PU and PB positions as noted on log page 122 which is based on the refractive effect of the PM window. From Snell's law:

$$\sin \theta_r = \frac{1}{n_Q} \sin \theta_i$$

where θ_r = angle of refraction, θ_i for incidence and n_Q the refractive index of the PM quartz window. Consider:

θ_i	n_Q	λ	θ_r
45°	1.461	5300 Å	28.9°
45°	1.477	3500 Å	28.6°
45°	1.495	2800 Å	28.2°

We see that as $\lambda \downarrow$, $\theta_r \downarrow$ so that in the PU position I_0 and I_R become more nearly overlaped as λ decreases, while in PB position θ_i is so small that the effect of quartz dispersion does not effect the degree of I_0 and I_R overlap. This could be why PU and PB give different results at 5300 Å but the same at 3500 Å and 2800 Å. Still, the variation in θ_r in PU above may still be too small to explain the whole effect.

During this time we also recieved a preprint of a paper by Jan Tauc on the Optical Properties of Non-Crystalline semiconductors in which he studies the optical properties of amorphous Ge deposited on fused quartz at room temperature and at vacuums of around 10^{-5} torr. Also, he deposited a film with the substrate heated to around 450°C which was apparently polycrystalline. Several results are of importance to me:

(1) Tauc interprets the reduction in reflectivity in the UV region of the polycrystalline film as due to scattering from a rough surface obeying a λ^4 law.

(2) In the far-UV region, the reflectivity of the amorphous Ge and crystalline Ge is nearly identical which indicates that the amorphous Ge has a smooth surface as in this region the reflectivity is governed by plasma effects in the valence band which is not changed very much on the transition from the crystalline to amorphous states.

(3) As I have observed faint DS rings in amorphous Ge reflection electron diffraction patterns, it may be interesting in the future to make Ge films on cold substrates in order to further reduce long-range order and then study the optical effects.

(4) In Tauc's polycrystalline film, it is very hard to tell whether or not there is observed the distortion of the λ fine structure observed by Donovan and now by me.

(5) It is intended to send Tauc a summary of all my film work in the very near future.

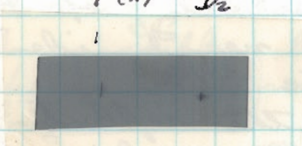
 23 JULY - 27 September 1964

3500 Å Discrepancy

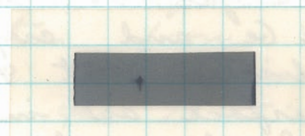
The activity during this period centered around perfecting and understanding measurement techniques for reflectivity experiments using the present design of reflectometer.

One of the first investigations made involved the reflectivity discrepancy for certain films when the source lamps were changed at 3500 Å. This investigation was made using X-ray film cut to the proper size and placed near the sample position and also in front of the PM window.

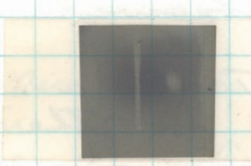
T(W) D_2



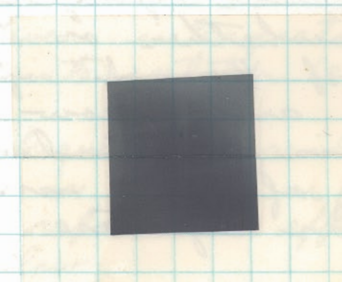
approximately at sample position, $\lambda = 3500$ Å, each taken separately



Both W and D_2 superposed



PM window position, both W and D_2 superposed



$\lambda = 3500$ Å, W lamp, I_0 and I_R superposed at PM window.

This study indicated that the D_2 lamp provides a point, not line, source and that there was a small vertical offset in its image with respect to the line image of the W source. This was also shown by the fact that the reflectivity discrepancy was adversely affected by closing down the slit height and favorably affected by increasing the slit height. No effect was noted by changing the slit width.

When the D₂ lamp elevation was situated properly by closing down the slit height to a minimum and positioning the lamp until maximum output was obtained, the reflectivity discrepancy disappeared almost entirely. In general, the results of this study have shown that this discrepancy was a geometrical one all along and not something else, like scattered light.

<u>Allignment Procedure</u>

During this period, an allignment procedure was evolved which gives reasonable, reproducible results on our standard MacLeod 2. The steps involved are as follows:

(a) Center the sample between the two diagonal mirrors with the use of a scale. The mean distance between the two mirrors is 3/4" so that the sample surface to reflectivity diagonal mirror is 3/8".

(b) Pick out the most likely spot on the sample surface and position the sample so that the beam strikes it there.

(c) The PM face is covered with a piece of white pasteboard with a round hole cut in it for the PM window. Position the diagonal mirrors so that both the I_0 and I_R beams are superposed. Adjust vertical alignment so that superposition takes place by turning the "flat" leg on the kinematical mount.

(d) If desired, make final adjustment by using high light intensity and low PM voltage to electronically aid in the allignment of the diagonal mirrors. Allign for maximum output for both I_0 and I_R.

(e) Scan the sample surface over a small area by using the x-y micrometer screws until optimum reflectivity at a particular wavelength is obtained. Sometimes, for rough samples, this should be done twice, once in the visible and once in the UV.

This method appears to give reasonable reproducible results with MacLeod 2 as long as one is careful to HF etch, wash, and position carefully, as can be seen below:

Date	Preparation	R: 5300 Å	3500 Å	2800 Å
8/31	None	51.8	47.1	64.6
8/31	HF & Wash	50.8	49.9	70.9
9/2	None	52.0	50.5	68.0
9/17	None	50.3	47.5	65.6
9/18	HF & Wash	52.5	49.9	70.4

See also 17 AUG 1 & 2 for scan reproducibility; they are nearly equal to 12 FEB 1 & 2.

Summary of Optical Measurements : 7/23 - 9/27

Run No.	Sample No	Measurement	Time Const	PM Voltage	Optics	Range	Scan
17 AUG 1	MacLeod 2	R	3	1260 V	100-5 PB-FM	6000-3500	125
17 AUG 2				2000 V		4000-2000	
18 AUG 1	CH-274			1340 V		6000-3500	
18 AUG 2				2170 V		4000-2000	
1 SEPT 1	CH-261			1260 V		6000-3500	
1 SEPT 2				2000 V		4000-2000	
2 SEPT 1	CH-261			1240 V		6000-3500	
2 SEPT 2				1980 V		4000-2000	
3 SEPT 1	CH-274			1250 V		6000-3500	
3 SEPT 2				2040 V		4000-2000	
15 SEPT 1	CH-272			1250 V		6000-3500	
15 SEPT 2				2000 V		4000-2000	
16 SEPT 1	5/21/64 Ge#1 (CaF_2)			1250 V		6000-3500	
16 SEPT 2				1990 V		4000-2000	
17 SEPT 1		T		1250 V		6000-3500	
17 SEPT 2			2	1990 V		4000-2000	
18 SEPT 1	5/18/64 Ge#2 (CaF_2)	R	3	1250 V		6000-3500	
18 SEPT 2				2000 V		4000-2000	

PM Trouble

Some trouble has developed with the 6256B PM in that at high light levels and low voltages, the PM gives a strongly non-linear response. This is probably due to a gassy situation resulting from (maybe) excessive anode current. However, it appears that at normal operating conditions the non-linearity is negligible, as measured using transmission screens:

Nominal	Measured (3500Å) W	Measured (3500Å) D_2
33.1	33.4	33.7
47.9	48.0	48.5

Slits = 100μ @ 5mm
Voltage = 1850V

Also, the tube now appears to be about twice as noisy as MacElroy's.

Roughness of 6/10/64 Ge#1 (FQ)

λ(μ)	R_F	$R_B - R_F$	R_B	$(R_B - R_F)/R_B$
.60	.458	.064	.522	.123
.55	.472	.053	.525	.101
.50	.445	.057	.502	.114
.45	.412	.056	.468	.120
.40	.395	.072	.467	.154
.35	.406	.094	.500	.188
.30	.434	.152	.586	.259
.25	.411	.261	.672	.388
.20	.356	.255	.611	.417

I_o Drift Correction

Let $(I_o)_i$ be measured at t_i and $(I_o)_f$ at t_f, all at the same wavelength. With drift, we have:

$$(I_o)_f = (1-D)(I_o)_i ,$$

D being the drift fraction. Assuming the drift to be linear with time, the drift rate is:

$$D_r = \frac{D}{t_f - t_i}$$

We assume that D_r is the same for all wavelengths of I_o. The question is, then, if we know D_r and have measured I_o and I, how do we apply a correction to the quotient I/I_o in order to accomadate the drift rate?

Each point in the "true" I_o, that is, the I_o that is actually occuring while I is being measured, will be different from the "measured" I_o by the relation:

$$I_{o\,true} = (1 - D_r T)\, I_{o\,measured}$$

where T is the time interval between equal wavelengths in I and $I_{o\,measured}$ and is constant and very nearly equal to the time of one scan when I_o and I are run consecutively. Hence the true ratio is given by:

$$R = \frac{I}{(1 - D_r T)\, I_o}$$

where I_o is understood to be the "measured" quantity. If we define the correction factor, C_f, to be:

$$C_f \equiv 1 - D_r T$$

or

$$C_f = 1 - D \frac{T}{t_f - t_i}$$

For a scan rate of 125 Å/min, $T = 20$ minutes for a 6000 Å – 3500 Å scan and $T = 16$ minutes for 4000 Å – 2000 Å.

For the visible scan range, the I_o drift is checked at 5300 Å. This means that:

$$t_f - t_i = 34.4 \text{ min}$$

For the UV region: $t_f - t_i = 28.95$ min

Hence:

$$C_f^{VIS} = 1 - .581\, D$$
$$C_f^{UV} = 1 - .553\, D$$

Films from Catlin

On July 31st, I recieved 3 Ge films on CaF_2 from Humphris of the University of Virginia Materials Science Group. These films have the following parameters:

	CH-274	CH-261	CH-272
Substrate Temperature	300 °C	350 °C	300 °C
Film Thickness	1200±100 Å	1200±100 Å	540±40 Å
Deposition Rate	400 Å/m	70 Å/m	320 Å/m

Generally, the results on these films indicate little Λ structure and a Σ, X amplitude no better than my films. There seems to be no terrible distinction between different film as regards structure dependence on film parameters, although the Σ, X amplitude was the lowest for the thinnest film.

Other Matters

I have made measurements on some of my old epitaxial Ge on CaF_2 films with the view toward eventually calculating optical constants, using much more careful alignment than previously.

I also discussed my memo on the fused quartz project, the Σ, X investigation, and the CaF_2 report. It seemed to be the general concensus that I continue on to calculate optical constants. (Note 10/2) I am also going to try an effort on etched Ge substrates in order to see whether or not I can make an epitaxial film whose reflectivity will match that of the substrate.

9 MAY 1965

Today, two years to the day since this log was started, on my thirtieth birthday, I finished the first draft of my thesis.

PURPOSE *Reflectivity of Ge: PDE (62)*
DATE *9/21/63* PAGE LOG BOOK *39* SPECTRUM # *2*
SAMPLE: MATERIAL *Ge* CODE *PDE (62)*
ORIENTATION *<111>* TEMP *RT*
THICKNESS ____ PREPARATION ____
STRESS: TYPE *—* MAGNITUDE ____ DIRECTION ____
SOURCE: TYPE *W lamp* STRENGTH *6 v*
MONOCHROMATOR: GRATING *30000* RANGE *6500-3500 Å*
SCAN RATE *250* SLIT WIDTH *100-5*
DETECTOR: TYPE *6256 B* TEMP *RT*
SETTING *1070 v*
POLARIZATION *—* FILTER ____
ELECTRONICS: PRE-AMP *Regular*
PSD *"*
TIME CONSTANT *3*
RECORDER: ____ A ____ B ____ C ____
SETTINGS ____
SPEED ____
REMARKS *(x, y, z) = 4.18, 6.08, 5.00*
OPERATOR *PMG*

21 Sept 2

PURPOSE *Reflectivity of Ge: PDE (62)*
DATE *9/21/63* PAGE LOG BOOK *39* SPECTRUM # *3*
SAMPLE: MATERIAL *Ge* CODE *PDE (62)*
ORIENTATION *<111>* TEMP *RT*
THICKNESS ____ PREPARATION ____
STRESS: TYPE *—* MAGNITUDE ____ DIRECTION ____
SOURCE: TYPE *D₂ lamp* STRENGTH *low (ccw)*
MONOCHROMATOR: GRATING *30000* RANGE *3500-2000 Å*
SCAN RATE *250* SLIT WIDTH *100-5*
DETECTOR: TYPE *6256B* TEMP *RT*
SETTING *1620 v*
POLARIZATION *—* FILTER *—*
ELECTRONICS: PRE-AMP *Regular*
PSD *"*
TIME CONSTANT *3*
RECORDER: ____ A ____ B ____ C ____
SETTINGS ____
SPEED ____
REMARKS *(x, y, z) = 4.18, 6.08, 5.00*
OPERATOR *PMG*

21 Sept 3

23 September 1963

Born today: One child, female, ~4 kg, ~50 cm, labelled Deborah Jean.

Today I am trying to make a reflectance run on sample Ge: MacLeod which was polished with as high degree of care as DM could muster.

PURPOSE: Reflectivity of Ge: MacLeod

DATE: 9/23/63 PAGE LOG BOOK: 40 SPECTRUM #: 1

SAMPLE: MATERIAL: Polished Ge CODE:

ORIENTATION: <111> TEMP: RT

THICKNESS: PREPARATION: Polish

STRESS: TYPE: — MAGNITUDE: DIRECTION:

SOURCE: TYPE: O_2 lamp STRENGTH: low

MONOCHROMATOR: GRATING: 30000 RANGE: 3500–2000 Å

SCAN RATE: 250 SLIT WIDTH: 100–5

DETECTOR: TYPE: 6256B TEMP: RT

SETTING: 1610 V

POLARIZATION: — FILTER: —

ELECTRONICS: PRE-AMP: Regular

PSD: "

TIME CONSTANT: 3

RECORDER: A B C

SETTINGS:

SPEED:

REMARKS: (x, y, z) = 4.18, 6.08, 5.00

OPERATOR: BMG

23 Sept 1

The finishing procedure followed by DM is as follows:

(1) Rough lap with Buehler #1200
(2) Fine lap with 3μ Al_2O_3
(3) Polished with Linde "A" on beeswax
(4) Final polish with Linde "B" on beeswax

It is hoped that this produced a highly reflecting flat surface with minimum damage and defect.

PURPOSE	Reflectivity of Ge: mac Loed
DATE	9/23/63
PAGE LOG BOOK	41
SPECTRUM #	2
SAMPLE: MATERIAL	Polished Ge
CODE	
ORIENTATION	<111>
TEMP	RT
THICKNESS	
PREPARATION	
STRESS: TYPE	—
MAGNITUDE	
DIRECTION	
SOURCE: TYPE	W lamp
STRENGTH	6 v
MONOCHROMATOR: GRATING	30000
RANGE	6500–3500 Å
SCAN RATE	250
SLIT WIDTH	100–5
DETECTOR: TYPE	6256B
TEMP	RT
SETTING	1070 v
POLARIZATION	—
FILTER	—
ELECTRONICS: PRE-AMP	Regular
PSD	"
TIME CONSTANT	3
RECORDER:	A B C
SETTINGS	
SPEED	
REMARKS	(x, y, z) = 4.18, 6.08, 5.00
OPERATOR	BMG

23 Sept 2

<u>24 September 1963</u>

Spent today processing the data of 21 Sept.

<u>25 September 1963</u>

Today I processed the data of 23 Sept. Also, tonight I installed the shutter in the system that is to block out I_R and I_T when needed. I made a measurement of the ratio of scattered light to incident light for the shutter in its two positions, using an aluminized mirror as a sample. The results are:

Shutter blocking I_0 ; $I_S/I_0 = 1.8 \cdot 10^{-4}$

Shutter blocking I_R ; $I_S/I_R = 1.15 \cdot 10^{-4}$

The situation is more serious in the I_R blocking position than in the I_0 blocking position as in the latter I_R will be incident on the PM and $I_S \ll I_R$ should be true at all times. However, in the former case, I_T is incident on the PM and there may be situations where $I_S \sim I_T$. We shall have to watch for these situations.

26 September 1963

Let us consider the consequences of the difference in linear thermal expansion coefficients of Ge and CaF_2. If we assume that the bulk of the CaF_2 substrate is so great that the Ge film does not stress it at all and that the expansion and contraction of the Ge film is governed by the CaF_2 substrate, and that the film-substrate system is unstressed when the film is being formed, we arrive at the following equations:

$$\Delta l_{CaF_2} = \Delta l_{Ge}$$

$$\Delta l_{CaF_2} = l\, \alpha_{CaF_2}\, \Delta T$$

$$\Delta l_{Ge} = l\, \alpha_{Ge}\, \Delta T - l\, F\, S_{11}$$

$$F = \frac{(\alpha_{Ge} - \alpha_{CaF_2})\,\Delta T}{S_{11}}$$

Here we use S_{11} without regard to crystal orientation.

Taking:

$\alpha_{Ge} = 5.75 \cdot 10^{-6}$ (300°K, TDC)
$\alpha_{CaF_2} = 19.5 \cdot 10^{-6}$ (CRC)
$\Delta T = -550°C$
$S_{11} = .98 \cdot 10^{-12}$ $cm^2/dyne$ (TDC)

Then:

$$F = 77 \cdot 10^{8}\ dyne/cm^2 = 7700\ atm.$$

Now, according to PDE (62), a uniaxial stress of about 4100 atm causes a shift (in compression) in the principal L reflectivity peak from about 5890 Å to about 5854 Å.

This is obviously a topic for investigation on the films and we shall begin to look for this by examining film 4 which appears to be a rather thick film.

PURPOSE Overall R and T of Film 4
DATE 9/26/63 PAGE LOG BOOK 43 SPECTRUM # 1
SAMPLE: MATERIAL Film 4 CODE Film log 45
ORIENTATION ______ TEMP ______
THICKNESS ______ PREPARATION ______
STRESS: TYPE — MAGNITUDE ______ DIRECTION ______
SOURCE: TYPE W lamp STRENGTH 6V
MONOCHROMATOR: GRATING 30000 RANGE 6500-3500Å
SCAN RATE 250 SLIT WIDTH 100-5
DETECTOR: TYPE 6256B TEMP RT
SETTING 1080 V
POLARIZATION — FILTER —
ELECTRONICS: PRE-AMP Regular
PSD "
TIME CONSTANT 3
RECORDER: ______ A ______ B ______ C ______
SETTINGS ______
SPEED ______
REMARKS (x, y, z) = 3.81, 6.08, 5.00
OPERATOR PMG

26 Sept 1

27 September 1963

The reflectivity of Film 4 seemed to be too low for its apparent thickness so I checked the adjustment of the diagonal mirrors and found them to be OK so apparently this is not an artifact.

Also, the transmission in the vicinity of 5000Å - 6000Å seems to be oddly shaped and not at all like results given by calculation using bulk optical constants. The edge due to the 5900Å transition seems to be very sharp and goes much deeper than one would expect. It is interesting to speculate whether or not this is due to an exciton at the first L transition. Such a possibility has been suggested by Fox but it is hard to see this because of the short hole lifetime at this point in the Brillouin zone. Observations should be made on this film some time at low temperatures in order to see if this structure sharpens or is merely an artifact.

28 September 1963

Today I want to complete at least the run on one side of Film 4.

PURPOSE	Overall R and T of Film 4
DATE	9/28/63
PAGE LOG BOOK	44
SPECTRUM #	1
SAMPLE: MATERIAL	Film 4
CODE	Film log 45
ORIENTATION	
TEMP	
THICKNESS	
PREPARATION	
STRESS: TYPE	—
MAGNITUDE	
DIRECTION	
SOURCE: TYPE	W lamp
STRENGTH	6V
MONOCHROMATOR: GRATING	30000
RANGE	6500-3500 Å
SCAN RATE	250
SLIT WIDTH	100-5
DETECTOR: TYPE	6256B
TEMP	RT
SETTING	1070 V
POLARIZATION	—
FILTER	—
ELECTRONICS: PRE-AMP	Regular
PSD	"
TIME CONSTANT	3
RECORDER:	
A	
B	
C	
SETTINGS	
SPEED	
REMARKS	(x, y, z) = 3.81, 6.08, 5.00
OPERATOR	PMG

28 Sept 1

The purpose of 28 Sept 1 was to check reproducibility by comparing with 26 Sept 1. The I_0 seemed to wander quite badly during this run.

The purpose of 28 Sept 2 was to examine the L transition in transmission and reflection. In all, 5 scans were made in the following order:

(1) I_0
(2) I_T
(3) I_0
(4) I_R
(5) I_0

The third I_0 (3) will be used as the final I_0 for transmission and the initial I_0 for reflection.

28 Sept 3 is an overall scan of the UV for film 4.

PURPOSE Examination of L Transition: Film 4
DATE 9/28/63 PAGE LOG BOOK 45 SPECTRUM # 2
SAMPLE: MATERIAL Film 4 CODE FL 45
ORIENTATION TEMP
THICKNESS PREPARATION
STRESS: TYPE — MAGNITUDE DIRECTION
SOURCE: TYPE 3W lamp STRENGTH 6V
MONOCHROMATOR: GRATING 30000 RANGE 6100 - 5100
SCAN RATE 125 SLIT WIDTH 100-5
DETECTOR: TYPE 6256B TEMP RT
SETTING 1070 V
POLARIZATION — FILTER —
ELECTRONICS: PRE-AMP Regular
PSD "
TIME CONSTANT 3
RECORDER: A B C
SETTINGS
SPEED
REMARKS (x, y, z) = 3.81, 6.08, 5.00
OPERATOR PMG

28 Sept 2

PURPOSE R and T of Film 4
DATE 9/28/63 PAGE LOG BOOK 45 SPECTRUM # 3
SAMPLE: MATERIAL Film 4 CODE FL 45
ORIENTATION TEMP
THICKNESS PREPARATION
STRESS: TYPE — MAGNITUDE DIRECTION
SOURCE: TYPE D2 lamp STRENGTH Low
MONOCHROMATOR: GRATING 30000 RANGE 3500 - 2000Å
SCAN RATE 250 SLIT WIDTH 100-5
DETECTOR: TYPE 6256B TEMP RT
SETTING 1630 V
POLARIZATION — FILTER —
ELECTRONICS: PRE-AMP Regular
PSD "
TIME CONSTANT 3
RECORDER: A B C
SETTINGS
SPEED
REMARKS (x, y, z) = 3.18, 6.08, 5.00
OPERATOR PMG

28 Sept 3

30 September 1963

Yesterday (Sunday) I prepared the data of 28 Sept. Today I made the first run on the reverse side of the film. This is 30 Sept 1, in the UV range.

A cursory review of todays results and those of 28 Sept reveals a very poorly developed X transition. This is as yet unexplained.

PURPOSE Reverse R and T of Film 4

DATE 9/30/63 PAGE LOG BOOK 46 SPECTRUM # 1

SAMPLE: MATERIAL Film 4 CODE FL 45

ORIENTATION ____ TEMP ____

THICKNESS ____ PREPARATION ____

STRESS: TYPE — MAGNITUDE ____ DIRECTION ____

SOURCE: TYPE D_2 lamp STRENGTH Low

MONOCHROMATOR: GRATING 30000 RANGE 3500-2000 Å

SCAN RATE 250 SLIT WIDTH 100-5

DETECTOR: TYPE 6256B TEMP RT

SETTING 1630 v

POLARIZATION — FILTER —

ELECTRONICS: PRE-AMP Regular

PSD "

TIME CONSTANT 3

RECORDER: ____ A ____ B ____ C ____

SETTINGS ____

SPEED ____

REMARKS (x, y, z) = 3.18, 6.08, 5.00

OPERATOR PMG

30 Sept 1

1 October 1963

Today I ran the 6500-3500 run on the reverse side of film 4. The results to date are beginning to indicate that more range is needed on the amplifier gain control, say, steps of two instead of ten. Also, I began giving some thought to the problem of a mount for the Iodine Quartz Lamp.

23 September 1963

Born today: One child, female, ~4 kg, ~50 cm, labelled Deborah Jean.

Today I am trying to make a reflectance run on sample Ge: MacLeod which was polished with as high degree of care as DM could muster.

PURPOSE	Reflectivity of Ge: MacLeod
DATE	9/23/63
PAGE LOG BOOK	40
SPECTRUM #	1
SAMPLE: MATERIAL	Polished Ge
CODE	
ORIENTATION	<111>
TEMP	RT
THICKNESS	
PREPARATION	Polish
STRESS: TYPE	—
MAGNITUDE	
DIRECTION	
SOURCE: TYPE	O_2 lamp
STRENGTH	low
MONOCHROMATOR: GRATING	30000
RANGE	3500 - 2000 Å
SCAN RATE	250
SLIT WIDTH	100 - 5
DETECTOR: TYPE	6256B
TEMP	RT
SETTING	1610 V
POLARIZATION	—
FILTER	—
ELECTRONICS: PRE-AMP	Regular
PSD	"
TIME CONSTANT	3
RECORDER: A	
B	
C	
SETTINGS	
SPEED	
REMARKS	(x, y, z) = 4.18, 6.08, 5.00
OPERATOR	DMG

23 Sept 1

The finishing procedure followed by DM is as follows:

(1) Rough lap with Buehler #1200
(2) Fine lap with 3μ Al_2O_3
(3) Polished with Linde "A" on beeswax
(4) Final polish with Linde "B" on beeswax

It is hoped that this produced a highly reflecting flat surface with minimum damage and defect.

FROM 5/15/64 TO 6/11/64

SOURCE MATERIAL	SOURCE POWER	SOURCE - SUBSTRATE DISTANCE	VACUUM SYSTEM - PRESSURE	TIME OF RUN - THICKNESS	DEPOSITION RATE	OPTICAL REFLEC… CONFIGURATION	5300 Å	3…
IBM Ge	1300°C (54-5)	5.3"	NRC $<1 \cdot 10^{-5}$	8 min		PU-FS	42.5%	
	1300°C (54-5)			5 min		PU-FS	33.6%	
	(60-5)			5 min		PU-FS	37.0% 33.1%R	
	(55-5)			5 min		PU-FS	37.5% 33.9%R	
	(55-5)			10 min		PU-FS	39.6% 46.7%S	
	(55-5)			10 min		PU-FS	41.2%	
OLD MIT Ge	(55-5)			2 min		PU-FS	46.0%	41.6
	(55-5)			3 min		PU-FS	43.7% 44.8%S	
	(55-5)			30 s		PU-FS	43.2%	39.
	(50-5)			20 s (300 Å)	(15 Å/s, 900 Å/m)	PU-FS	52.7%	41.6
	(45-5)			60 s		PU-FS	35.4%	37.4
	(45-5)			5 min		PU-FS	42.2% 47.0%S	35.7
	(50-5)			60 s		PU-FS	42.6% 43.3%S	37.7
NEW LINCOLN Ge	(60-5)			11.5 s		PB-FM	42.7%	40.0
	(60-5)			11.5 s		PU-FM	40.8%	42.5
	(65-5)			13 s		PU-FM	37.3%	26.1
	(65-5)			30 s				
	(65-5)			1 min				
	(60-10)			47 s		PU-FM	39.8%	40.6
	(90-10)			25 s (ro) (10 s)		PU-FM	34.9%	36.6
	(49-10)			25 s (ro) (10 s)		PU-FM	44.1%	44.8
	(50-10)			14 s		PU-FM	44.5%	44.9
	(53-10)			20 s (ro)		PU-FM	45.5%	43.6
	(50-10)			15 s (?)		PU-FM	42.2%	38.4
	(50-10)	11"		18 s (?)		PU-FM	43.6% 35.3%R	40.1
						PB-FM	47.0%	40.6
	(50-10)			(?) 20 s		PU-FM	42.2% 31.6%R	42.6
						PB-FM	45.2%	48.8

PU = PM UP FS = FOCUS ON SAMPLE VR = VISIBLY ROUGH MR = MICROSCOPICALLY ROUGH P = …

PB = PM BACK FM = FOCUS ON MIRROR VS = VISIBLY SMOOTH MS = " SMOOTH

...ON Ge FILMS DEPOSITED ON FUZED QUARTZ AND CaF_2 SUBSTRATES FROM 7/1/6...
...US DEPOSITIONS ON CaF_2

...CE ...RATION	SOURCE MATERIAL	SOURCE POWER	SOURCE – SUBSTRATE DISTANCE	VACUUM SYSTEM – PRESSURE	TIME OF RUN – THICKNESS	DEPOSITION RATE	OPTICAL REFLE... CONFIGURATION	5300 Å
W(.005)	New Lincoln Ge .3204 g	(25-5)	10 5/8"	NRC $1\cdot10^{-6}$	121 s		NO MEASUREMENT	
		(25-5,6)		$<1\cdot10^{-6}$	121 s		PB-FM	50.2%
	.3242 g added	(25-5,6.2)		$5\cdot10^{-7}$	121 s		PB-FM	62.1%
		(25-5,6.3)		$8\cdot10^{-7}$	121 s		PB-FM	60.5%
		(25-5,6)		$8\cdot10^{-7}$	121 s		PB-FM	57.0%
W(.005)	New Lincoln Ge .3160 g	(18.5-5,5.2)		$8\cdot10^{-7}$	360 s		PU-FM	12.1%
		(30-5,6.6)		$8\cdot10^{-7}$	90 s		PB-FM	50.0%
	.3243 g added	(35-5)		$5\cdot10^{-7}$	14 s		PB-FM	48.1%
W(.005)	New Lincoln Ge .3204 g	(25-5,6.1)		$2\cdot10^{-6}$	92 s		PU-FM	45.4%
?	?	?		?	?		PB-FM	45.6%
...at	IBM Ge	1525 °C	15 cm	VEECO $<1\cdot10^{-5}$	10 min			
		1050-1110 °C			10 min			
...t		?			4 min		THIS FILM WAS ALUMINIZE...	
...t		1300 °C		NRC $<1\cdot10^{-5}$	5 min			
...at		1315 °C	13.5 cm		5 min			
...at		1040 °C			5 min			
...t	Rediker Ge	VAR45, 138, V1.7	7"	Little NRC $<1\cdot10^{-5}$	2 min			
...	Rediker Ge	VAR50, I136, V1.85	2 3/4"	Little NRC $<1\cdot10^{-5}$	62 sec			