NAME OF CONTRACTOR: Dr. Paul M. Raccah

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PRINCIPAL INVESTIGATOR: Paul M. Raccah

PHONE NUMBER: (312) 996-3400

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SIMPLE APPROXIMATION FOR EFFECT OF ALLOYING ON THE PHENOMENOLOGICAL LINEWIDTH Γ

Consider that $E_{cv}(\vec{k})$ is not a unique, sharply defined energy, but that for the absorption of a photon "locally", it depends on the local concentration c_{loc} averaged over a cluster of N atoms on the Hg-Cd sublattice.

$$E_{cv}^{loc}(\vec{k}) \approx E_{cv}^{loc}(\vec{k}_{cr}) + \frac{\hbar^2}{2\mu}(\vec{k} - \vec{k}_{cr})^2;$$

i.e., the dominant source of variation in $E_{cv}^{loc}(\vec{k})$ is the variation in the local critical point energy

$$E_0(c_{loc}) \equiv E_{cv}^{loc}(\vec{k}_{cr}).$$

Then, for $N >> 1$,

$$P(E_0) \approx (\sigma\sqrt{2\pi})^{-1} \exp\{-[E_0 - E_0(c)]^2/2\sigma^2\}$$

with $\sigma^2 = E_1\, c(1-c)/N$,

where $E(c_{loc}) \approx E(c) + (c_{loc} - c)\, E_1$.

This leads to a replacement of the lineshape

$$L(E,\vec{k},\Gamma_0) = -[E - E_{cv}(\vec{k}) + i\Gamma_0]^{-1}$$

by $\bar{L}(E,\vec{k},\Gamma_0) = -\int_{-\infty}^{\infty}\{E - E_{cv}(\vec{k}) - [E_0 - E_0(c)] + i\Gamma_0\}^{-1} P(E_0)\, dE_0$

The only simple analytic result is obtained by replacing the Gaussian probability $P(E_0)$ by a Lorentzian probability. If one does this and chooses the Lorentzian probability to have width

$$\Gamma^1 = \sqrt{2}\sigma,$$

which follows from an expansion of e^{-u^2} as $[1 + u^2 + \ldots]^{-1}$, one finds that Γ_0 is replaced by

$$\Gamma_m = \Gamma_0 + \sqrt{2}\sigma = \Gamma_0 + E_1\sqrt{2c(1-c)/N} + kT$$

This gives the following table:

$\Gamma-(\Gamma_0+kT)$	.04eV	.06eV	.08eV	.10eV
N	200	88	50	32

A better numerical approximation leads to values of N approx 40% larger.

PHYSICAL MEANING OF ΔE_1 and $\Delta\sigma^2$

$$\Delta E_1 = \Delta E_{cb} - \Delta E_{vb}$$

$\Delta E_1 > 0$ means $\Delta E_{cb} > \Delta E_{vb}$

$\Delta E_1 = 0$ means $\Delta E_{cb} = \Delta E_{vb}$

$\Delta E_1 < 0$ means $\Delta E_{cb} < \Delta E_{vb}$

TWO CAUSES FOR THE CONTRIBUTION

a - Piezoelectric effect in non-centrosymmetric materials.

b - Breakdown of symmetry induced by overlapping structural defects.

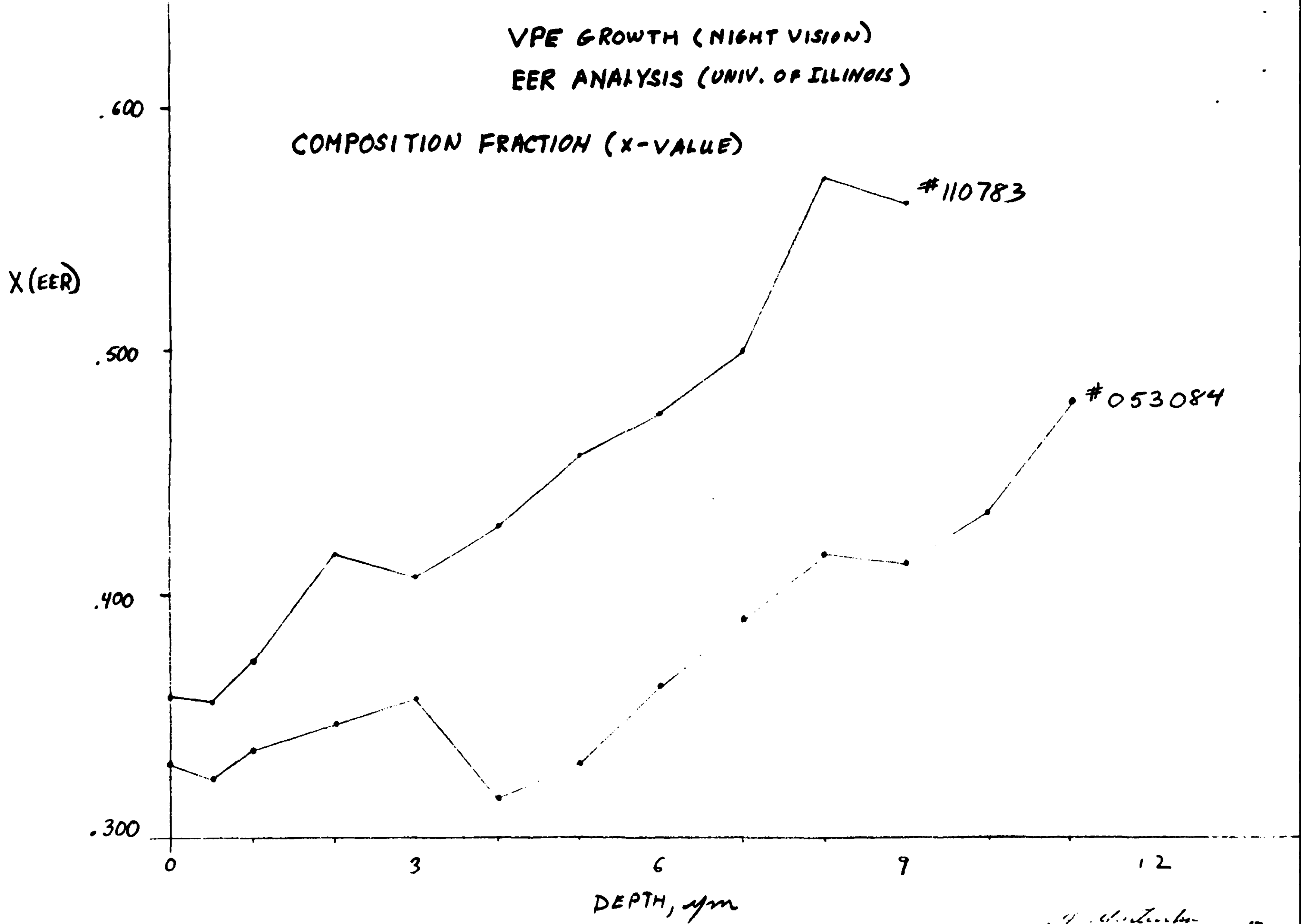
$\Delta\sigma^2$ is proportional to the density of polarizable defects is in first approximation related linearly to ΔE_1

ELECTROLYTE ELECTROREFLECTANCE ANALYSIS
OF VARIOUS VAPOR PHASE EPITAXIAL GROWTHS
FROM NIGTH VISION.

GROWTH FACES- BOTH A AND B (111)
GROWTH SUBSTRATES-CDTE AND CDZNTE

NVL SAMPLES (DATA SUMMARY)

		#053084	#40284	#110783
SUBSTRATE :		CDZNTE (4.5%)	CDTE	CDTE
		<111>B	<111>B	<111>A
GROWTH :		CSVPE	CSVPE	CSVPE
SOURCE :	TYPE	HGTE SINTERED	HGTE SOLID (4th USE)	HGTE PIECES
	COMP.	HGTE + 10% TE	47/53	1/1
	wt.	35 gm	50 gm	20 gm
TEMP :		540 °C	540 °C	545 °C
TIME :		65 min.	55 min.	70 min.
ENVIRON. :		800 PSI, H_2	690 PSI, H_2	1100 PSI, H_2
EST. THICKNESS :		14 μm	12 μm	10.4 μm


VPE GROWTH (NIGHT VISION)
EER ANALYSIS (UNIV. OF ILLINOIS)
COMPOSITION FRACTION (X-VALUE)
X (EER)
.600
.500
.400
.300
0
3
6
9
12
DEPTH, μm
#110783
#053084

UNIV. OF ILLINOIS DATA

SAMPLE #110783

Etch Depth in Microns	C	ΔE_1	$\Delta\sigma^2$	θ	E_1	Γ	x
0	4.050	1.520	-2.090	4.817	2.431	.120	.358
.5	2.386	-0.974	-3.664	4.646	2.430	.129	.356
1	3.927	.947	-2.279	5.029	2.449	.148	.374
2	1.621	26.801	.941	6.071	2.497	.110	.417
3	1.430	10.810	4.423	6.901	2.486	.121	.407
4	1.706	-1.217	-3.178	4.901	2.509	.136	.428
5	1.070	26.770	-1.890	5.706	2.542	.113	.457
6	1.272	26.995	-1.679	5.737	2.563	.144	.474
7	1.036	10.217	1.050	6.467	2.595	.114	.500
8	3.859	-5.941	3.295	1.877	2.684	.227	.570
9	8.320	1.804	1.085	6.975	2.672	.204	.560

SAMPLE #053084

Etch Depth in Microns	C	ΔE_1	$\Delta\sigma^2$	θ	E_1	Γ	x
0	1.973	-65.548	4.571	5.624	2.404	.095	.331
.5	2.330	-5.796	3.449	4.771	2.397	.111	.324
1	1.788	-14.889	3.810	5.065	2.409	.104	.336
2	4.468	-3.100	1.256	4.585	2.420	.132	.347
3	2.004	-3.394	2.384	4.676	2.430	.116	.357
4	-.561	68.486	-5.404	5.496	2.389	.091	.316
5	-.521	39.402	-11.528	5.110	2.405	.096	.332
6	.633	-31.714	9.116	5.135	2.437	.097	.363
7	2.954	-2.548	2.149	4.640	2.468	.126	.391
8	1.638	-7.286	3.090	4.946	2.496	.116	.417
9	-1.070	18.478	-3.713	5.314	2.491	.111	.412
10	-.290	109.621	-4.101	5.642	2.515	.070	.434
11	-.248	67.353	-9.137	5.355	2.569	.103	.478

SAMPLE # 40284

HAD NO SIGNAL

COMPARISON OF REFLECTANCE (@NIGHT VISION) AND ELECTROREFLECTANCE (@UNIVERSITY OF ILLINOIS) ANALYSIS OF VAPOR PHASE EPITAXIAL GROWTHS FROM NIGHT VISION.

GROWTH FACES- BOTH A AND B (111)
GROWTH SUBSTRATES-CDTE AND CDZNTE

SEE ATTACHED FOR EER RESULTS DMK ILL

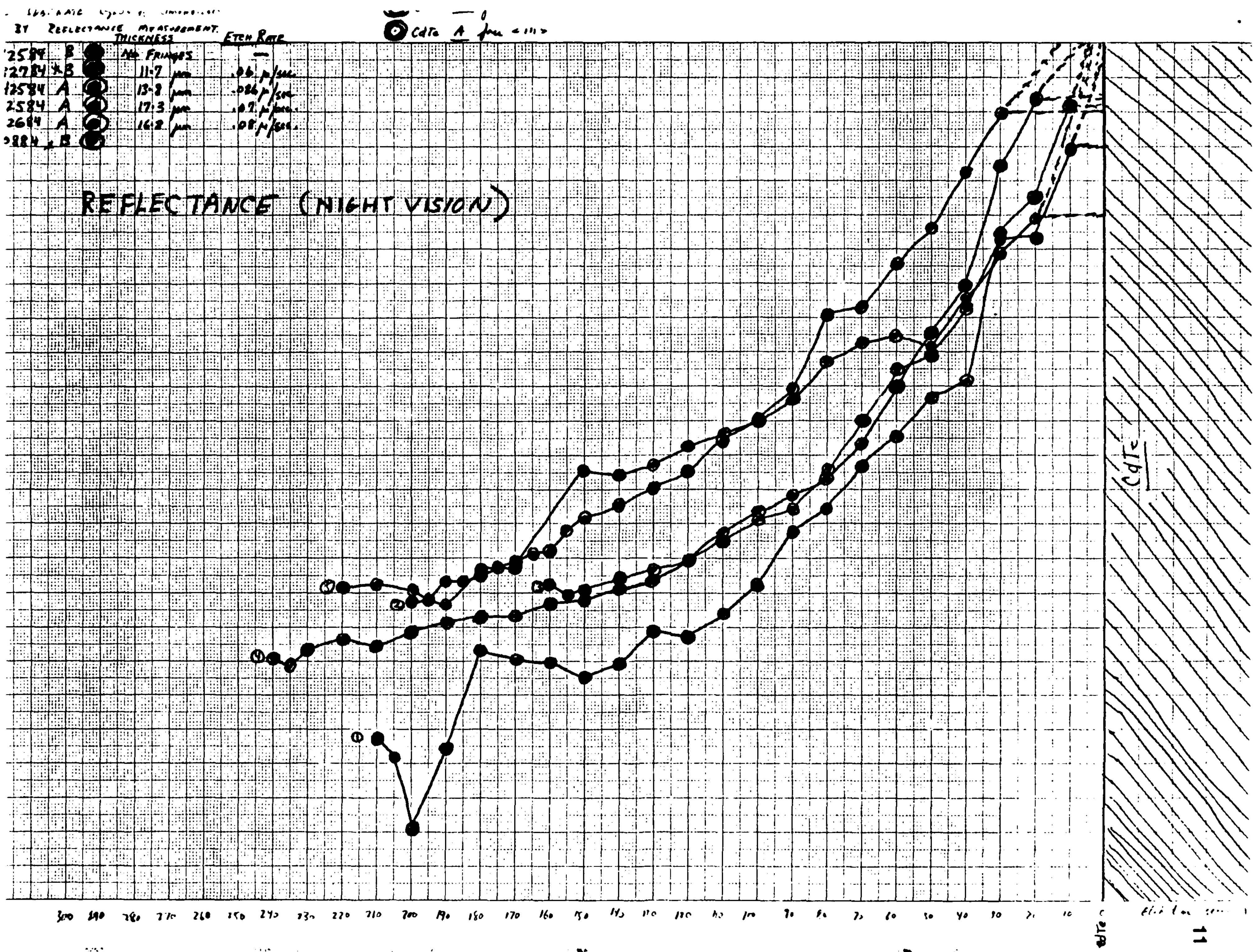
SURFACE x, Thickness (µm) COMPARISON BETWEEN EER AND REFLECTANCE SAMPLES.

BEGIN 13 Dec. 1984

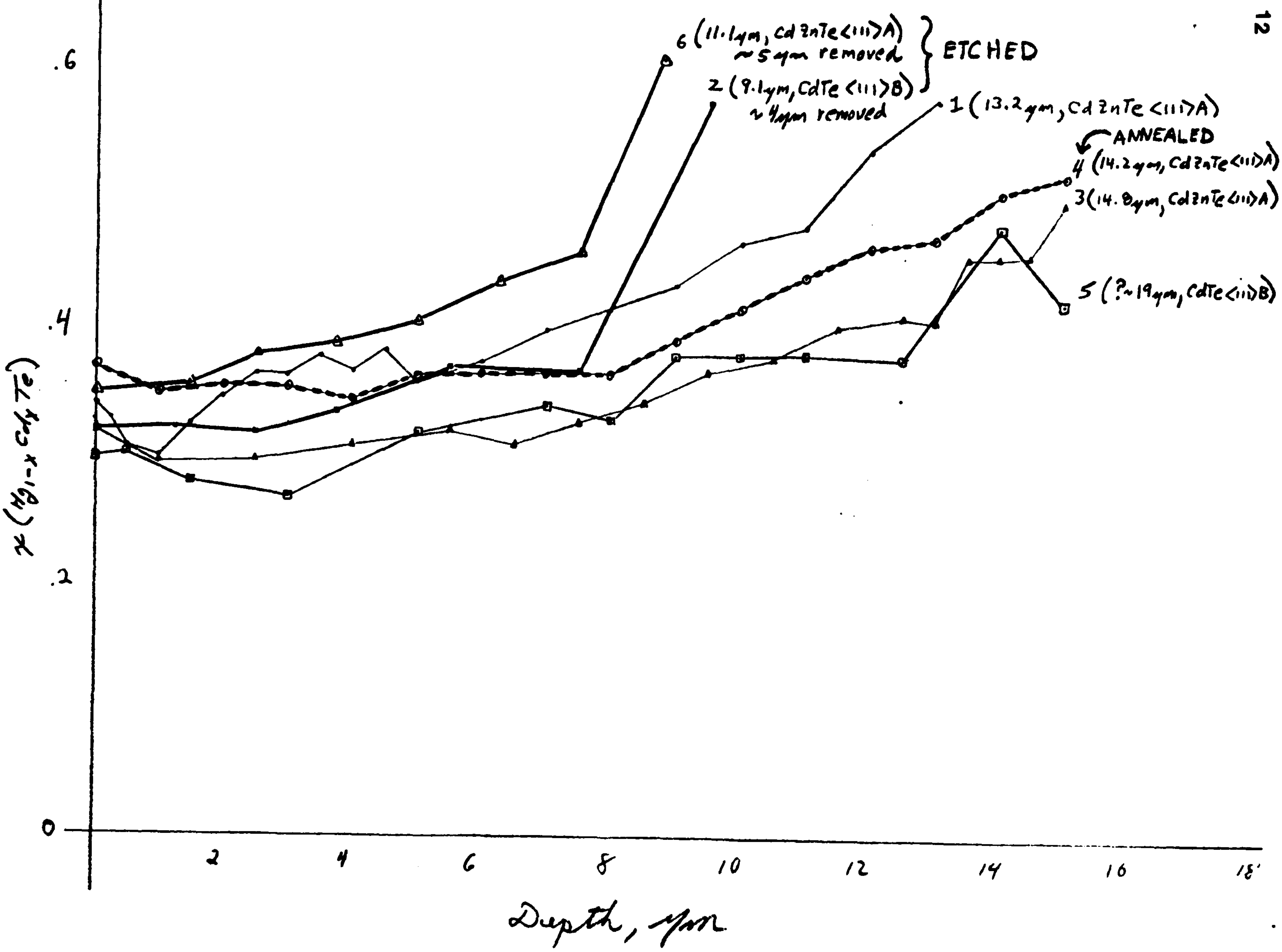
NVL DATA

	NVL-VPE		by reflectance EER Sample		Reanalysis preliminary by EER	Reflectance Sample		Charge Transfer Device Team Data Thickness	Δx	Δt (µm)	
1	101884	VERY Good Fringes (CdZnTe <111 A>)	.295	13.2	.335	.286	14.1	(12.5 µm)	.009	.9	(.7)
2	032784	Good Fringes (CdTe <111 B>)	.294	9.1	~~.300~~ .315	.275	10.8	(12 µm)	.019	1.7	(1.2)
3	052984	VERY Good Fringes (CdZnTe <111 A>)	.284	14.8	.316	.283	12.6	(13 µm)	.001	2.2	(.4)
4	102384	Good Fringes (CdZnTe <111 A>)	.345, .339	14.2	~~.345~~ .365	.282	16.6	(15 µm)	.057	2.4	(.8)
5	020884	Poor Fringes (CdTe <111 B>)	.298	NO * FRINGES	.294	.300	16.3	(19 µm)	.002	–	(2.7)*
6	102484	Poor Fringes (CdZnTe <111 A>)	.334, .337	11.1	.350	.272	12.0	(11 µm)	.042	.9	(.1)

	102484 6	020884 5	102384 4	052984 3	032784 2	101884 1	Comments
Melt Type	Sintered HgTe Powder 3rd use	HgTe	Sintered HgTe Powder	Sintered HgTe Powder + 10% Te by weight	HgTe	Sintered HgTe Powder 1st use	
Temp.	555 °C	540°	545°	540°	540°	550°	
Time	45 min	90 min	50 min	70 min	60 min	55 min	
Spacing	1.0 mm	2.5 mm		2.5 mm	2.5 mm	1.5 mm	[illegible]
Etching	110 Sec. 1% Br/MeOH (5µ removed)	NONE	*	NONE	95 sec. 1% Br/MeOH removed ~ 4 µm	NONE	Etch rate?
Melt Portions	1/1 Atomic } 80g	52% Hg, 48% Te } 50g	1/1 Atomic } 60g	1/1 Atomic HgTe + 10% Te by wt. } 50g	47% Hg, 53% Te } 50g 3rd use	1/1 Atomic } 80g	effect of variable melt composition?
Substrate Prep.	5% Br/MeOH Mech/Chem Polish 60 sec.	Standard	5% Br/MeOH Mech/Chem. Polish 60 sec.	Standard	Standard	5% Br/MeOH Mech/Chem Polish 60 sec.	Recommended?
Back Surface x	CdTe (~1)	CdTe (~1)	x ≈ .664	x ≈ .723 (EER), .660 (R)	CdTe (~1)	x ≈ .644	020884
Anneal	No.	No.	4 Times, total 500 min. at 410° ETCHED Each time [illegible]	No.	No.	NO.	why Anneal 4 times? Fringe patterns are improved with Anneal.


BY REFLECTANCE MEASUREMENT.
THICKNESS
ETCH RATE
CdTe A
2584 B NO FRINGES —
12784 B 11.7 μm .06 μ/sec
12584 A 13.8 μm .086 μ/sec
2584 A 17.3 μm .07 μ/sec
2684 A 16.2 μm .08 μ/sec
2884 B
REFLECTANCE (NIGHT VISION)
CdTe
300 290 280 270 260 250 240 230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0

VPE ($Hg_{1-x}Cd_xTe$) — EER DATA (UNIV. OF ILLINOIS)



1 NVL-VPE 121884

D (micron)	E_1 (ev)	x	Γ (eV)	$\frac{\Delta E_1}{(\hbar\Omega)^3}$ (eV^{-2})
0	2.408	0.335	0.123	18.5
0.25	2.398	0.325	0.110	22.1
0.5	2.376	0.303	0.146	10.2
1.0	2.369	0.296	0.141	4.1
1.5	2.394	0.322	0.138	3.3
2.0	2.416	0.343	0.157	1.6
2.5	2.433	0.359	0.126	4.1
3.0	2.432	0.358	0.107	20.5
3.5	2.449	0.374	0.117	5.1
4.0	2.438	0.363	0.115	-3.0
4.5	2.453	0.378	0.098	29.0
5.0	2.428	0.354	0.148	11.8
6.0	2.444	0.370	0.126	23.4
7.0	2.472	0.395	0.125	16.3
9.0	2.512	0.430	0.121	18.4
10.0	2.551	0.464	0.134	5.8
11.0	2.567	0.477	0.105	53.5
12.0	2.642	0.537	0.143	8.3
13.0	2.671	0.574	0.159	10.2
14.0				

14

2 NVL-VPE 032784

D (micron)	E_1 (ev)	x	Γ (ev)	$\frac{\Delta E_1}{(\hbar\Omega)^3}$ (eV^{-2})
0	2.3[illegible]8	0.315	0.14[illegible]	-0.20
1.25	2.391	0.318	0.124	-060
2.50	2.387	0.314	0.124	-5.65
3.15	2.404	0.331	0.130	-2.46
5.50	2.440	0.366	0.112	-14.66
7.50	2.437	0.363	0.111	47.61
9.50	2.690	0.574	0.097	0.10
10.00				

3 NVL VFE 05-2934

D (micron)	E_1 (ev)	χ	Γ (eV)	$\frac{\Delta E_1}{(\hbar\Omega)^3}$ (eV^{-2})
0.0	2.388	0.316	0.124	14.9
1.0	2.364	0.292	0.113	-3.5
2.5	2.367	0.294	0.110	-3.1
4.0	2.378	0.306	0.108	-3.2
5.5	2.372	0.319	0.109	-3.2
6.5	2.380	0.307	0.107	-6.0
7.5	2.395	0.323	0.110	-4.3
8.5	2.412	0.337	0.115	-3.9
9.5	2.438	0.363	0.135	-2.1
10.5	2.448	0.373	0.135	-2.4
11.5	2.475	0.372	0.129	-3.2
12.5	2.482	0.405	0.117	-5.3
13.0	2.481	0.403	0.113	-7.4
13.5	2.537	0.452	0.135	-2.8
14.0	2.538	0.453	0.124	-4.1
14.5	2.539	0.454	0.118	-4.2
15.0	2.591	0.497	0.153	-0.3

4 NVL-VPE 102384

D (micron)	E_1 (ev)	x	Γ (eV)	$\frac{\Delta E_1}{(\hbar\Omega)^3}$ (eV^{-2})
0	2.440	0.365	0.124	5.4
1.0	2.418	0.345	0.120	-1.8
2.0	2.426	0.352	0.122	-1.8
3.0	2.423	0.350	0.124	-1.2
4.0	2.422	0.340	0.118	-1.5
5.0	2.431	0.358	0.118	-1.7
6.0	2.435	0.361	0.121	-0.6
7.0	2.436	0.362	0.123	-1.1
8.0	2.435	0.361	0.123	-3.8
9.0	2.464	0.388	0.149	0.5
10.0	2.492	0.413	0.130	-1.1
11.0	2.520	0.438	0.107	31.5
12.0	2.548	0.461	0.100	44.7
13.0	2.556	0.468	0.115	28.2
14.0	2.600	0.504	0.161	5.5
15.0	2.617	0.517	0.174	6.5
16.0				

5 NVL - 020884

D (micron)	E_1 (ev)	x	Γ (eV)	$\frac{\Delta E_1}{(\hbar\Omega)^3}$ (eV^{-2})
0	2.360	0.295	0.127	-0.05
0.5	2.371	0.278	0.077	-127.5
1.5	2.347	0.276	0.127	0.02
3.0	2.334	0.265	0.093	47.25
5.0	2.387	0.314	0.101	-20.33
7.0	2.411	0.338	0.102	-69.07
8.0	2.401	0.328	0.130	2.18
9.0	2.431	0.376	0.109	-67.98
10.0	2.451	0.376	0.099	-85.57
11.0	2.454	0.378	0.115	-2.78
12.5	2.449	0.374	0.105	140.93
14.0	2.565	0.476	0.135	-42.56
15.0	2.479	0.419	0.104	53.54
17.0				

6

NVL-VPE 102434

D (micron)	E_1 (ev)	x	Γ (ev)	$\frac{\Delta E_1}{(\hbar\Omega)^3}$ (eV^{-2})
0	2.416	0.342	0.124	-2.32
1.25	2.425	0.351	0.116	-3.85
2.50	2.449	0.374	0.127	-3.61
3.75	2.459	0.383	0.115	-5.90
5.00	2.479	0.402	0.117	-5.40
6.25	2.516	0.434	0.123	-4.46
7.50	2.542	0.456	0.125	-2.30
8.75	2.735	0.607	0.151	-23.59
10.00				