Material characterization of unirradiated diodes for the CiS-HH SRD project

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Topics

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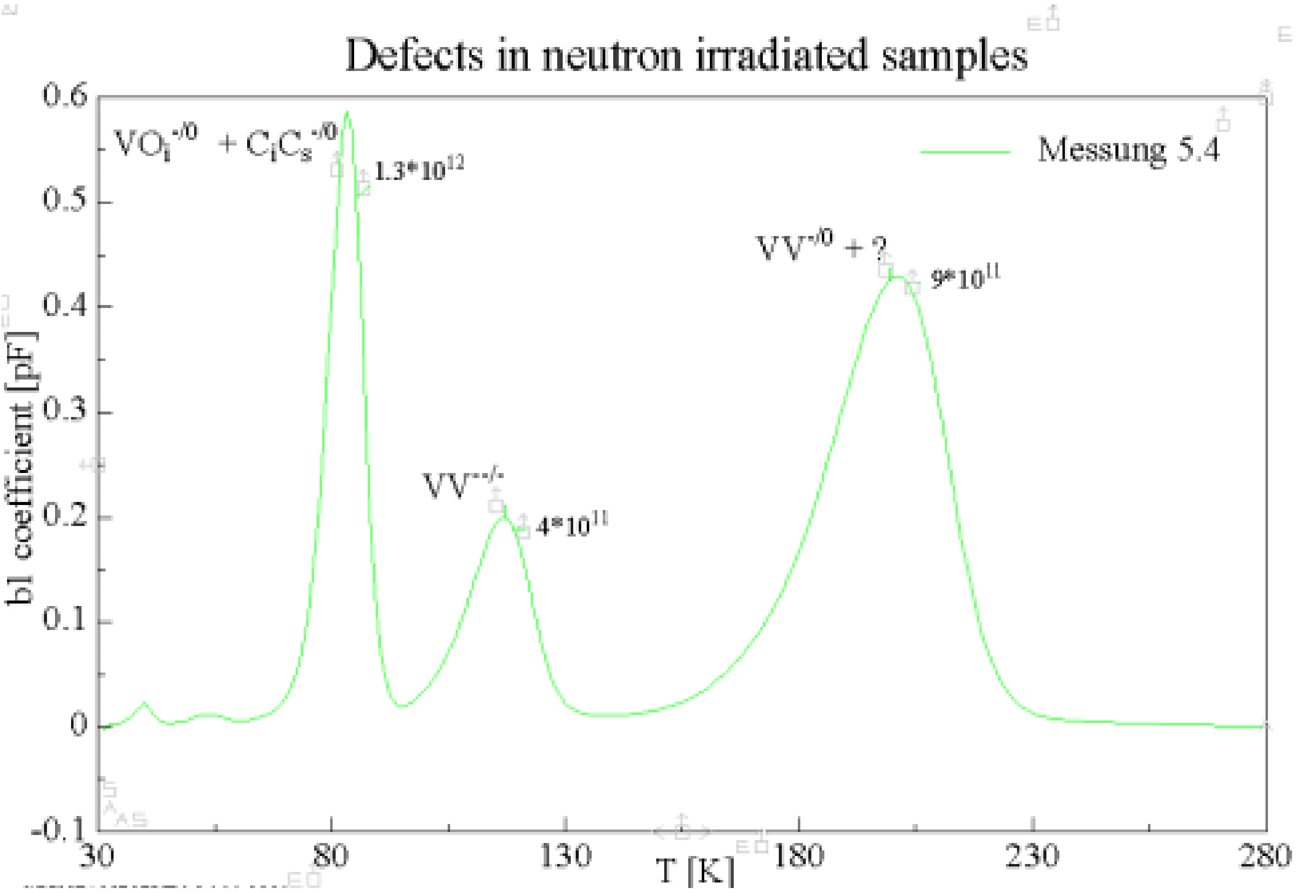
Motivation



"big" defects have been characterized

no explanation for macroscopic properties

investigation of smaller defects

material characterization

Experimental Methods

- CV/IV curves

  - check for functionality
  - characteristics for selection
  - fast (20 min per sample)

- DLTS

  - (<u>D</u>eep <u>L</u>evel <u>T</u>ransient <u>S</u>pectroscopy)
  - useful for low trap concentrations
  - determination of all trap parameters:
    conc. , cross section, energy level
  - disadvantage: measuring time (12 h)

- Other Methods: TSC, TCT

Detector properties

- material: Wacker <111>

- fabricated by CiS with FZ-process

- p+n-n+ samples

-Vol: 1 cm x 1cm x 280 µm
active area: 0.5cm x 0.5 cm x 280 µm

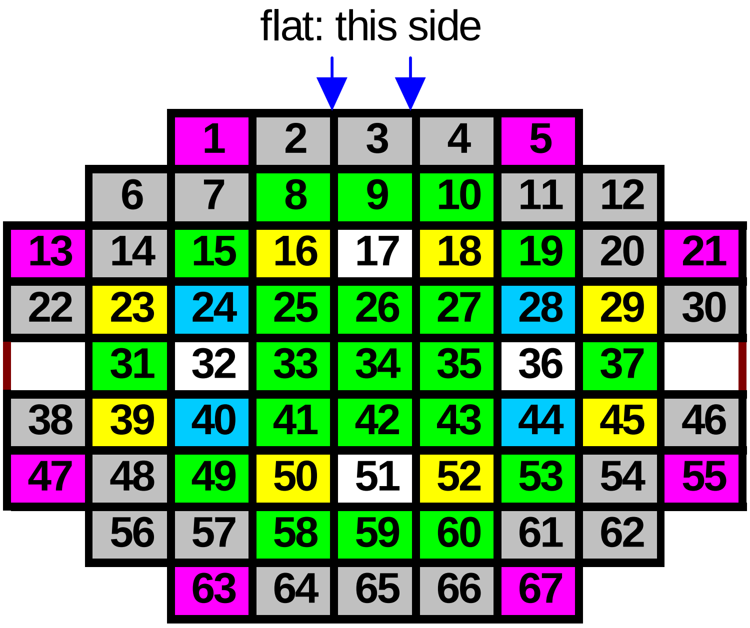
- Aluminum contacts

- Multiple guard ring structure

-Different oxygenation's (0 -72h)

-other material Cz <100>

Waferlayout



		1	2	3	4	5		
	6	7	8	9	10	11	12	
13	14	15	16	17	18	19	20	21
22	23	24	25	26	27	28	29	30
	31	32	33	34	35	36	37	
38	39	40	41	42	43	44	45	46
47	48	49	50	51	52	53	54	55
	56	57	58	59	60	61	62	
		63	64	65	66	67		

☐ = teststructures: CiS

🟨 = teststructures: Dortmund

🟦 = teststructures: babystrip

5 = samples too close to wafer rim

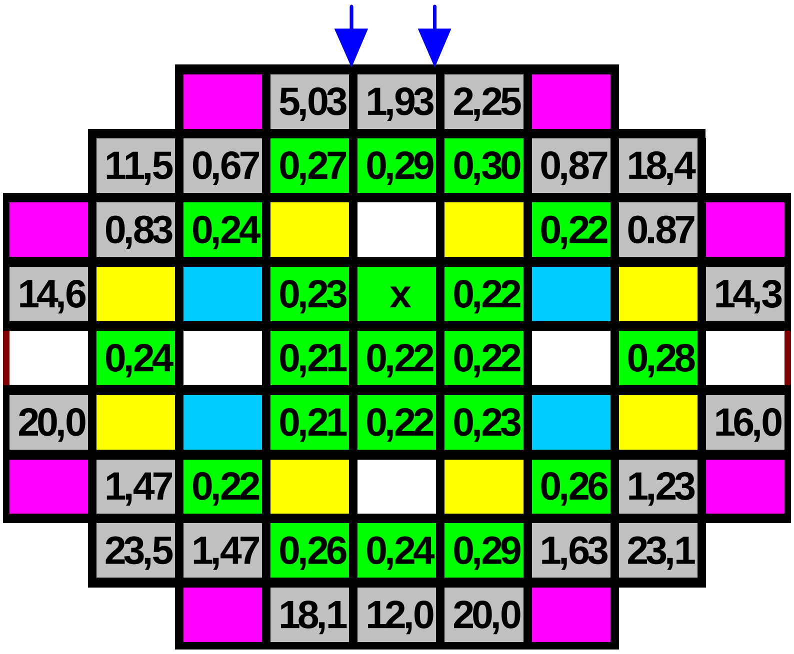
33 = 21 useful diodes inside 3" dia
62 = 22 useful diodes outside 3" dia

Leakage Current CA07

Distribution over the wafer [nA]

I(Vdepl) at 20 C

flat: this side

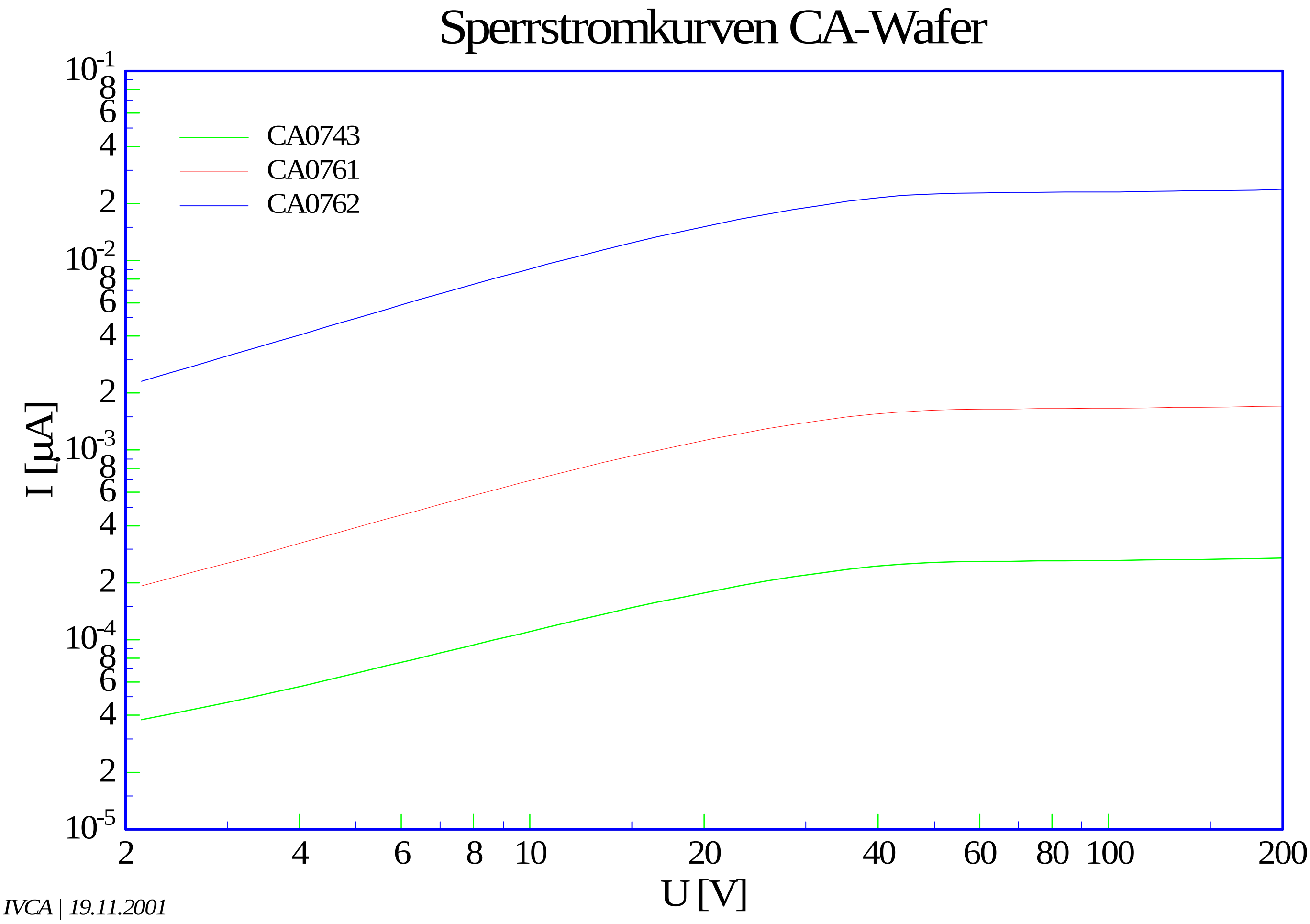


		🟪	5,03	1,93	2,25	🟪		
	11,5	0,67	0,27	0,29	0,30	0,87	18,4	
🟪	0,83	0,24	🟨	⬜	🟨	0,22	0.87	🟪
14,6	🟨	🟦	0,23	x	0,22	🟦	🟨	14,3
⬜	0,24	⬜	0,21	0,22	0,22	⬜	0,28	⬜
20,0	🟨	🟦	0,21	0,22	0,23	🟦	🟨	16,0
🟪	1,47	0,22	🟨	⬜	🟨	0,26	1,23	🟪
	23,5	1,47	0,26	0,24	0,29	1,63	23,1	
		🟪	18,1	12,0	20,0	🟪		

Depletion voltage:

homogeneous (47V -52 V)

IV - curves

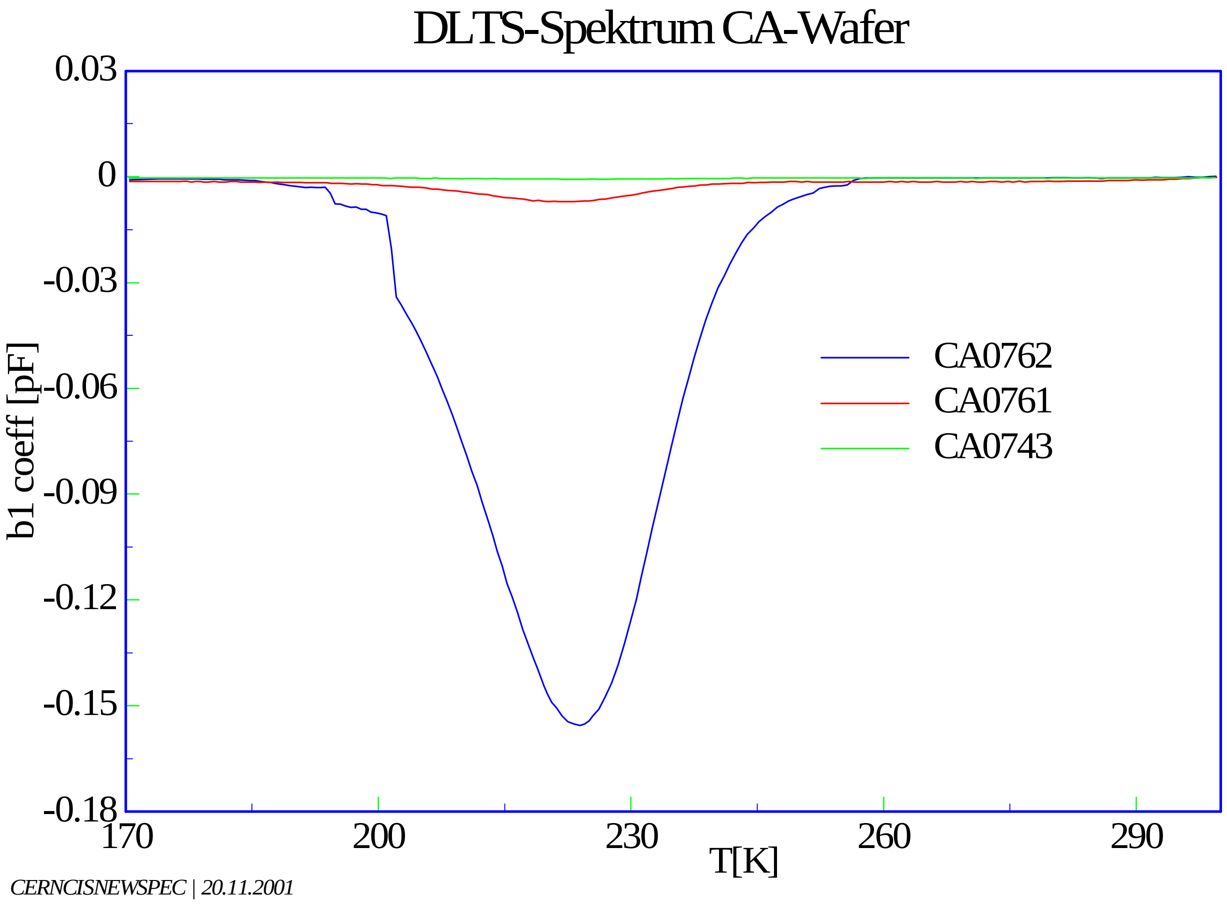


IVCA | 19.11.2001

Slopes

CA0743	0,60
CA0761	0,73
CA0762	0,78

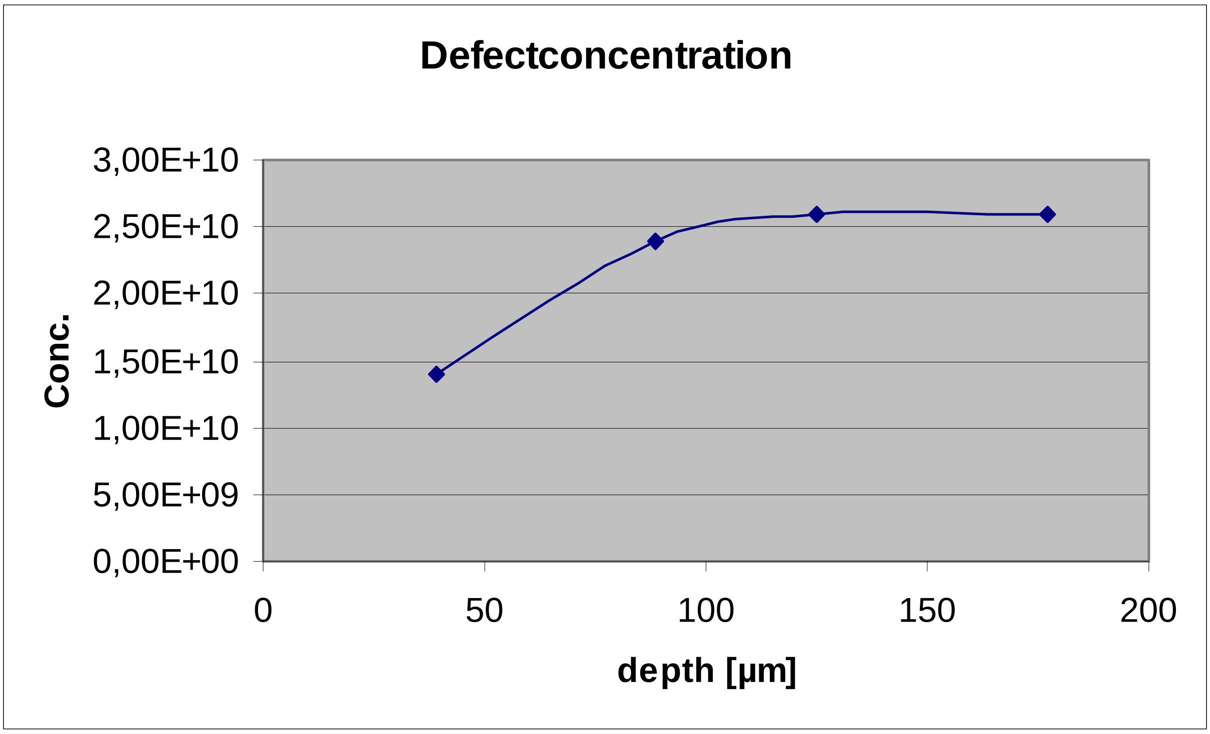
DLTS- Spectra



Sample	Art	E [eV]	σ [cm^2]	NT
CA0743	O	0,490	$6{,}42*10^{-15}$	$2.4*10^{9}$
CA0761	O	0,471	$3.00*10^{-15}$	$3.9*10^{9}$
CA0762	O	0,491	$6.75*10^{-15}$	$8*10^{10}$

Defect Concentration

depletion length: $d^2 \sim V$

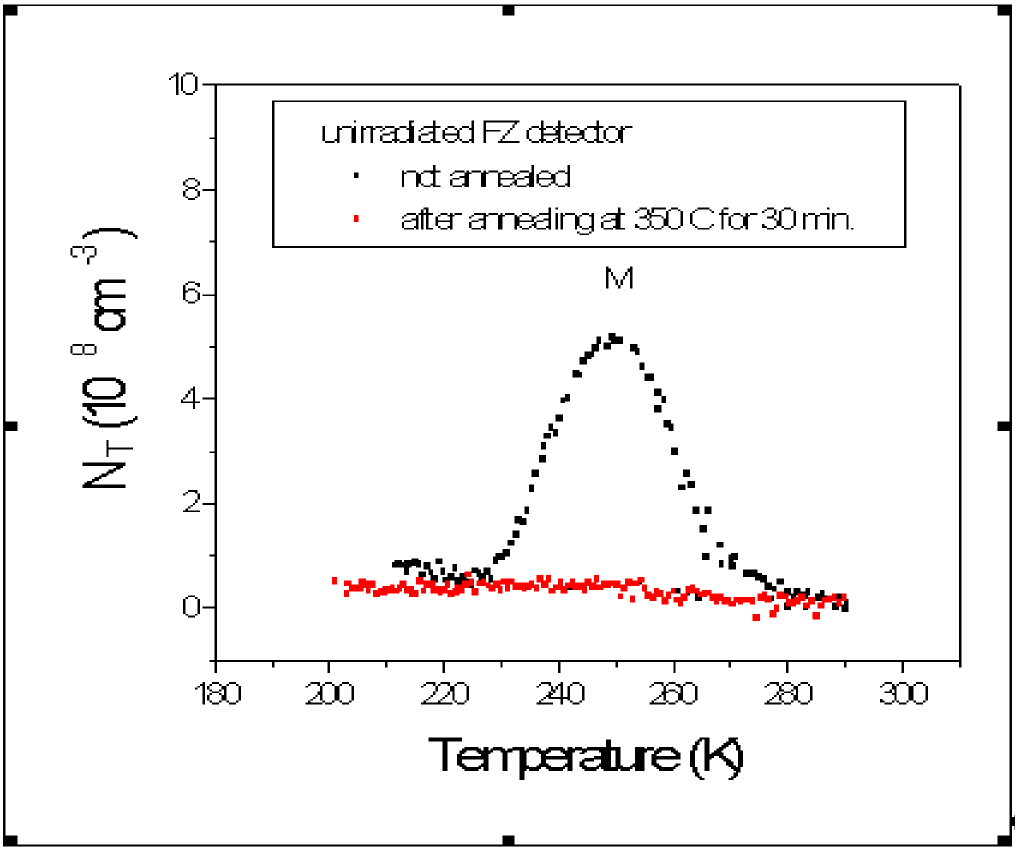


theoretical calculation for $\sigma_e = \sigma_h$:

$$j = q_0 G_t \qquad G_t = \frac{N_t n_i c_n}{2\cosh(\frac{E_t - E_i}{k_B T})}$$

$I_L \sim$ pA,
so this trap is not responsible for I_L

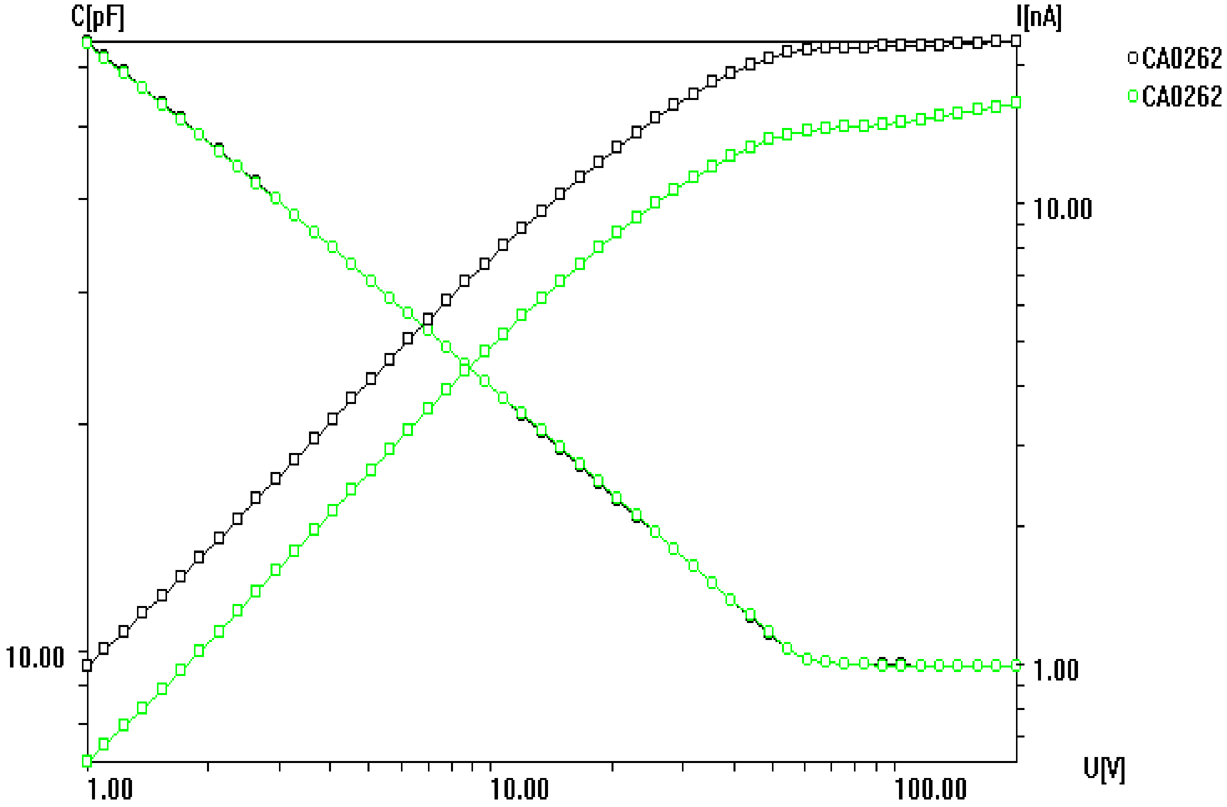
Electron trap



Sample	Art	E [eV]	σ [cm^2]	NT
CA0743	E	0,661	$2*10^{-14}$	$1*10^{8}$
CA0761	E	0,738	$1.45*10^{-12}$	$6.5*10^{8}$
CA0762	E	0,786	$7.4*10^{-11}$	$8*10^{8}$

leakage current

Annealing at 350°C



change in leakage current from
21 nA to 15 nA

old samples

Topsil <100>

Edge: U = 192 V, I = 11.6 nA

Neff = 4E12

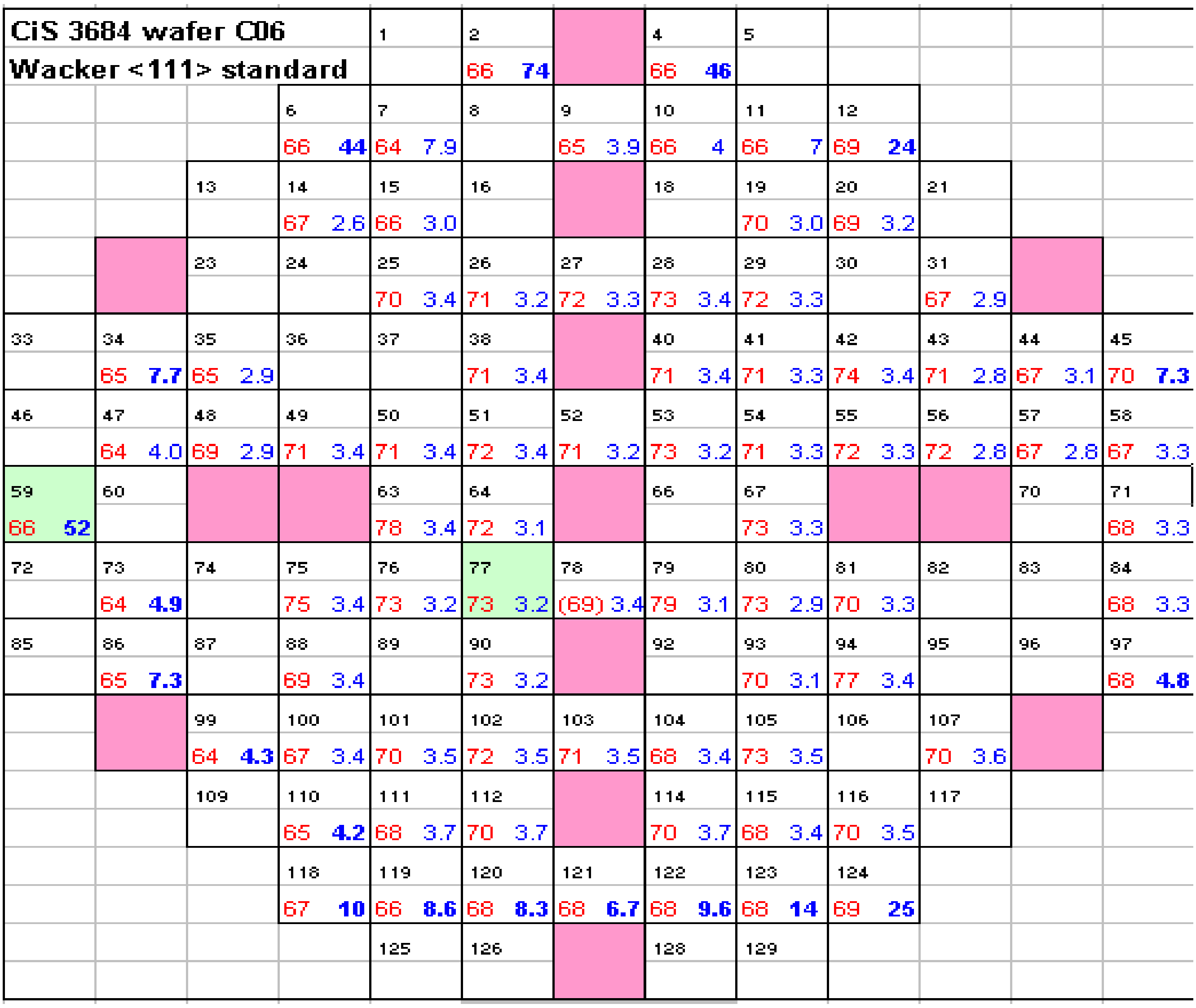
no peaks in the spectra visible

Middle: U = 144 V, I = 3.65 nA

Neff = 3.12E12

Sample	Art	E [eV]	σ [cm^2]	NT
C03052	E	0,532	4.78E-14	3.9E8

Map C06

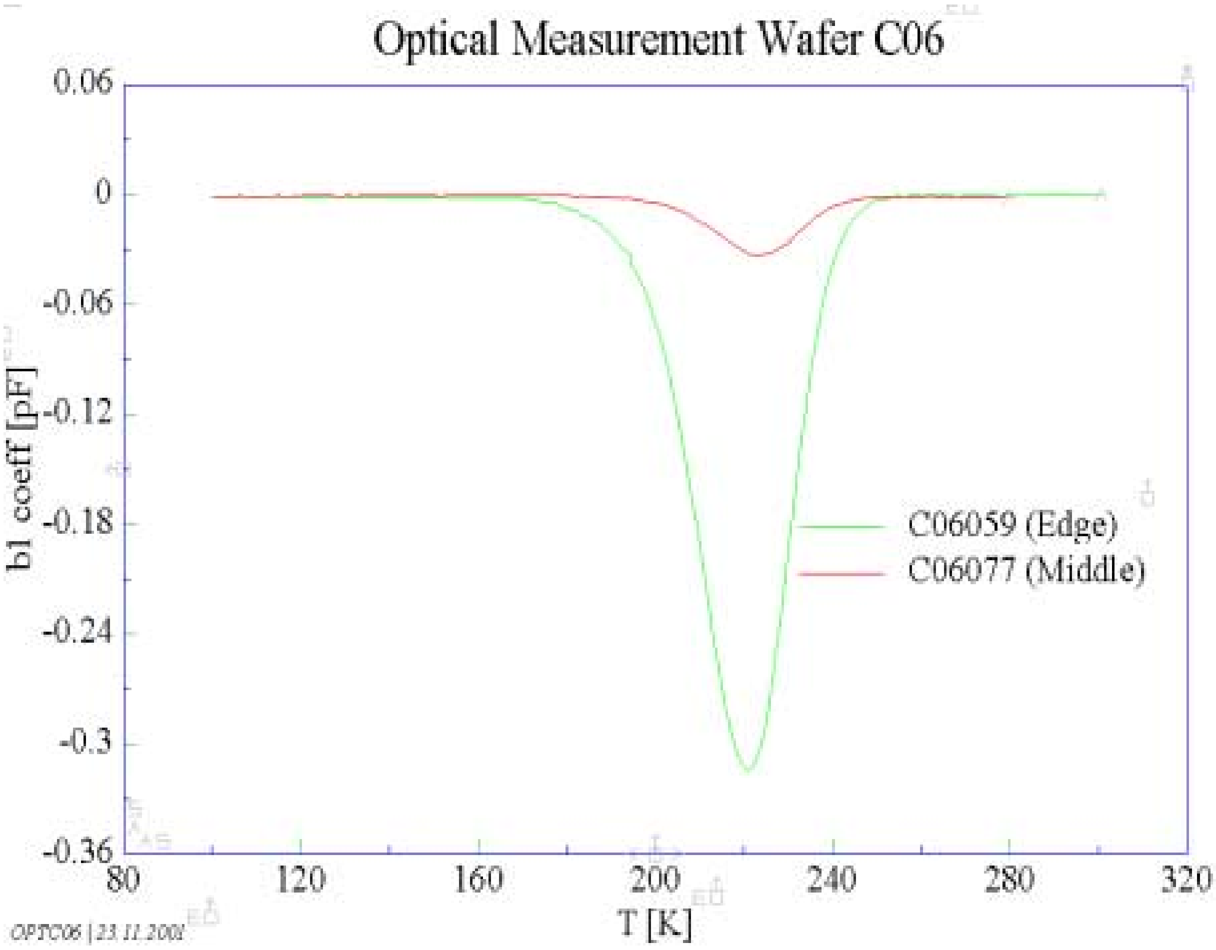


CiS 3684 wafer C06 **Wacker <111> standard**				1	2 66 **74**	▨	4 66 **46**	5				
			6 66 **44**	7 64 7.9	8	9 65 3.9	10 66 4	11 66 7	12 69 **24**			
		13	14 67 2.6	15 66 3.0	16	▨	18	19 70 3.0	20 69 3.2	21		
	▨	23	24	25 70 3.4	26 71 3.2	27 72 3.3	28 73 3.4	29 72 3.3	30	31 67 2.9	▨	
33	34 65 **7.7**	35 65 2.9	36	37	38 71 3.4	▨	40 71 3.4	41 71 3.3	42 74 3.4	43 71 2.8	44 67 3.1	45 70 **7.3**
46	47 64 4.0	48 69 2.9	49 71 3.4	50 71 3.4	51 72 3.4	52 71 3.2	53 73 3.2	54 71 3.3	55 72 3.3	56 72 2.8	57 67 2.8	58 67 3.3
59 66 **52**	60	▨	▨	63 78 3.4	64 72 3.1	▨	66	67 73 3.3	▨	▨	70	71 68 3.3
72	73 64 **4.9**	74	75 75 3.4	76 73 3.2	77 73 3.2	78 (69) 3.4	79 79 3.1	80 73 2.9	81 70 3.3	82	83	84 68 3.3
85	86 65 **7.3**	87	88 69 3.4	89	90 73 3.2	▨	92	93 70 3.1	94 77 3.4	95	96	97 68 **4.8**
	▨	99 64 **4.3**	100 67 3.4	101 70 3.5	102 72 3.5	103 71 3.5	104 68 3.4	105 73 3.5	106	107 70 3.6	▨	
		109	110 65 **4.2**	111 68 3.7	112 70 3.7	▨	114 70 3.7	115 68 3.4	116 70 3.5	117		
			118 67 **10**	119 66 **8.6**	120 68 **8.3**	121 68 **6.7**	122 68 **9.6**	123 68 **14**	124 69 **25**			
				125	126	▨	128	129				

Volume: 0.7 cm x 0.7 cm x 280 µm

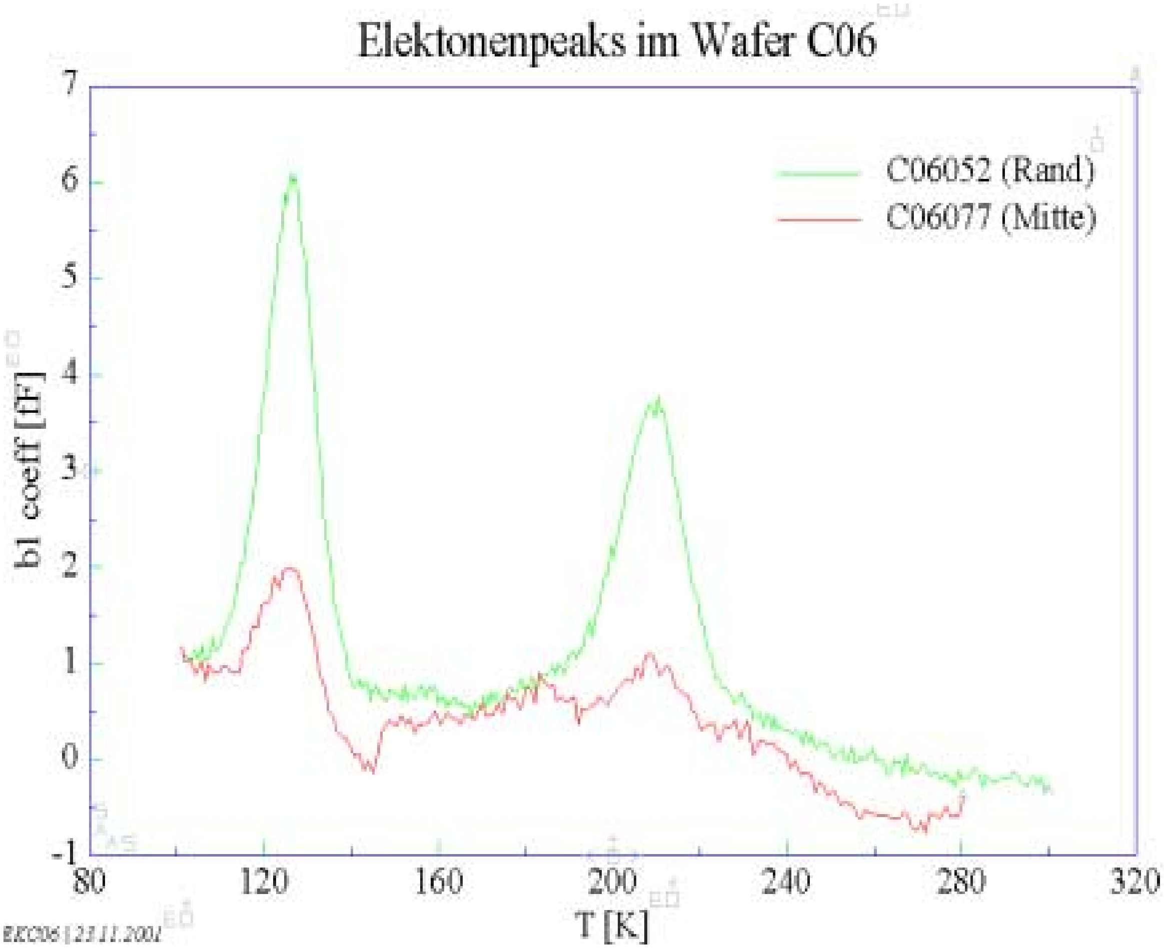
same active area

defects in old samples



Sample	Me	E [eV]	σ [cm^2]	NT
C06077	O	0,462	1,75E-15	2.5E10
C06059	O	0,474	4.06E-15	1.8E11

Elektronmeasurement



Sample	Art	E [eV]	σ [cm^2]	NT
C06077	E	0,268	1.09E-15	9.9E8
	E	0,519	2.64E-14	5.8E8
C06059	E	0,278	2.52E-15	4.5E9
	E	0,522	2.90E-14	8.8E8

Conclusion

Unirradiated samples may have a lot of defects

Measurements before irradiation are necessary for selection

The concentration of traps before irradiation should not be bigger than $5*10^8$

Further investigations should be done, especially to see a relation between the traps and the leakage current