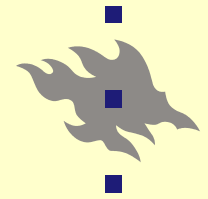


Degradation effects in TlBr single crystals under prolonged bias voltage



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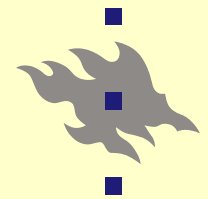
(Thermo) Electro aging

V. Kozlov*, M. Leskelä, M. Kemell and M. Vehkamäki

Department of Chemistry, University of Helsinki, P.O. Box 55, FIN-00014,
Helsinki, Finland

* - E-mail address: kozlov@mappi.helsinki.fi

IWORID-8, Pisa, Italy, 2006

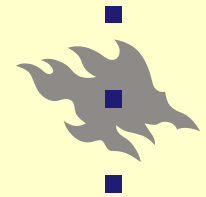


TlBr properties

- high atomic numbers $Z: 81+35$ \Rightarrow stopping power
- density (7.56 g/cm³) \Rightarrow compact device
- bandgap (2.68 eV) \Rightarrow room temperature
- inter-pixel resistance $\sim 500 \text{ G}\Omega$ (gap 100 μm , 50V) \Rightarrow 2D-array detector*
- optical transparency: 440nm – 50 μm \Rightarrow scintillation spectroscopy

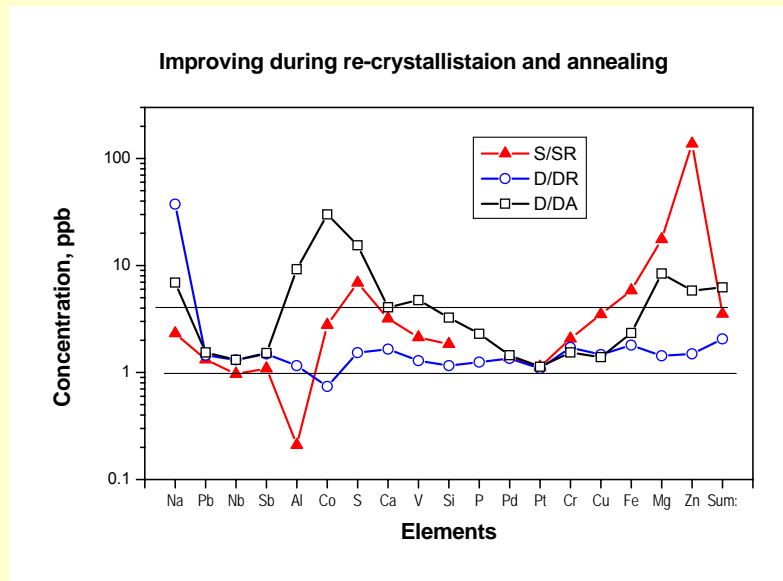
*Owens *et al.*, Nucl. Instr. and Meth. A 531, 18 (2004)

Material problems



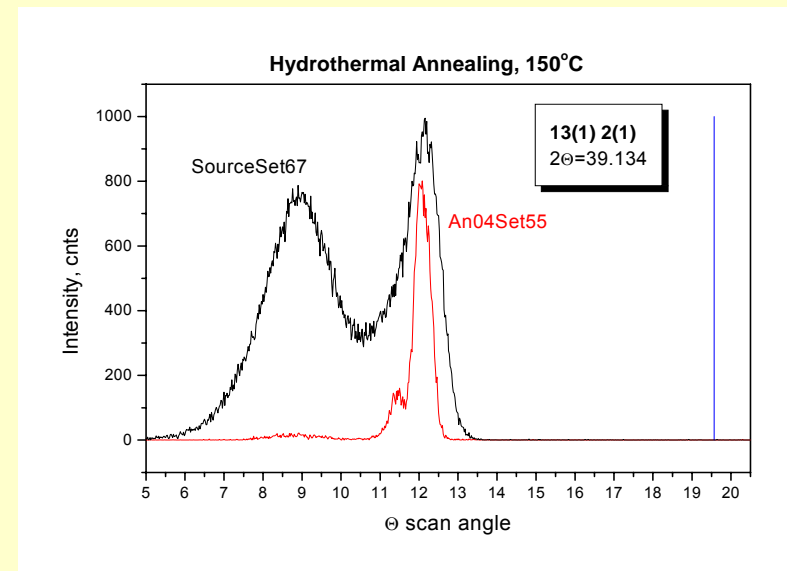
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- **Purity**



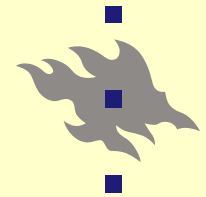
V. Kozlov, et. al., Nucl. Instr. and Meth. A 531, 165 (2004).

- **Crystal quality**



- **Hardness** (Knoop: 12 kg / mm²) => Manufacturing process
- **TIBr** – toxic compound

Instability of electrical properties



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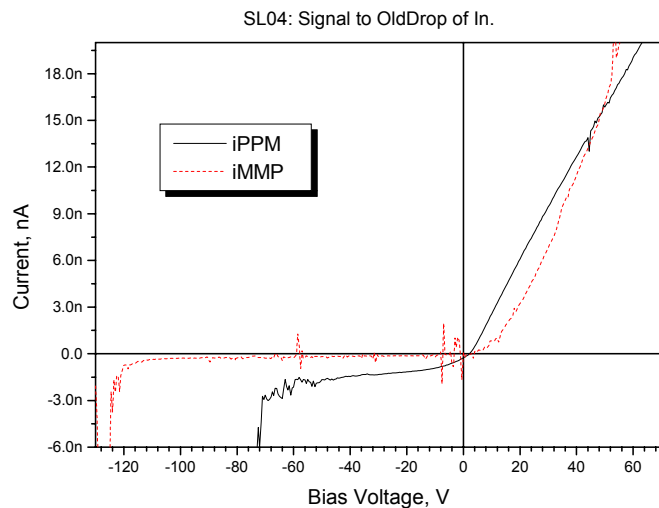
Height pulse spectra

^{109}Cd source at 100V

time, min	0	10	130
Relative peak position	1	0.7	0.36

K. Hitomi, et al., IEEE Transactions on Nuclear Science 49(5, Pt. 2) 2526 (2002).

“Diode” breakdown



Degradation of photoconductivity

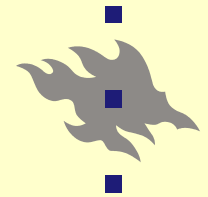
Ionic conductivity => channel structures

J. Vaitkus, et al., Nucl. Instr. and Meth. A531 192 (2004)

Tl^+ electro-diffusion => polarisation phenomena

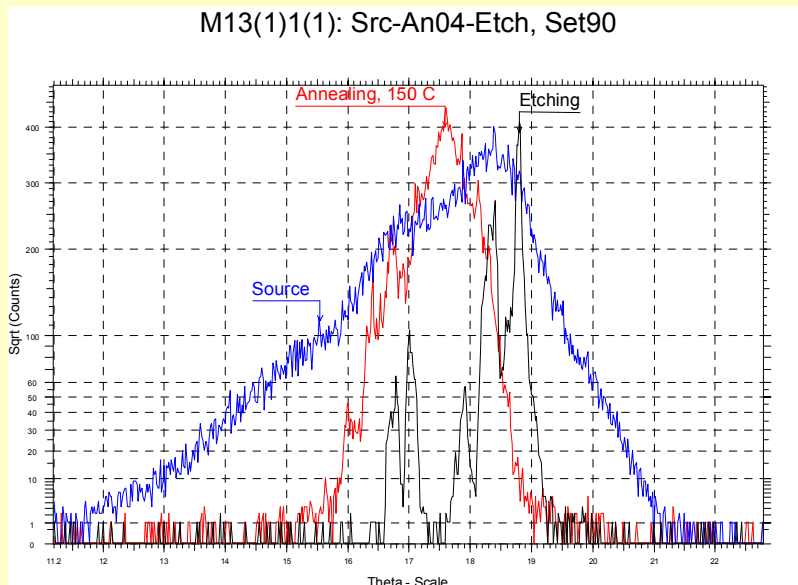
J. Vaitkus, et. al., Nucl. Instr. and Meth. A546(1-2), 188 (2005)

Sample preparation



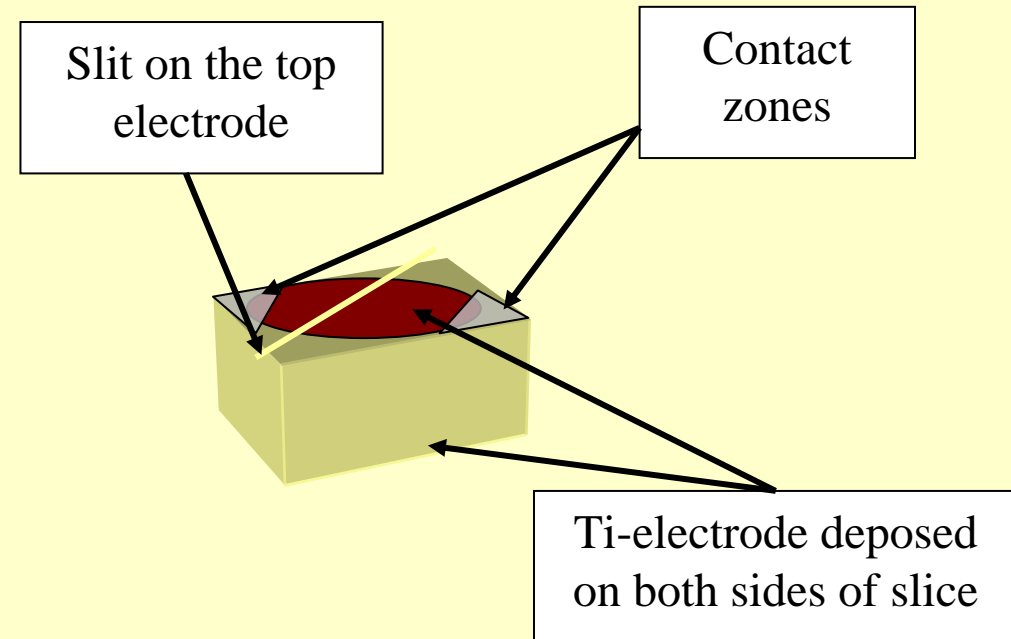
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X-ray rocking curves



M13(1)1(1)Src-An04-Etch_Set90.EVA

Slice formation



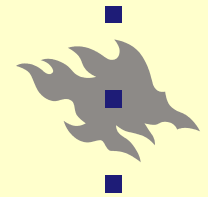
FWHM

- Source 2.8°
- Annealing 1.5°

Size: 4.22 * 4.19 * 1.55 mm³

Ti electrode: 14 mm² * ~40 nm

I-V sweeps



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jW1: 0V => +200V

+ Standby ~1h

jW2: +200V => -200V

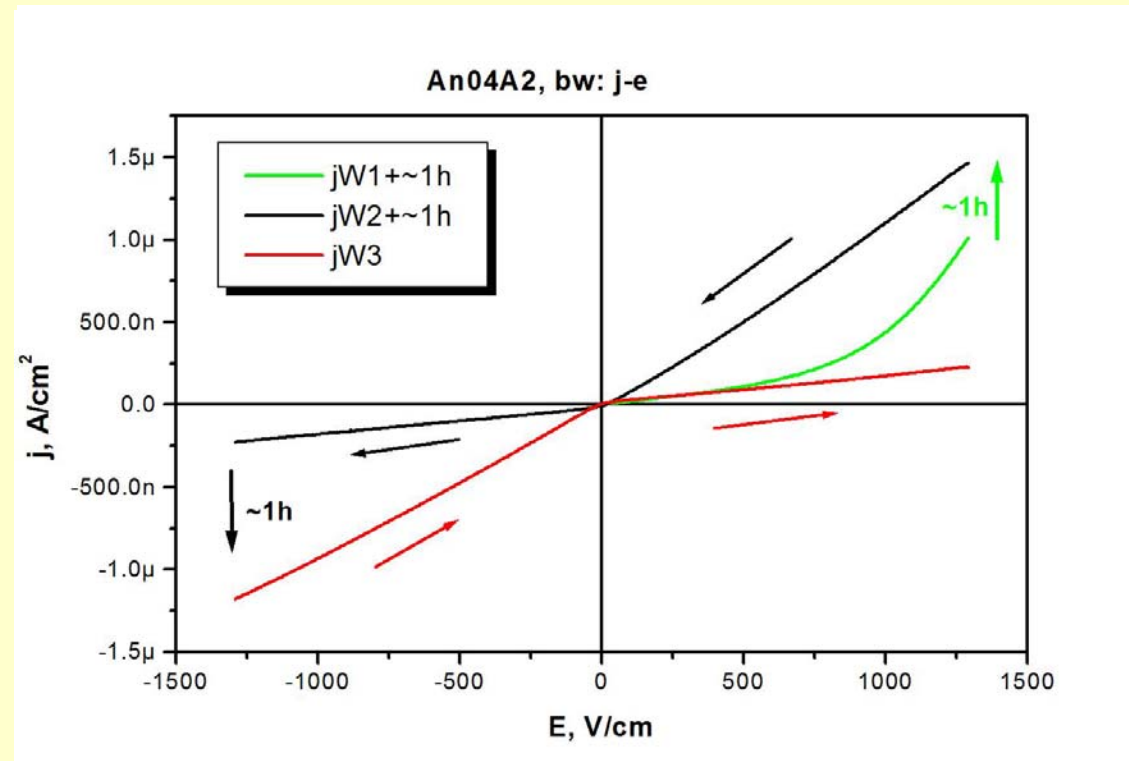
+ Standby ~1h

jW3: -200V => +200V

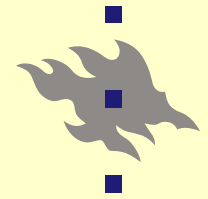
Conductivity, $t=23.8^{\circ}\text{C}$

•Max: $1.18\text{E}-09$ [ohm.cm] $^{-1}$

•Min: $1.61\text{E}-10$ [ohm.cm] $^{-1}$

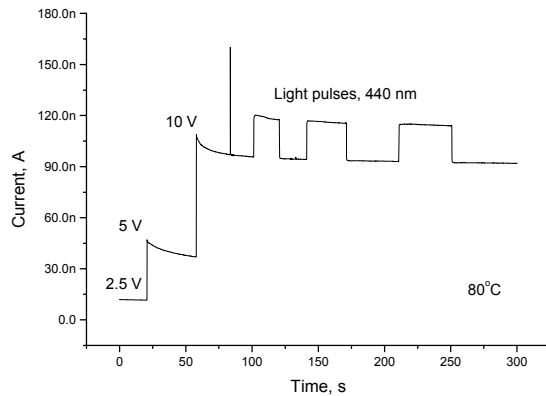


Current-time characteristics



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“Sweep” mode



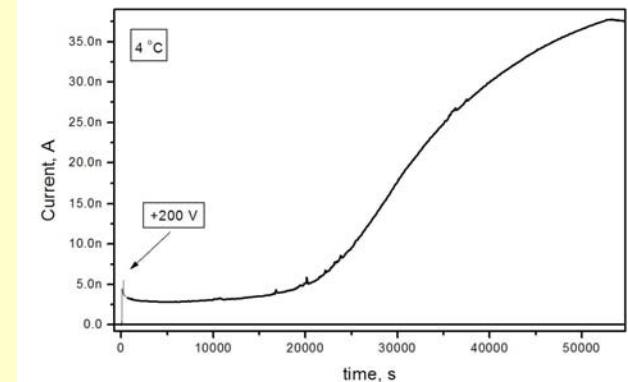
Temperature

4, 20, 40, 60 and 80°C

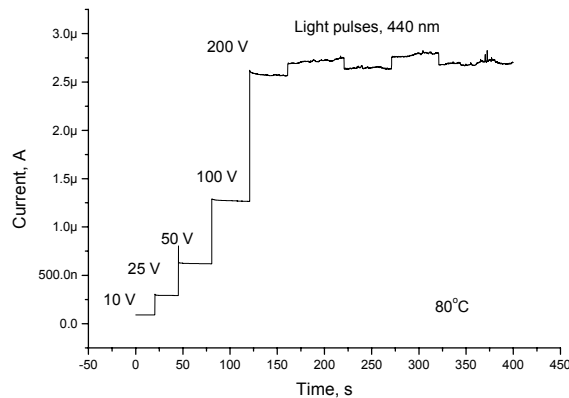
Voltage range

0 – +200 V

Standby mode

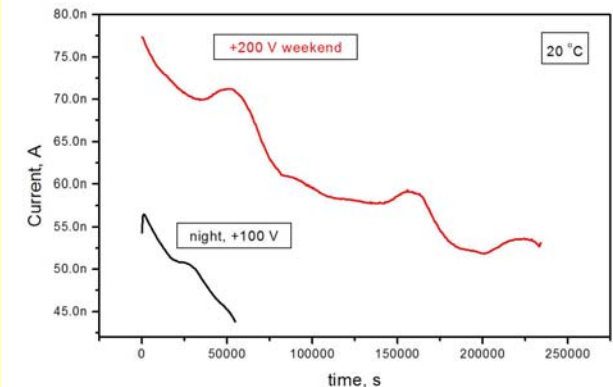


A8ElectroAging4deg.JPG



Prolonged aging

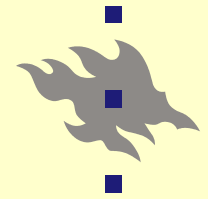
=> Electrode process?



A9ElectroAging20deg.JPG

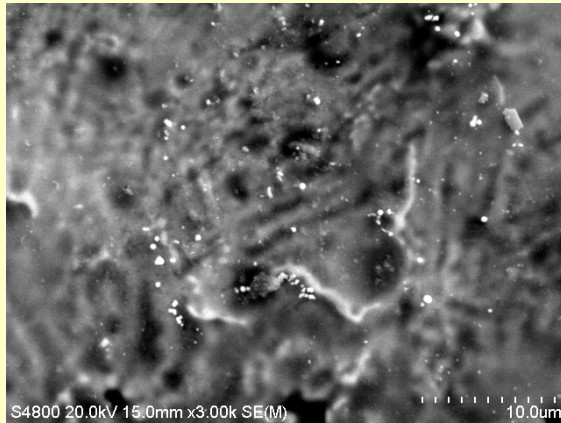
IWORID-8, Pisa, Italy, 2006

SEM-EDS Measurements

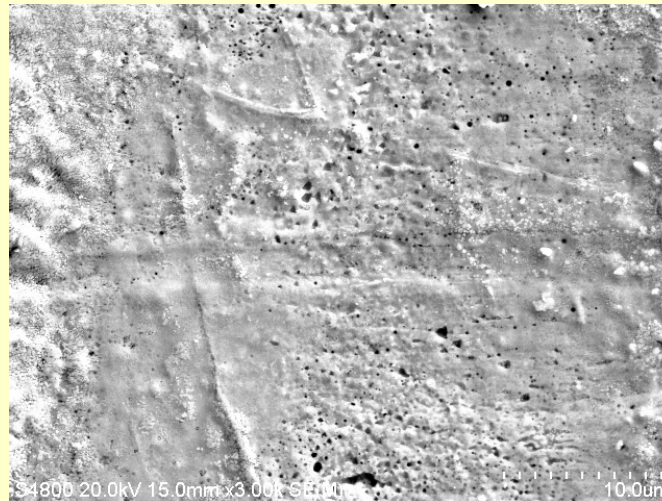


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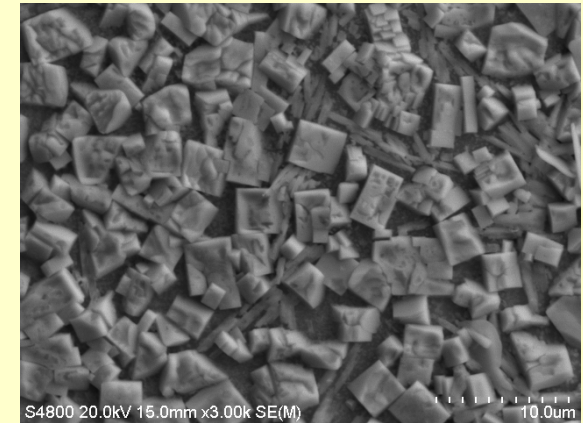
Positive Ti-electrode



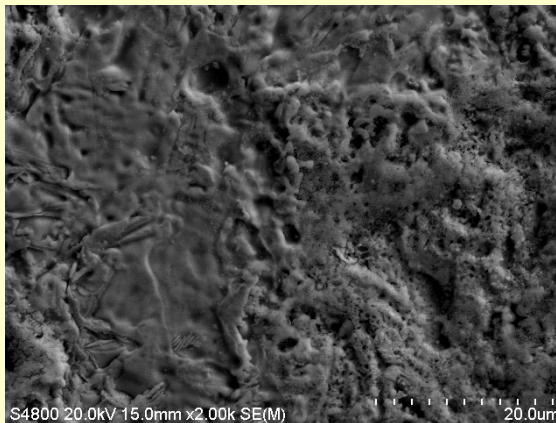
Material of slit on (+) electrode



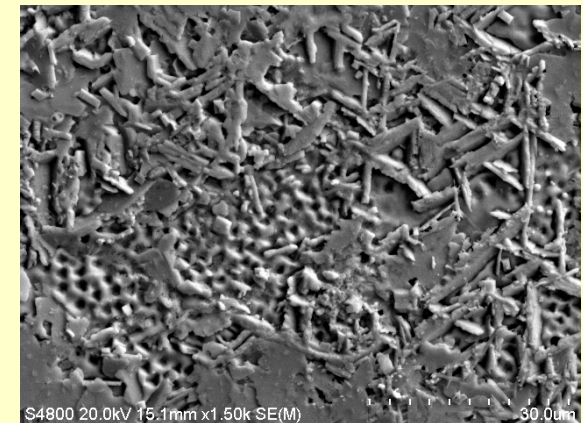
Negative Ti-electrode



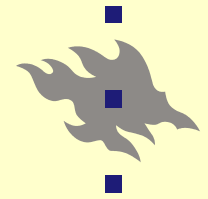
Under (+) Ti



Under (-) Ti

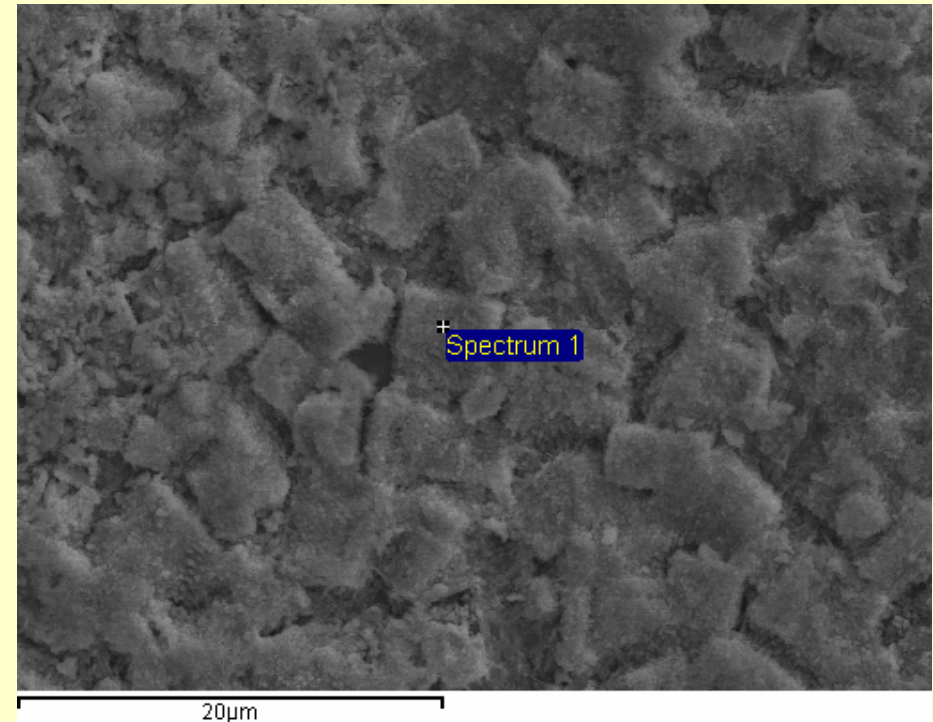
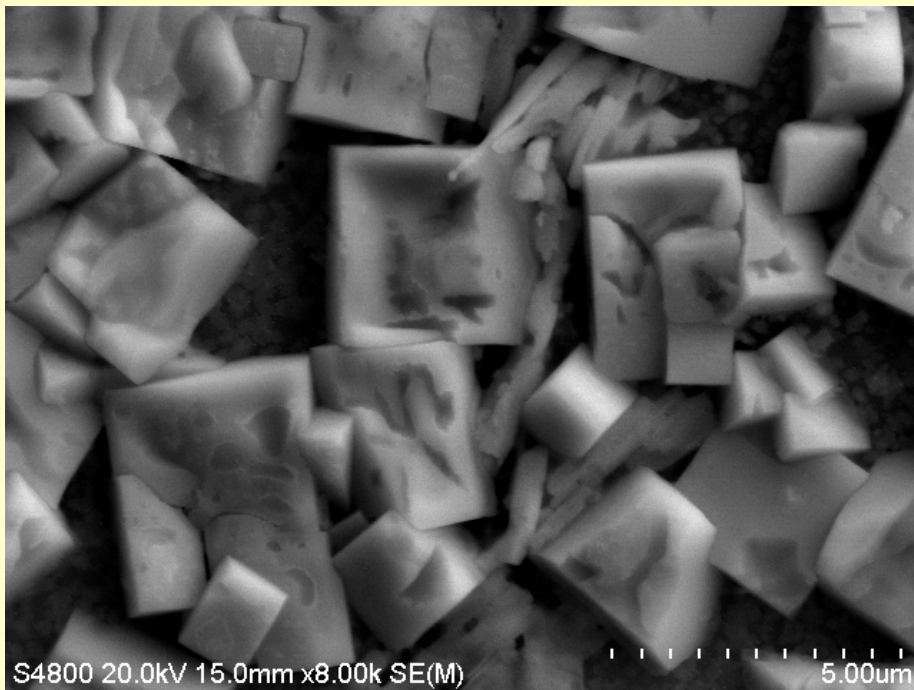


Negative Ti surface aging

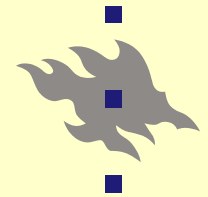


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Negative Ti surface degradation
after electro aging and + 2 weeks, laboratory conditions

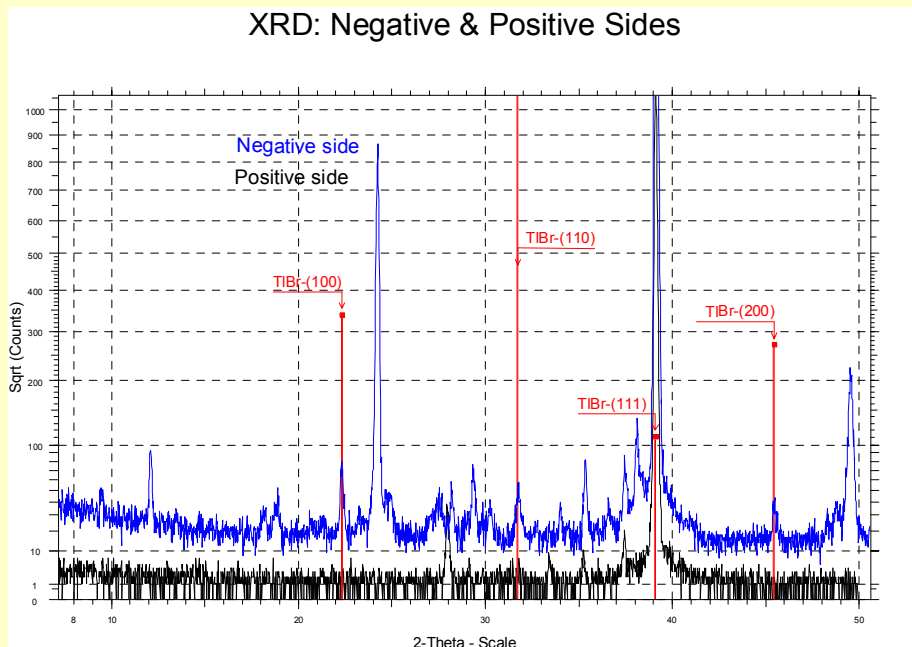


XRD & EDS results



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XRD: degradation of negative electrode



EDS: Composition

Atomic% Element	Standard slit	on (+) Ti	under (+)Ti	on (-) Ti	under (-) Ti
C	50.75	41.51	44.37	40.4	40.42
O	9.52	18.99	14.02	30.60	24.4
Br	20.38	10.65	21.83	2.96	11.85
Tl	17.84	9.45	18.19	15.4	23.33
Ti	0.97	18.76	0.11	10.16	
Pb*	0.16	0.08	0.19	0.21	
Cl*	0.22	0.13	0.21		
W*	0.15	0.07	0.15	0.2	
Si		0.38	0.74		
Ag			0.19		
Ta*				0.07	
Co*	0.01				
Hal / Tl	1.15	1.14	1.21	0.19	0.51

Max

Min

*

Elements added by the fitting program

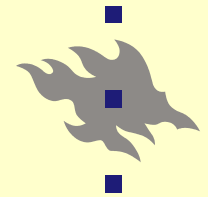
Electrodes:

Negative & Positive

(-) side: Tl and O - max

Hal/Tl ratio – min

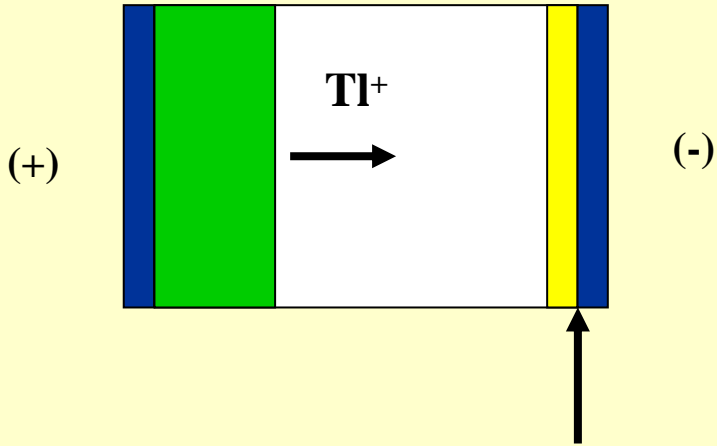
(+) side: Br and Ti -max.



Model picture

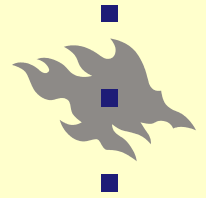
Zone of concentration
of Br and defects by Tl^+

$Tl^+ + e = Tl$ (metal)



Formation of Tl / Ti couple

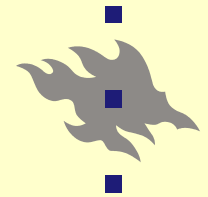
Conclusions



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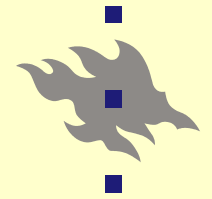
- TI^+ ionic current
 - => polarisation effects & degradation
 - => TIBr room **temperature detector** – myth?
- Role of material quality and purity?
- Could be the electro-aging used for purification?

Acknowledgements



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- **Crystal growth:** I.S. Lisitsky and M. Kuznetsov (GIREDMET, Russia)
- **Financial support:** Finnish Technology Agency **TEKES**



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END

- Thank You!

IWORID-8, Pisa, Italy, 2006