Biomedical Engineering and Nanotechnologies Institute

RIGA TECHNICAL UNIVERSITY

On application of photothermostimulated exoelecron emission for characterisation of Nb films, deposited on copper

A. Katashev, C. Pira, A. Sublet, M. Vogel, R. Valizadeh

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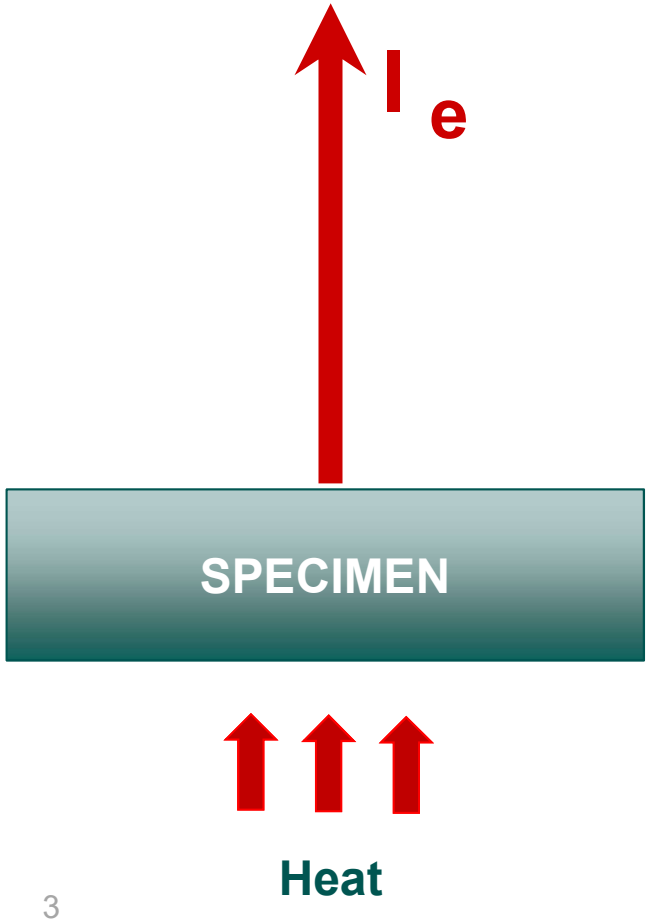
Exoelectron emission

- J. Mclenann, 1902. "On a Kind of Radioactivity Imparted to Certain Salts by Cathode Rays"; The London Edinburgh and Dublin Philosophical and Journal of Science Series 6, vol. 3 no. 14p 195 - 203.
- M. Tanaka, 1935. "After Effect of Aluminum Bombarded by Electrons"; Physical Review, vol. 48 p916.
- J. Kramer, 1949. "Spitzenzahler and Zahlrohr bei Metallographischen ober Flachen-unter Suchungen";, Zeitschrift fur Physik, vol. 125 pp739 - 75

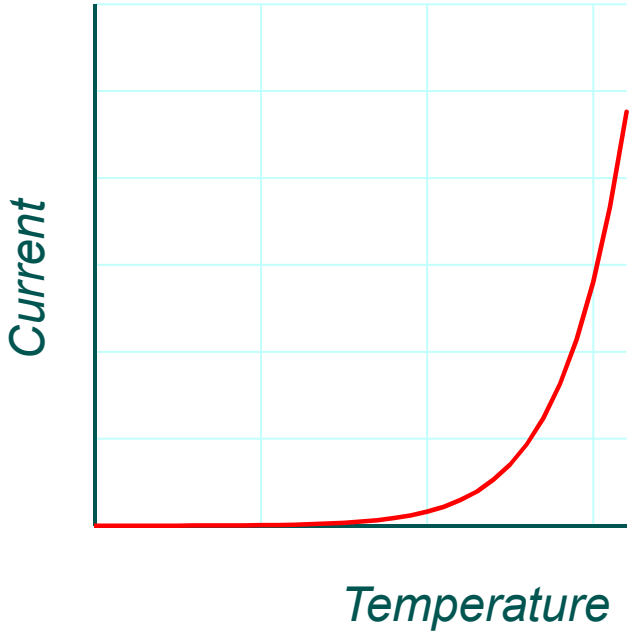
Emission of the defect surface

Thermoionic emission



$$I = A_G T^2 e^{-\frac{W}{kT}}$$

Richardson's law



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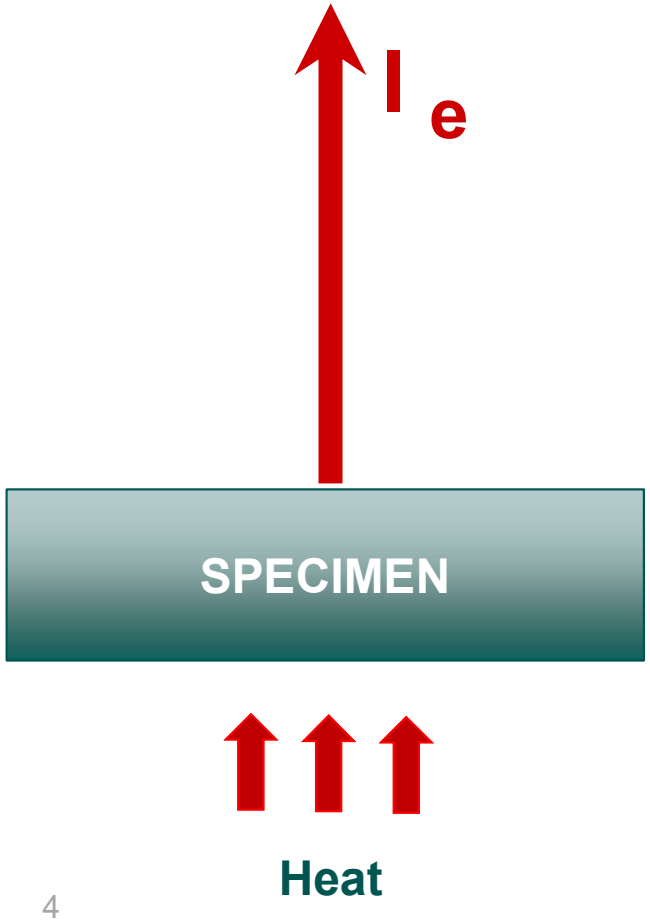
Thermostimulated Exoelectron emission



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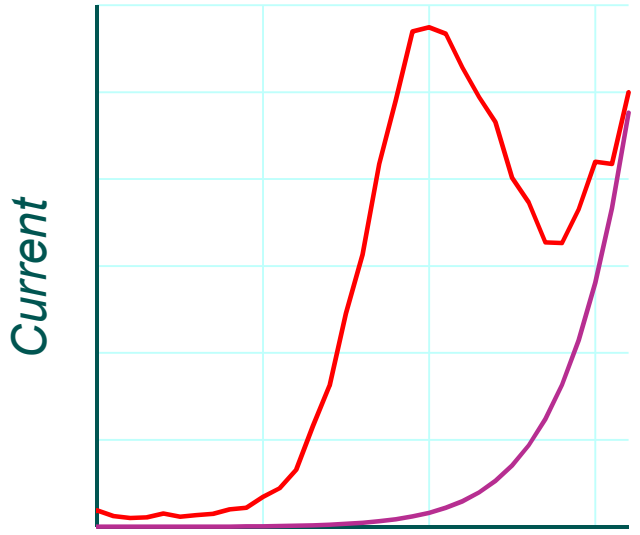

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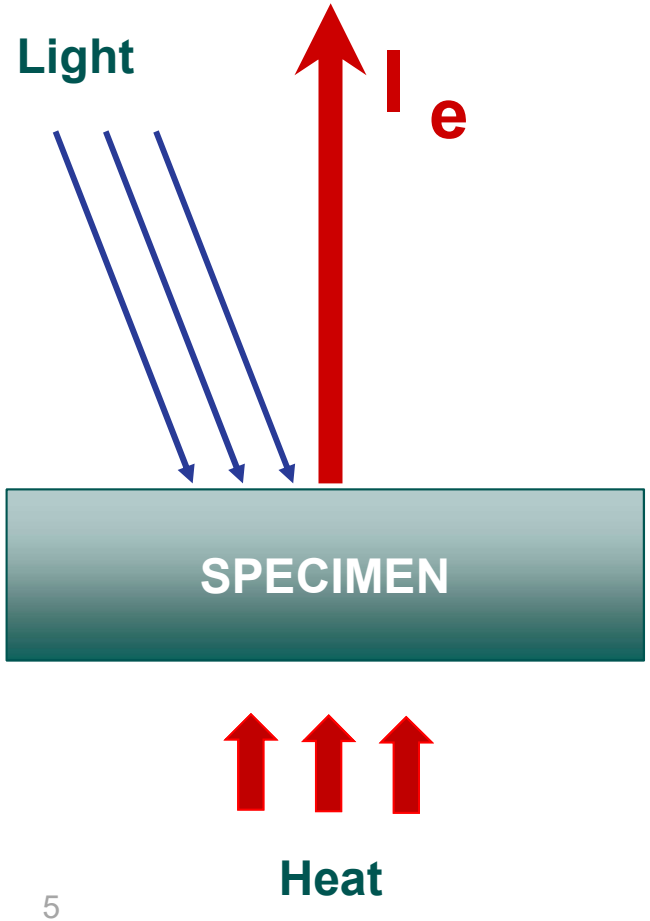
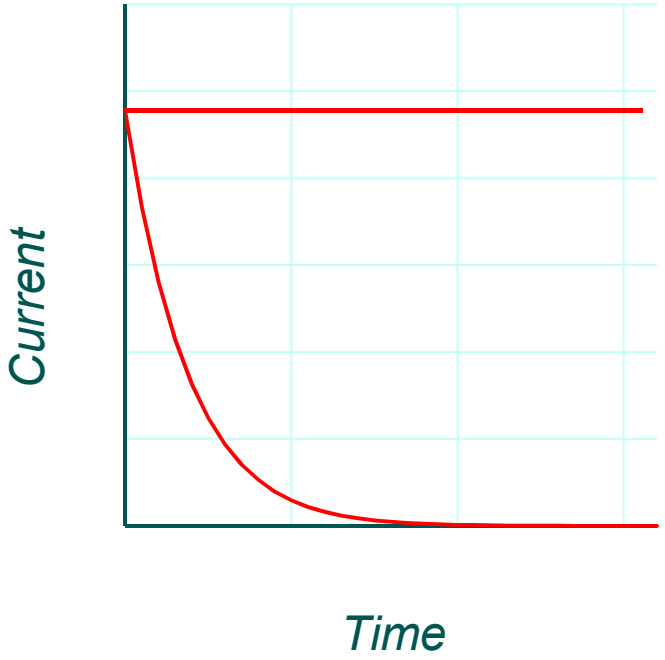
Photoelectron emission



$$I_e \sim (h\nu - \varphi)^m$$



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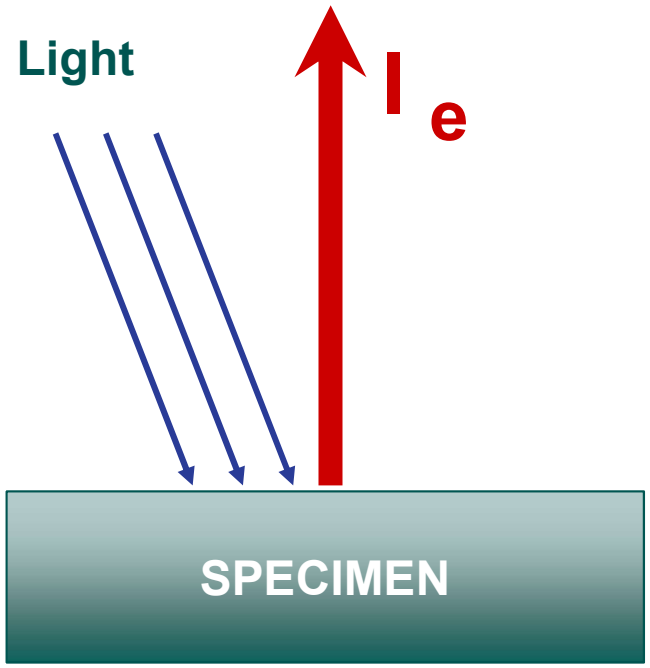
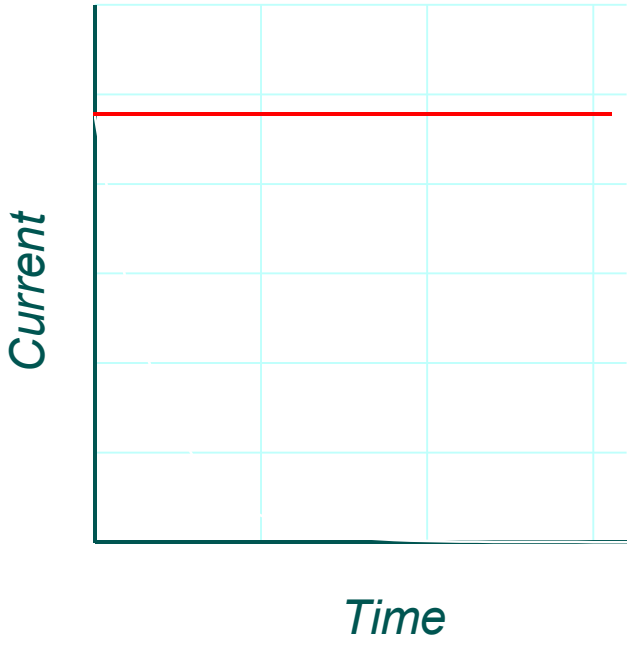
Photoelectron emission



$$I_e \sim A\,(h\nu - \varphi)^m$$



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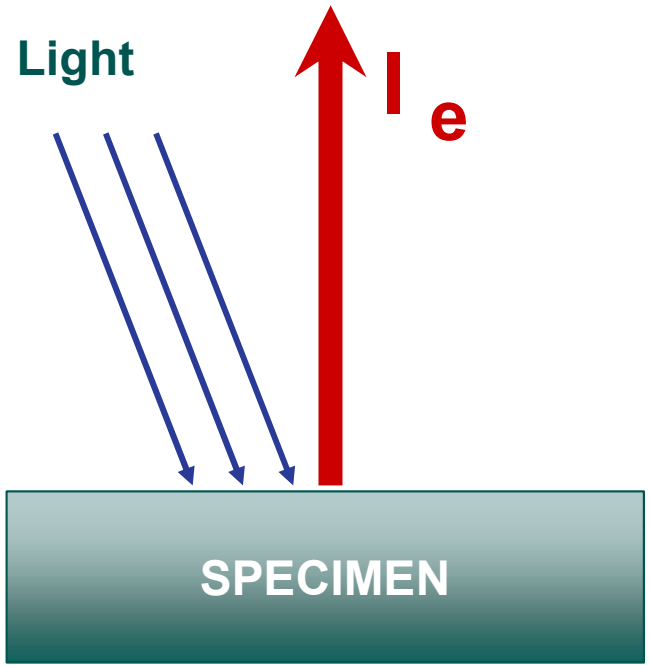
Optically stimulated exoemission



$$I_e \sim A(t)\,(h\nu - \varphi)^m$$

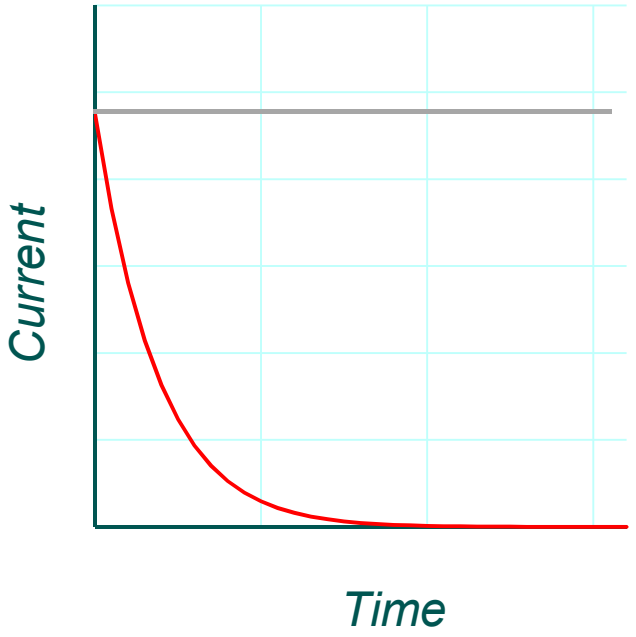
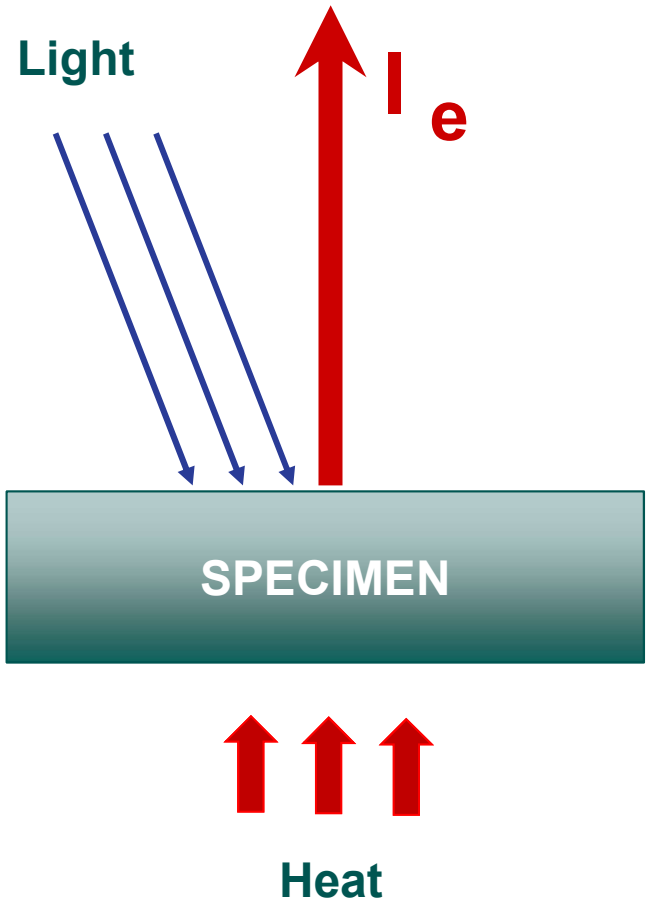


Photo-termostimulated exoemission



$$I_e(t) \sim A(t)\,(h\nu - \varphi(t))^m$$

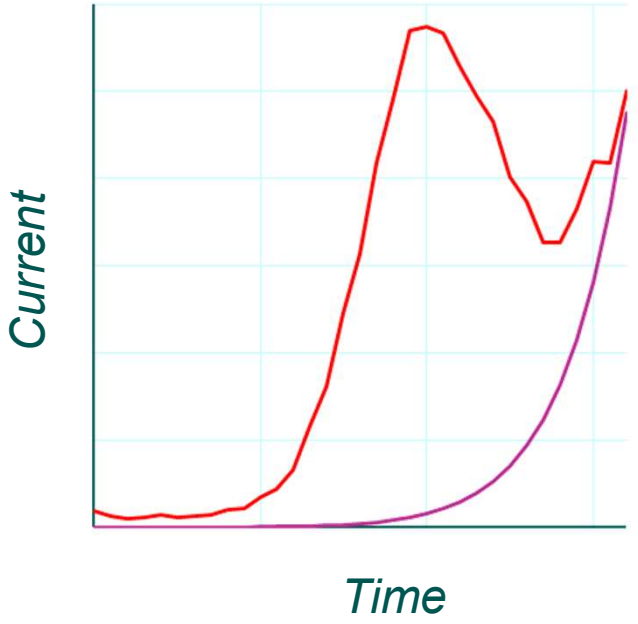
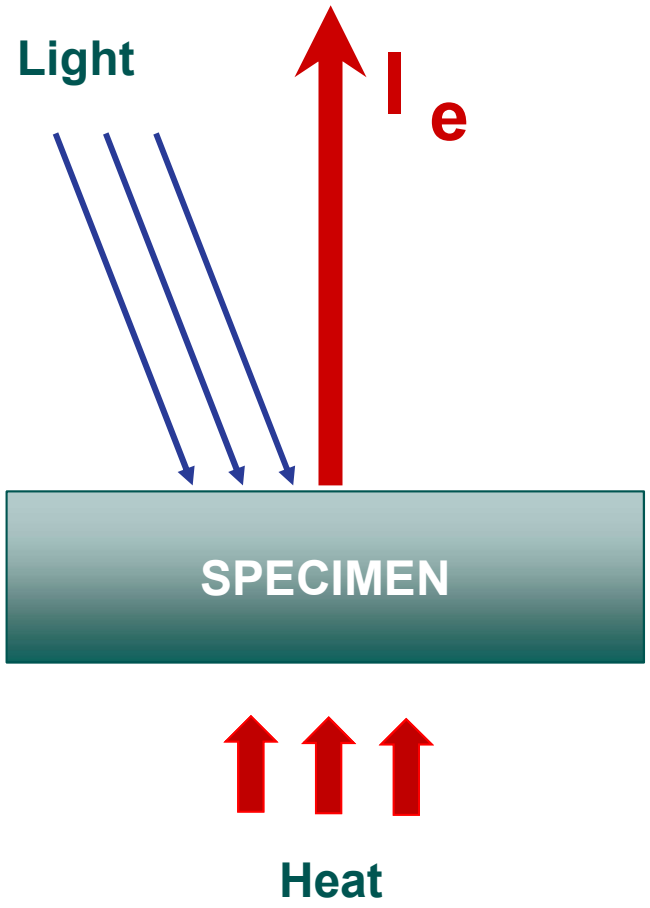
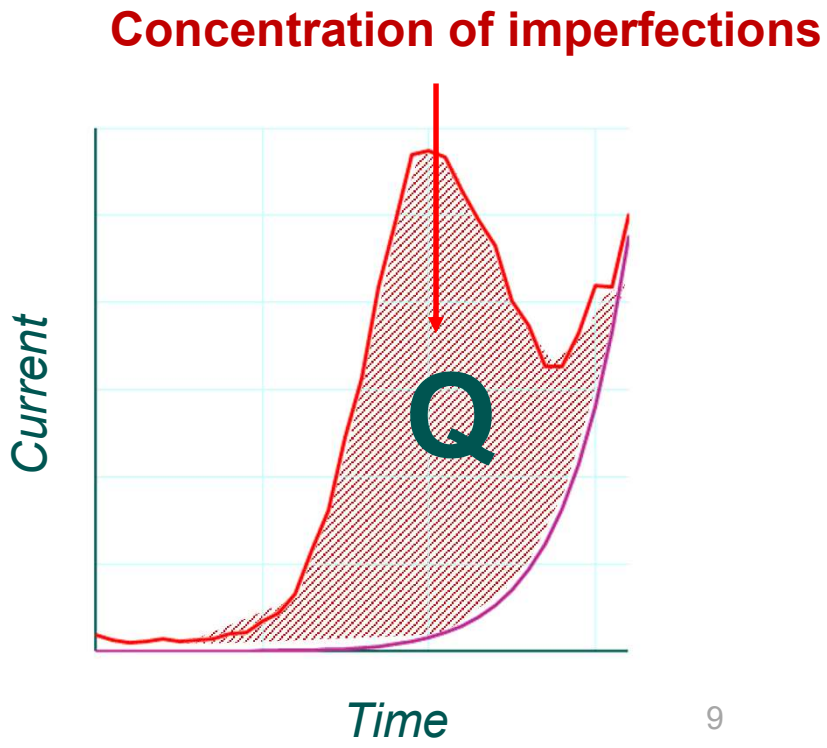


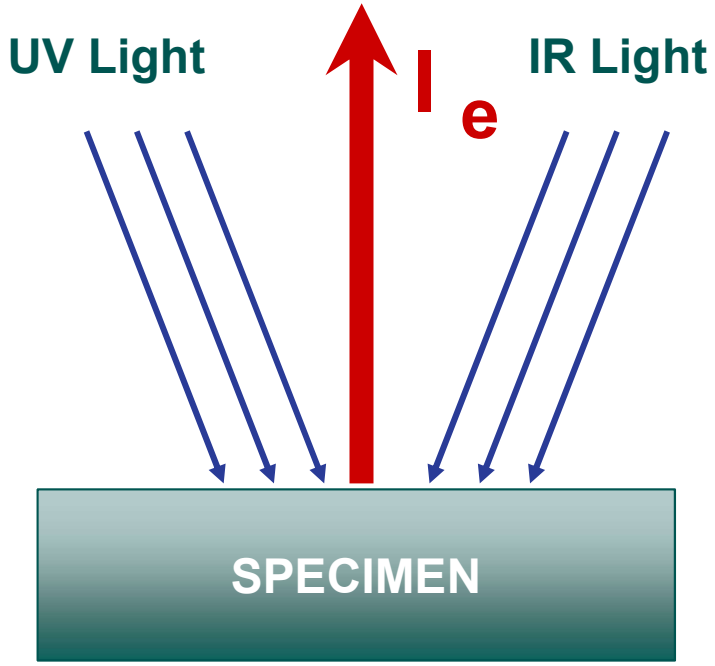
Photo-termostimulated exoemission

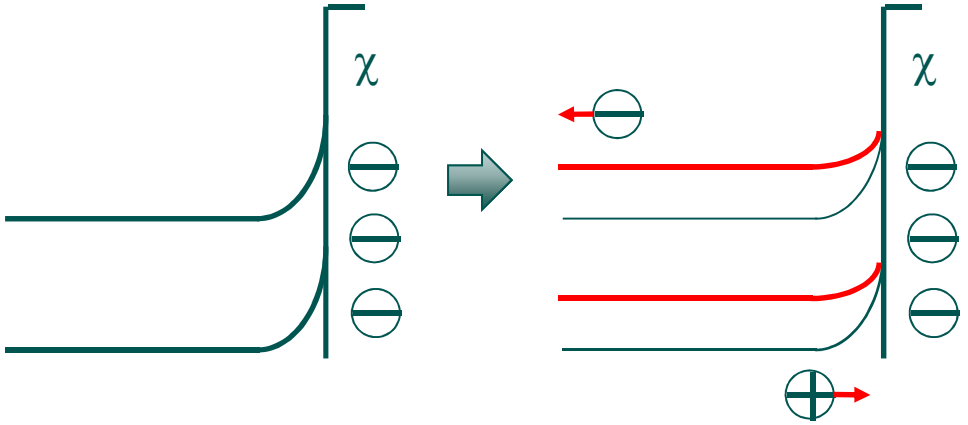


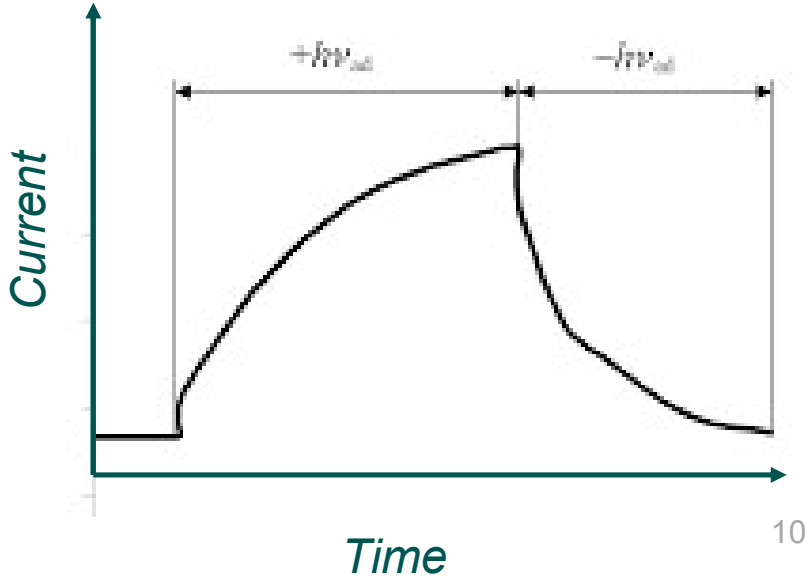
$$I_e(t) \sim A(t)\,(h\nu - \varphi(t))^m$$



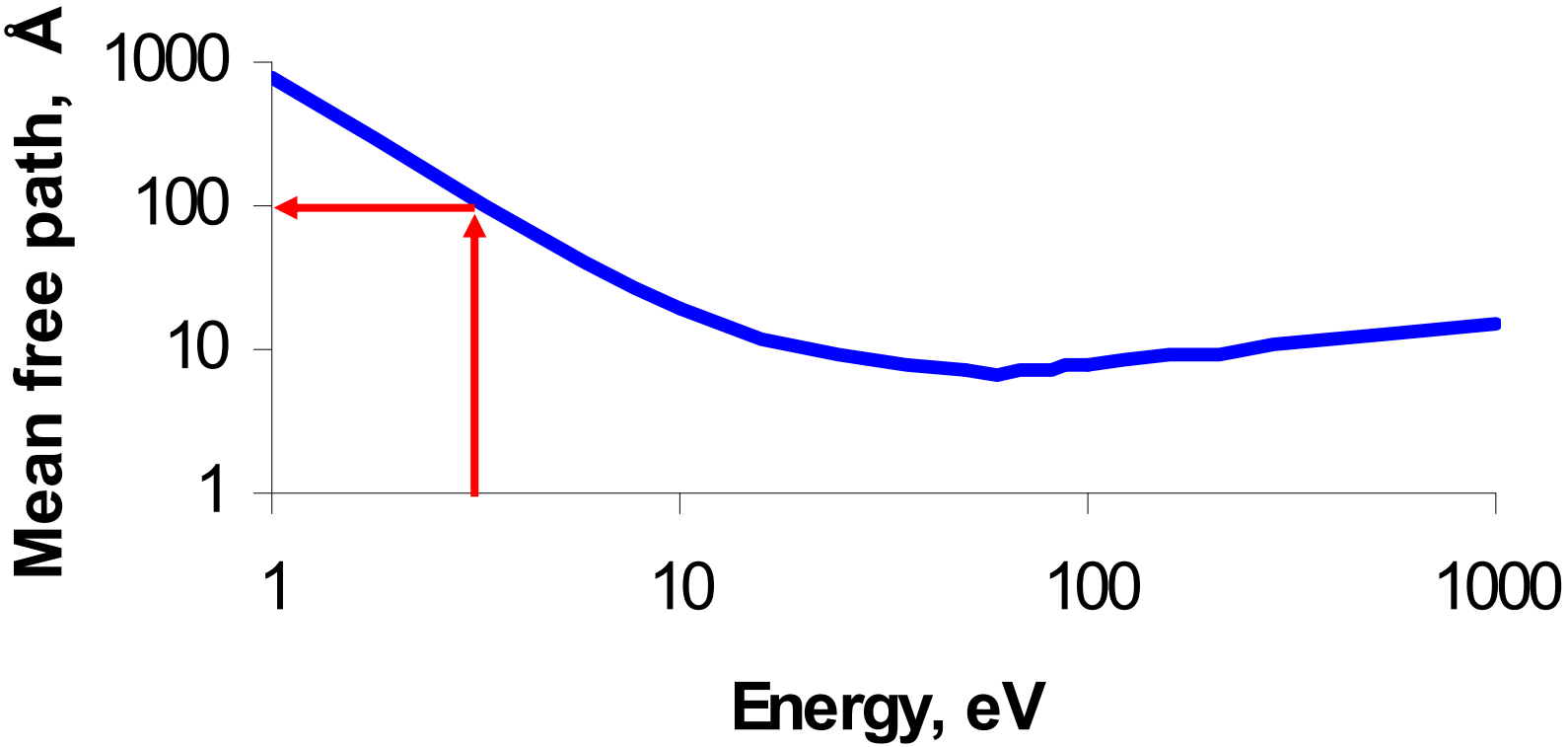
Dual photostimulated emission



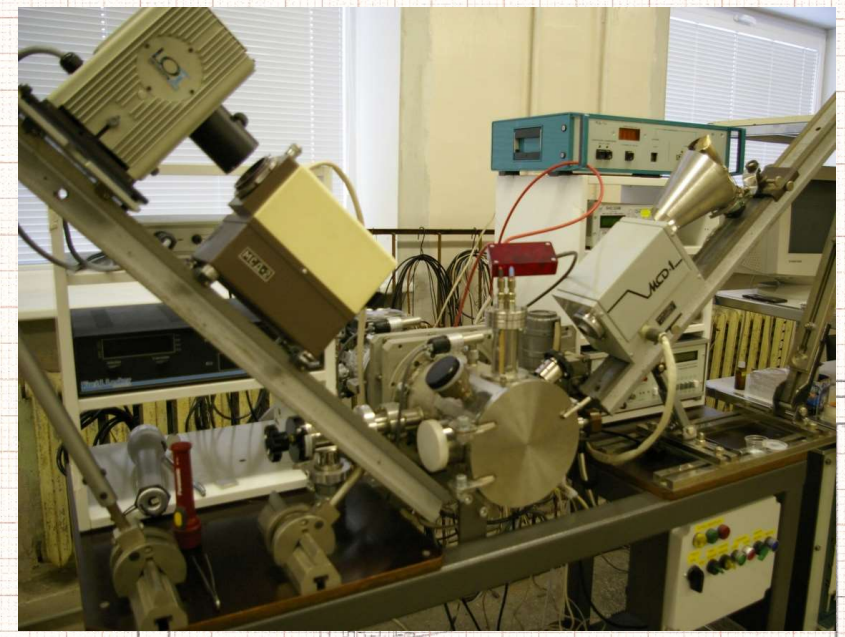


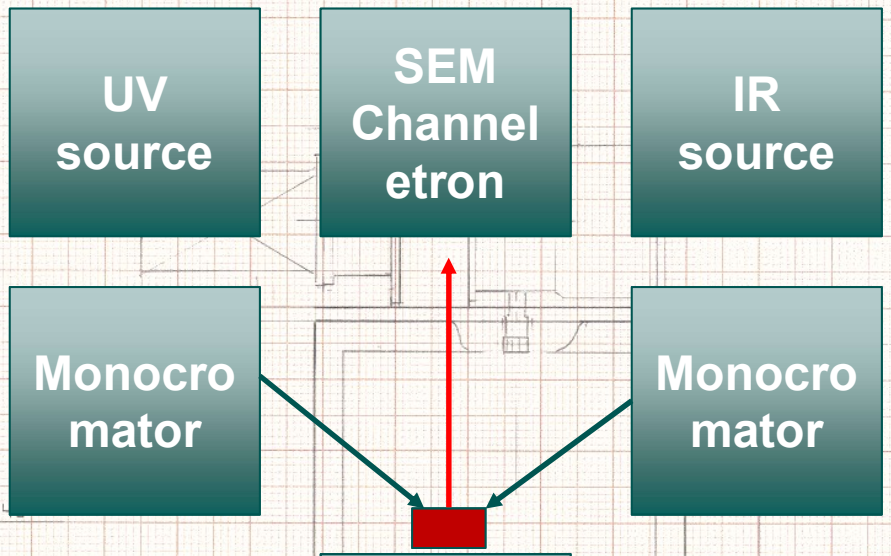


Electron escape depth



Exoelectron spectrometer

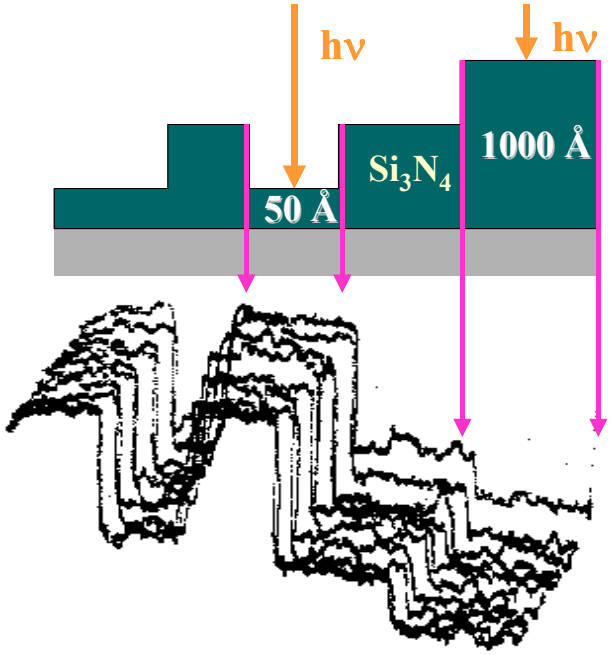




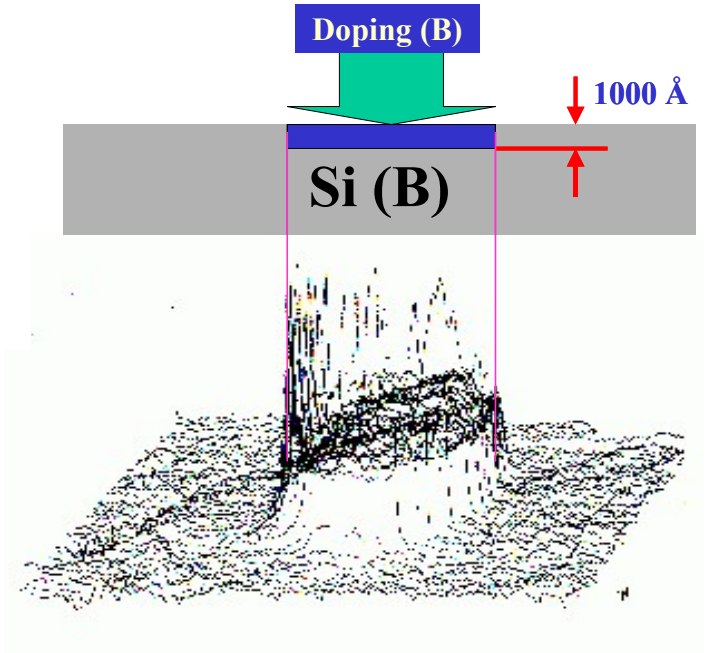
+ Scanning over 50 x50 mm
+ Stretching *in vaccuo*

Photoemission: applications

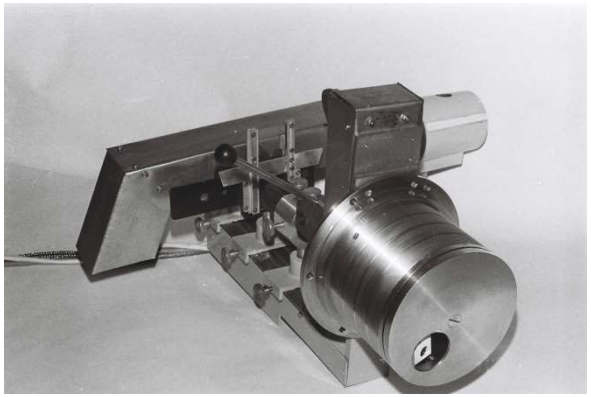
Evaluation of thin film thickness

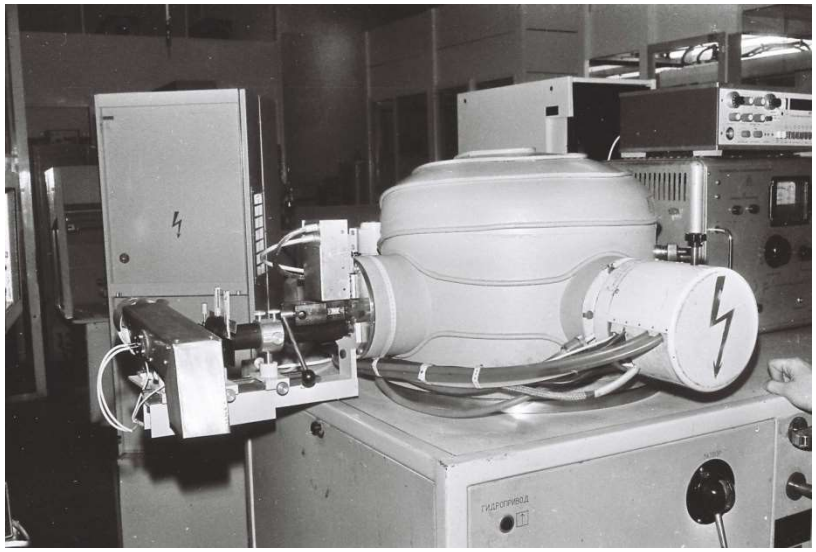


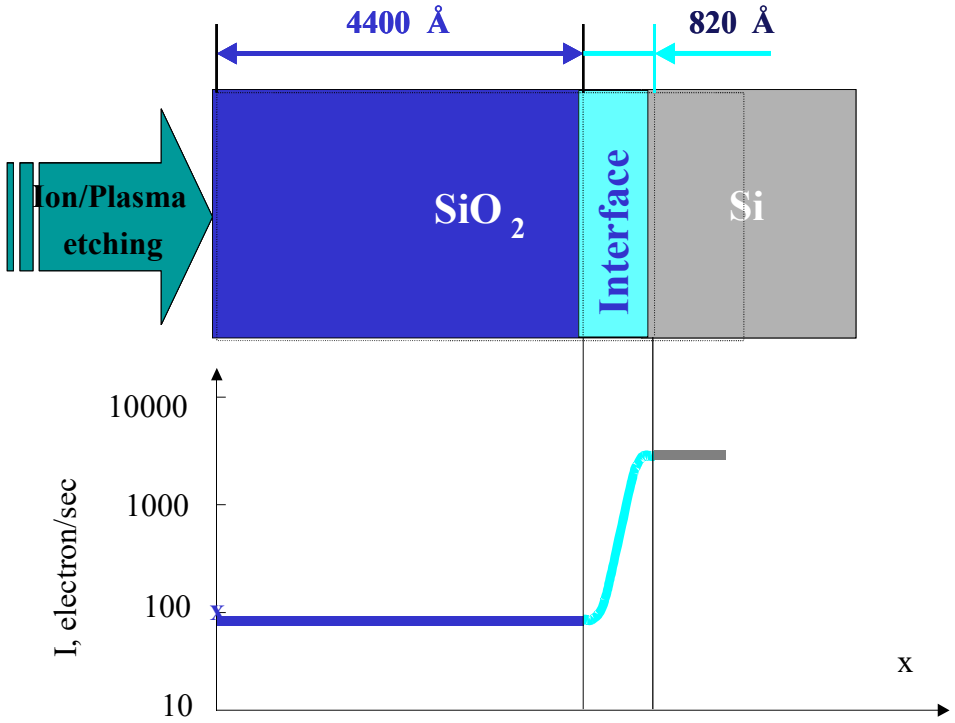
Detection of lattice distortion



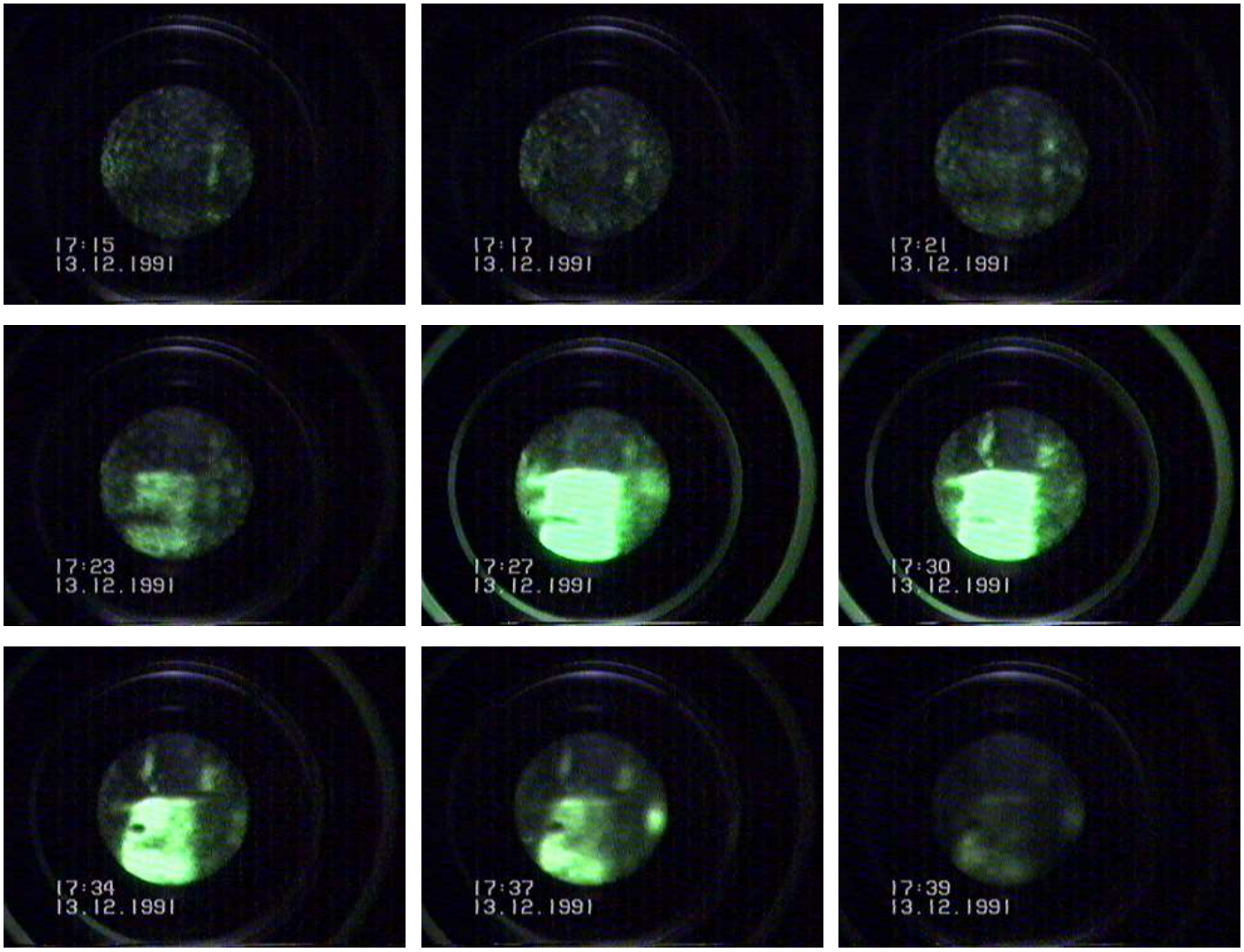
In situ monitoring of the etching process







Exoemission of abraded Al



T: 100 – 550°C

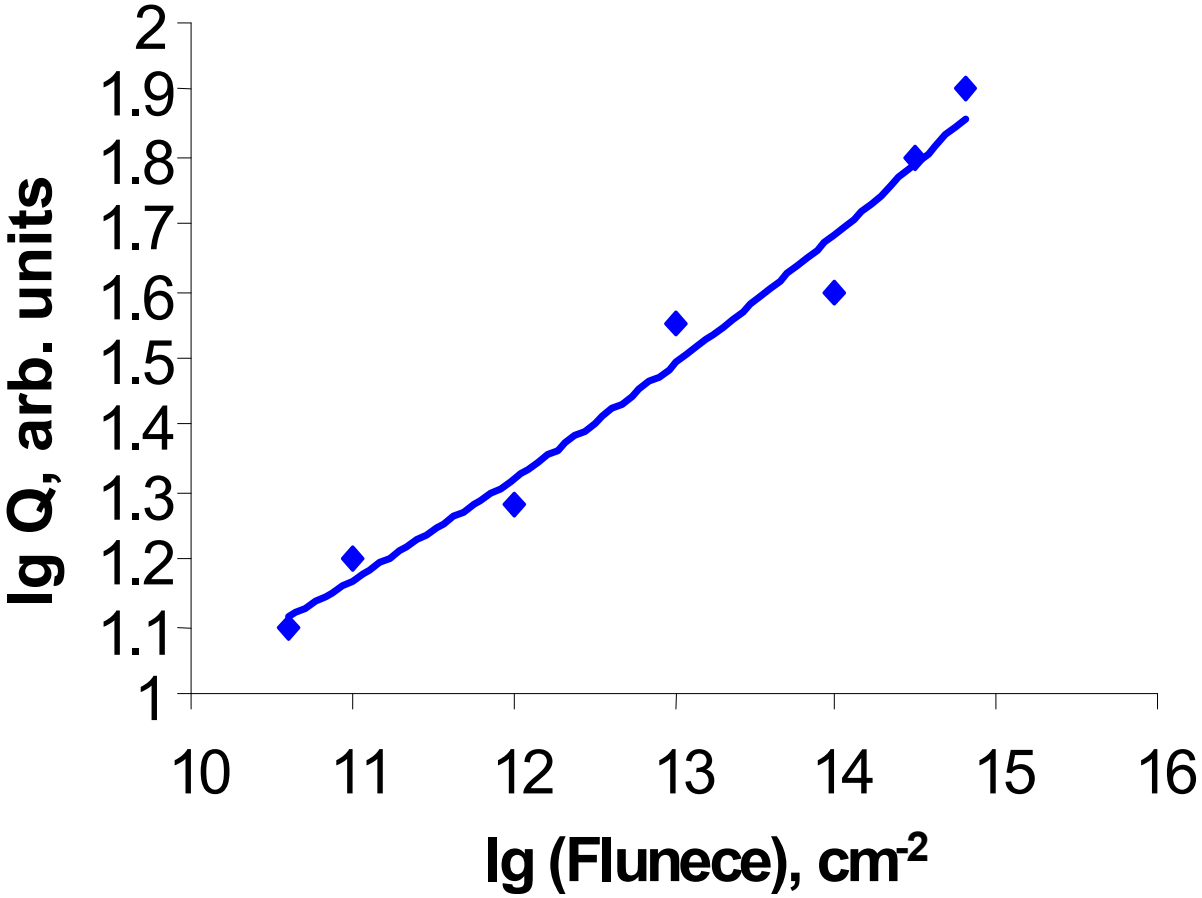
15

Exoemission: Imperfections

Sensitivity

10^{-6} atomic

%



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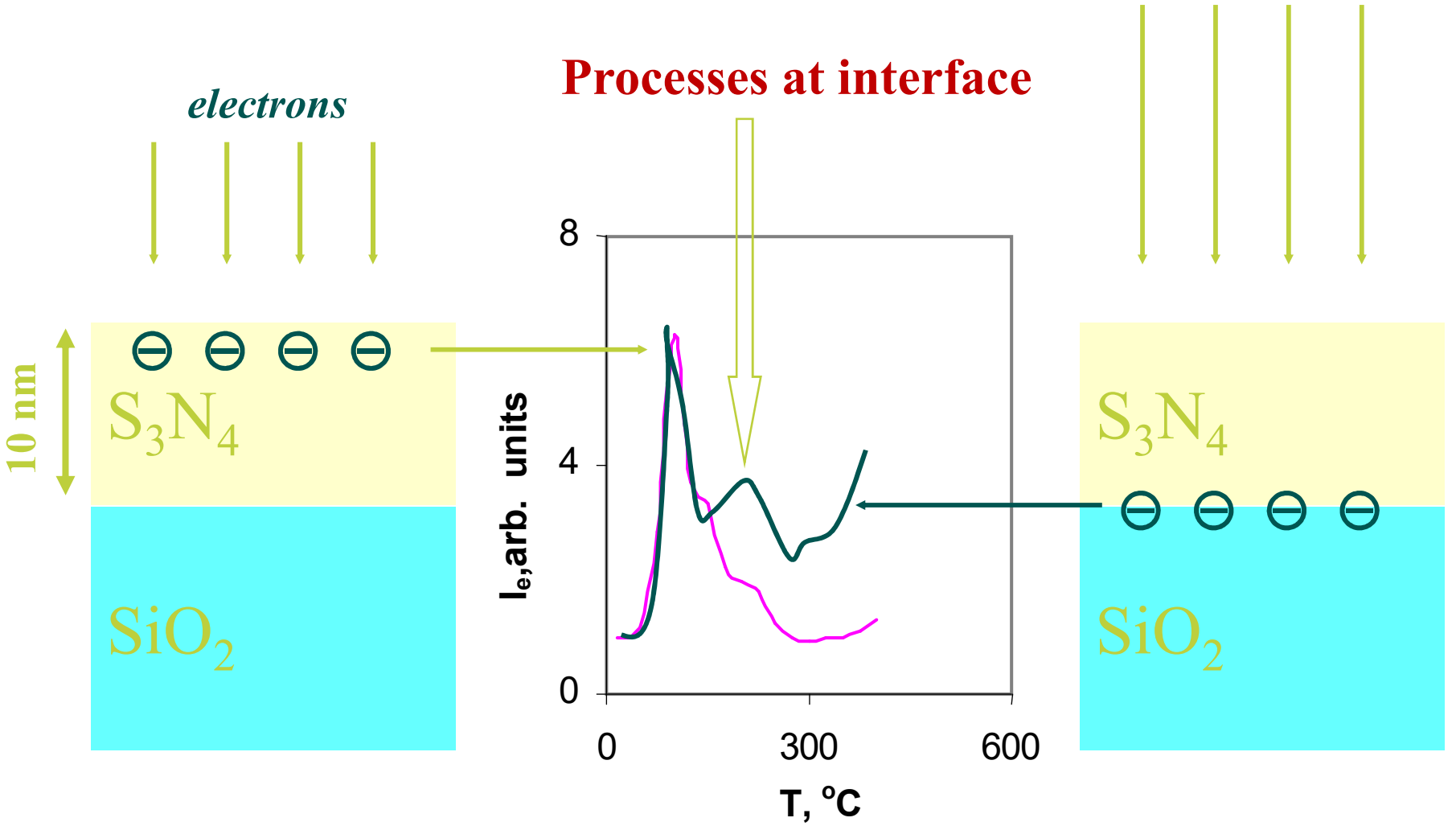
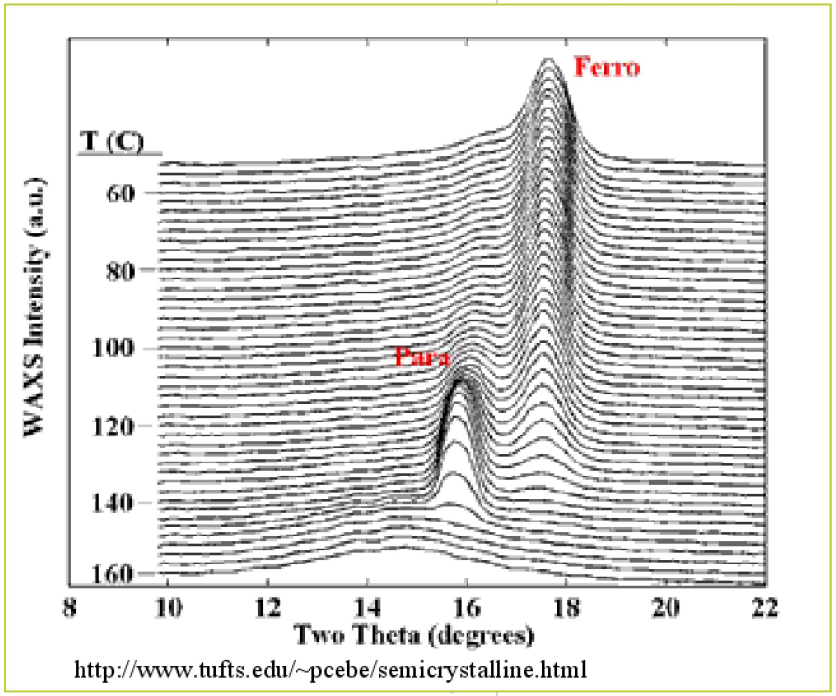
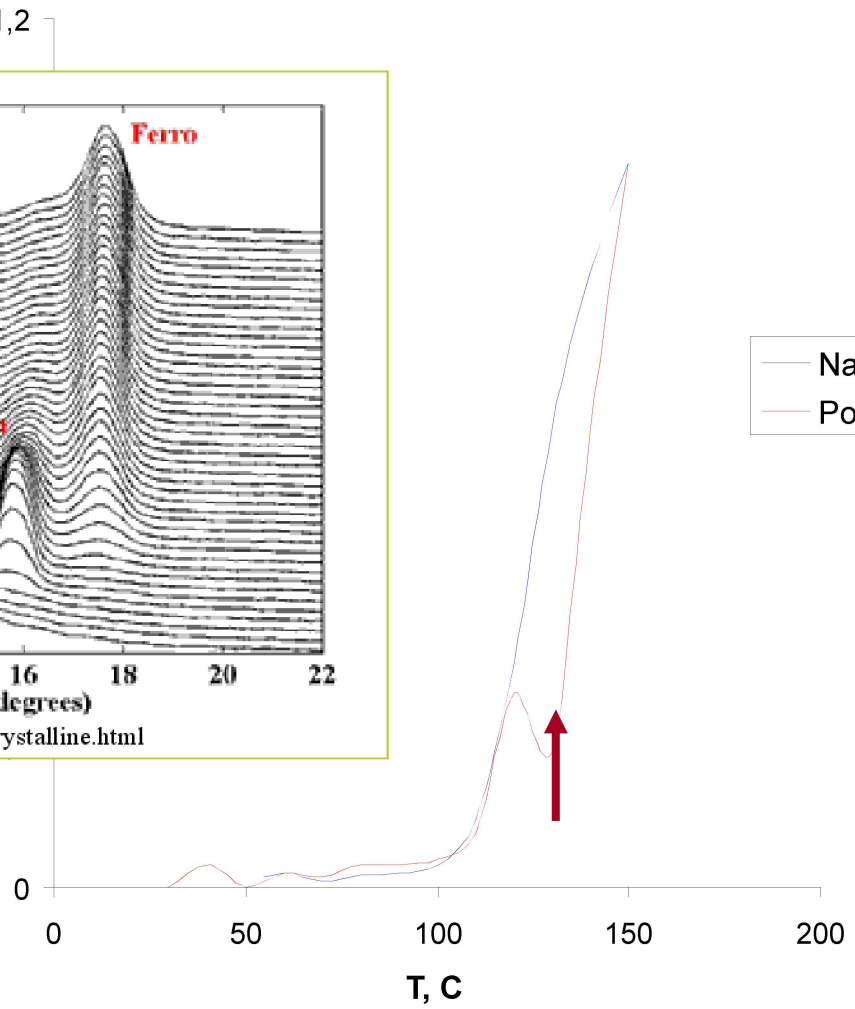
Exoemission: Thin films

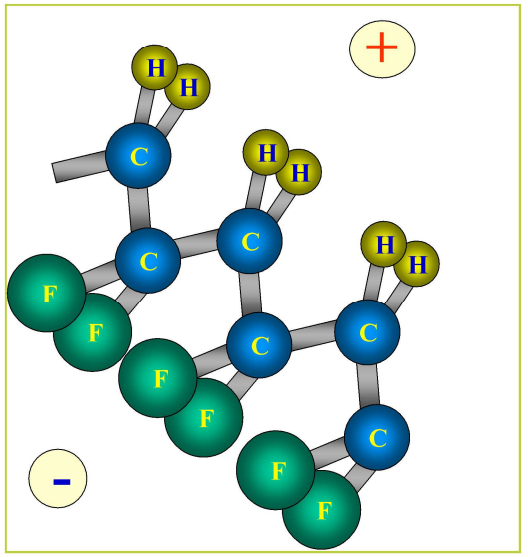


Exoemission: phase transitions



PVDF





2004 – 2007. INTAS projekts 03-51-3967 “Ferroelectricity on molecular level”

Application for Nb on Cu

- **Motivation: explore possibility to apply exoelectron emission technique for early prediction of the Nb coating quality**

Effect of the substrate preparation

	Deposition		
Surface preparation technology	**INFN**	**Universitat Siegen**	**ASTeC**
SUBU CERN	C10	C1	Under processing
SUBU INFN	L20	L1	Under processing
EP INFN	L21	L10	Under processing
EP+SUBU INFN	L16	L23	Under processing
TUMBLING	L8	L9	Under processing

(Yesterday talk by Cristian Pira, 15.40)

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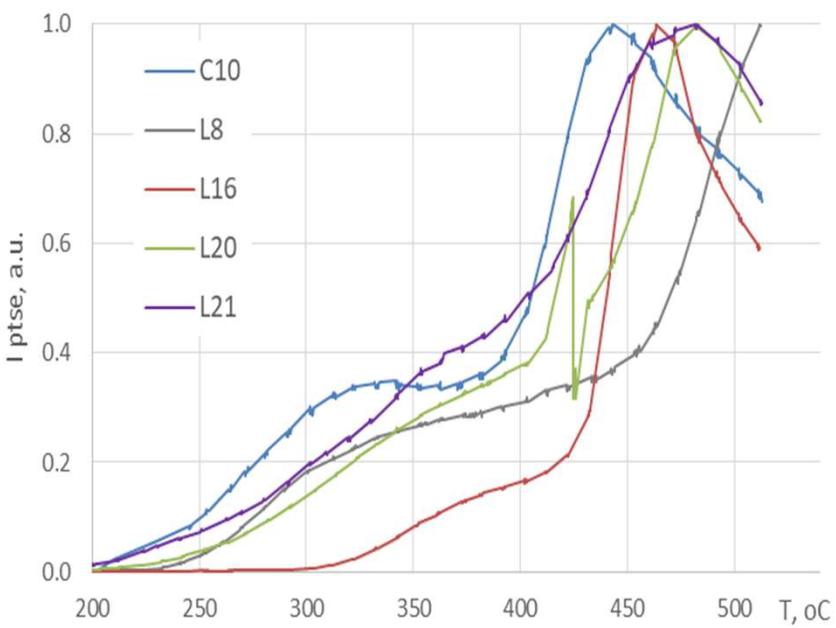
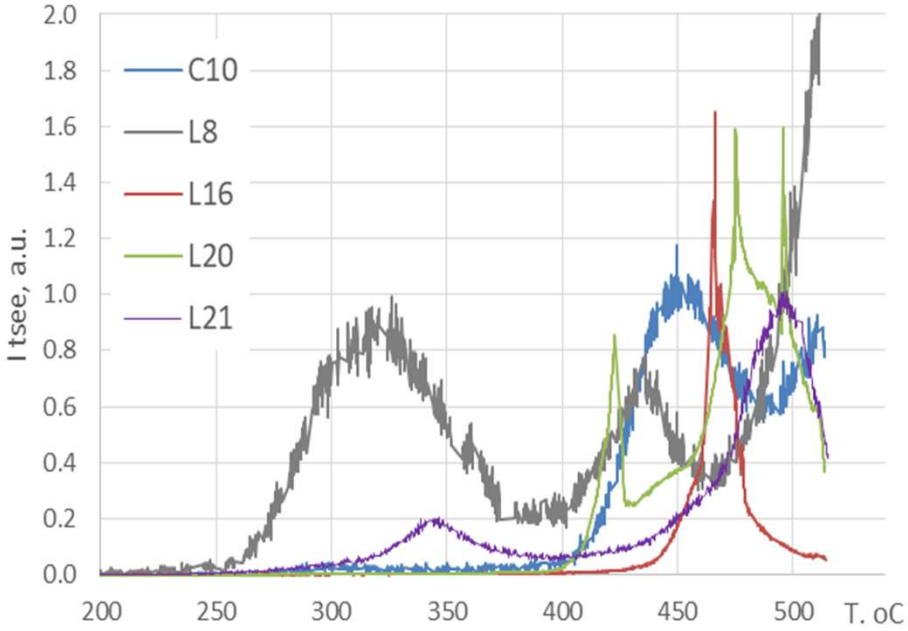
Typical spectra of Nb on Cu samples (INFN batch)

PTSE



TSEE



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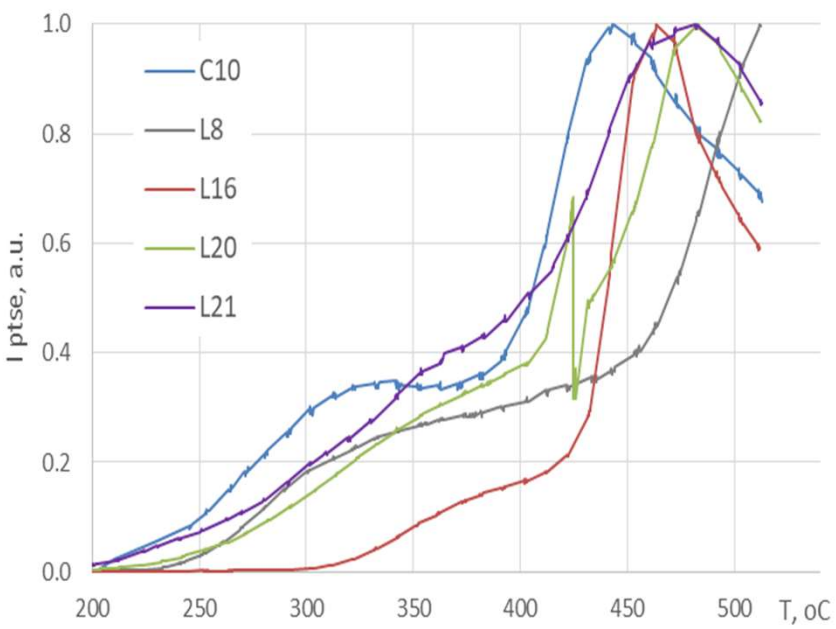
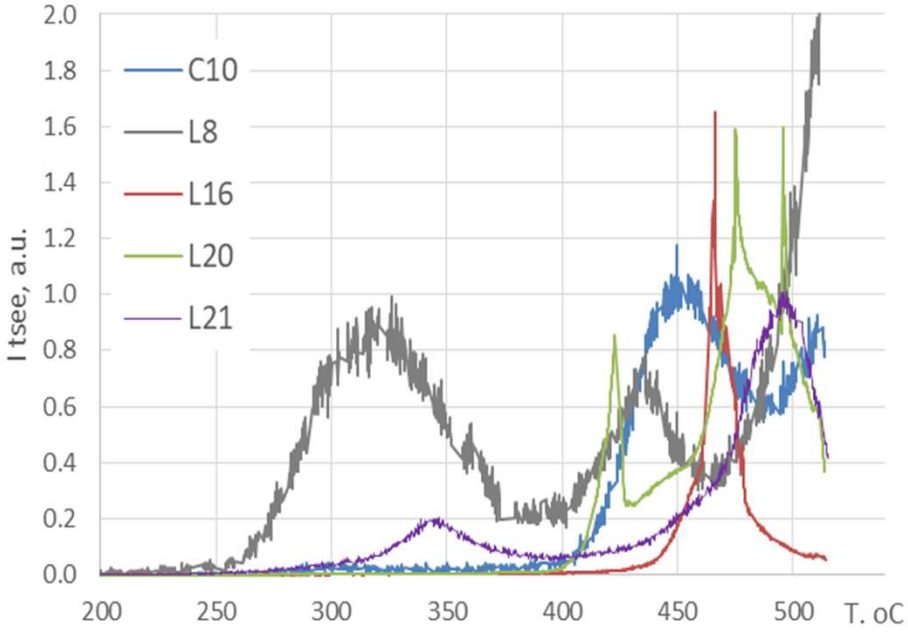
Typical spectra of Nb on Cu samples (INFN batch)

PTSE



TSEE



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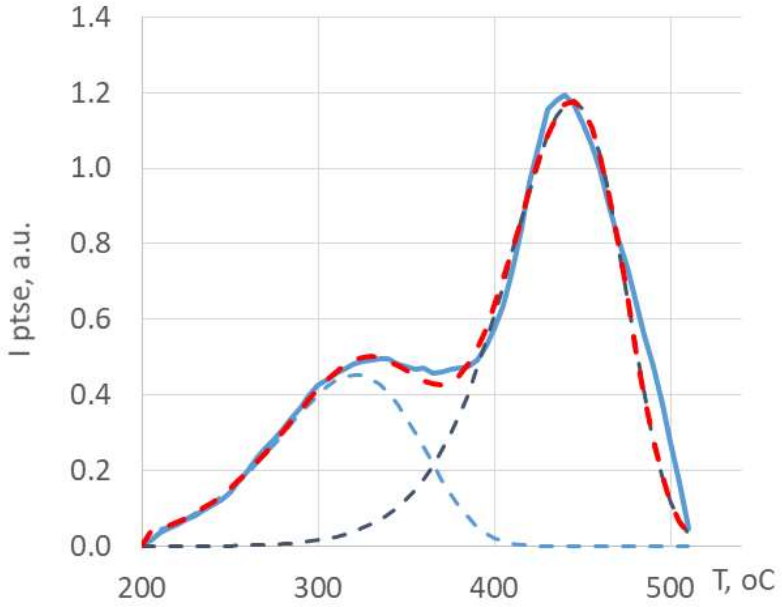
Peaks deconvolution

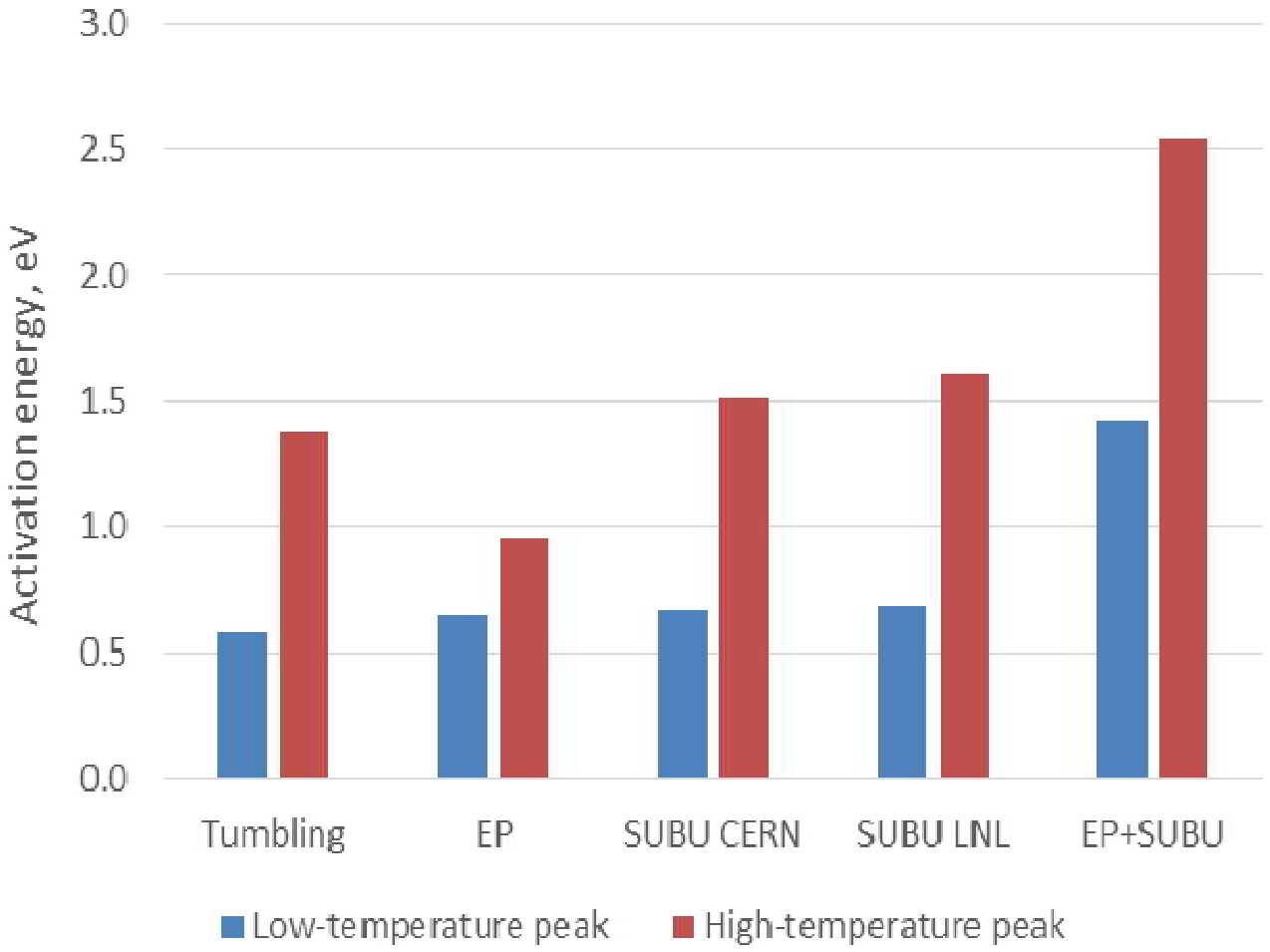


Randal-Wilkins expression

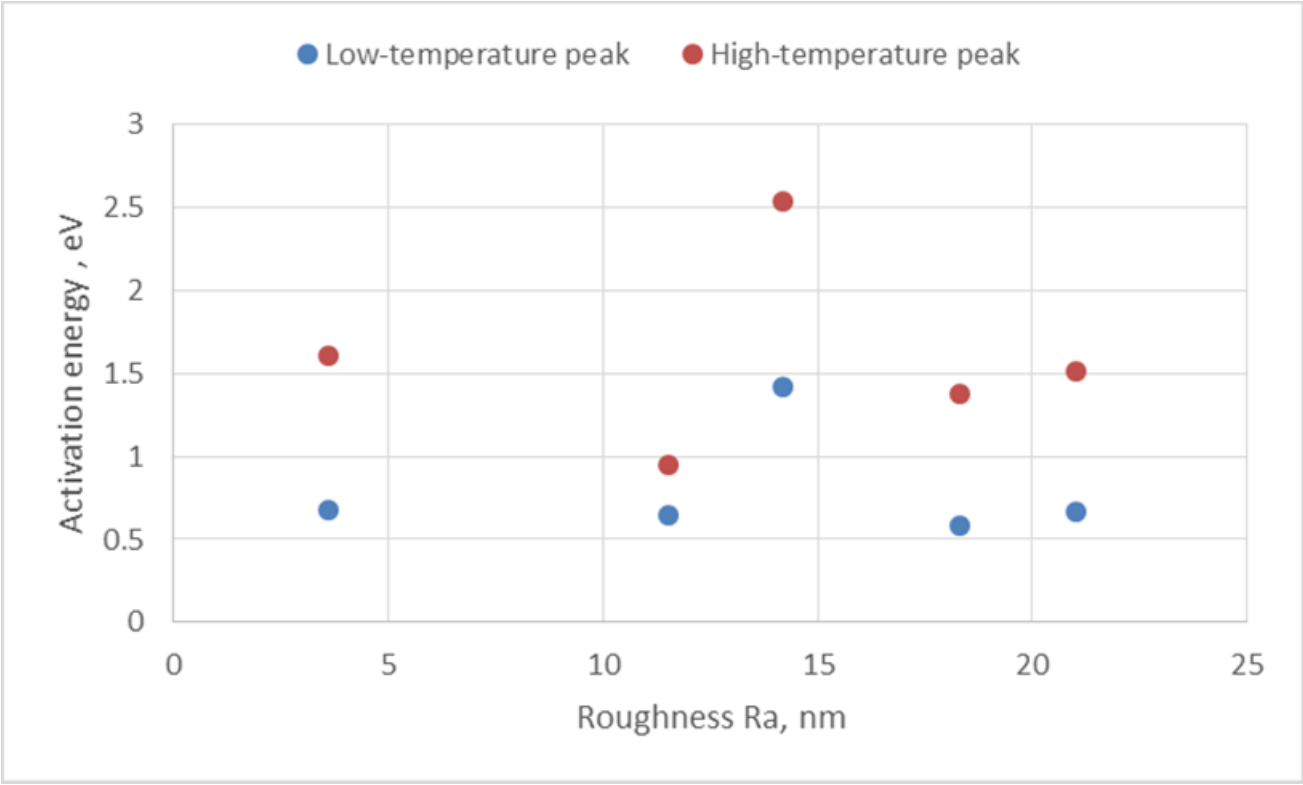
$$I \sim -\frac{dN}{dT} = A \cdot e^{-\frac{E}{kT}} \cdot N(T)$$

Spec.	PTSE				TSEE	
	Low-temperature peak		High-temperature peak		Low-T peak	High-T peak
	T_{max}, °C	E, eV	T_{max}, °C	E, eV	T_{max}, °C	T_{max}, °C
C10	320	0.67	450	1.51	310	450
L8	362	0.58	> 500	1.38	320	425
L16	375	1.42	460	2.54	-	470
L20	370	0.68	490	1.61	425	490
L21	342	0.65	480	0.95	347	500

Activation energies for low temperature and high temperature annealing for different CU substrate preparation technologies



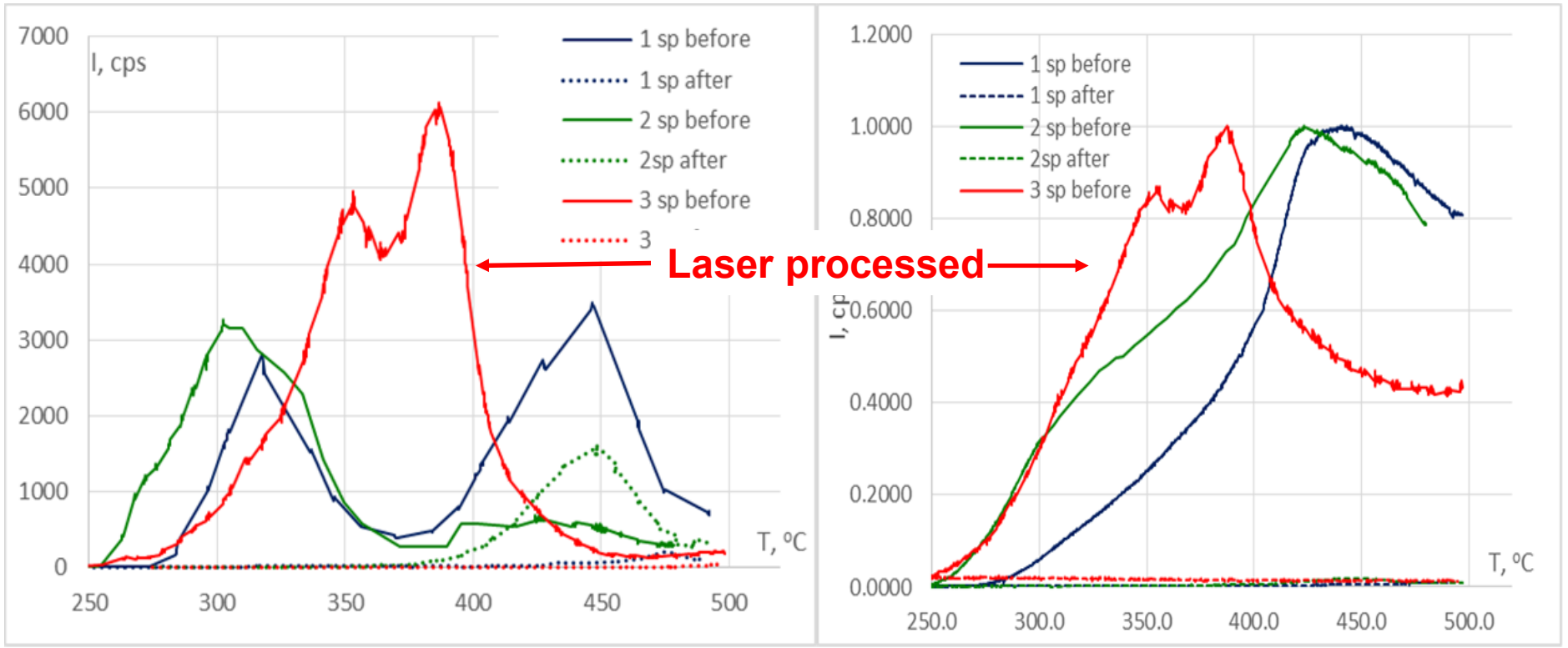
Correlation roughness-activation energy



Effect of the laser processing:

Laser processing by RTU Institute of Technical Physics, prof. A. Medvid
(Yesterday talk, 15.55)

PTSE **TSEE**



Conclusion:

- Spectra of the exoelectron emission of the Nb deposited on Cu and corresponding activation energies indicates that structure / nature of imperfections in the Nb film is changed due to different pre- processing of the Cu substrate.
- TSE/PTSE activation energies does not correlate with surface roughness .
- The position of maxima of the TSE/PTSE spectra of laser – processed Nb suggests that the nature of defects, induced by laser treatment, differs from defects, existed in the film after deposition.
- **The interpretation** of the results required additional research to understand the nature of the introduced defects and physics of TSE/PTSE in Nb and to evaluate prognostic value of the method for the early/ *in situ* prediction of Nb film quality.

Paldies ! (Thank you!)

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