PAUL SCHERRER INSTITUT

Emilio Andrea Maugeri:: Scientist :: Paul Scherrer Institut

Targetry of Rare Isotopes at PSI

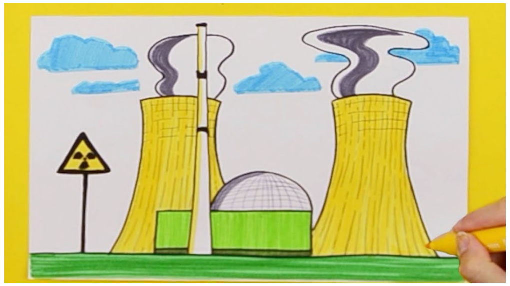
30th Conference of the International Nuclear Target Development Society_ INTDS2022

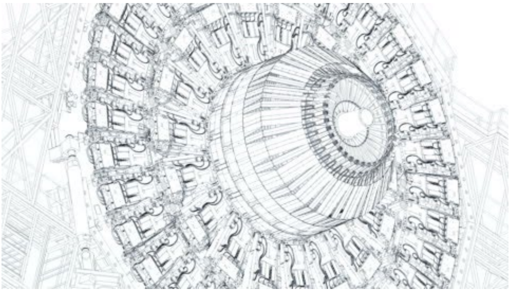
Samples of Radioactive Materials

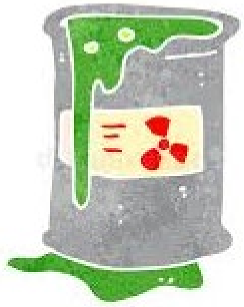
Can not be found in nature

Must be produced in
Nuclear power plant,
Accelerators
Or retrieved from
radioactive waste

Rare and very Costly



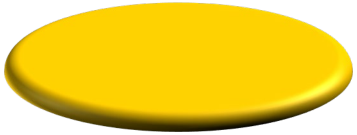




Thursday, 29.09.2022

Session: Isotope production (chair: G. Sibbens)	
9:00–9:30	Water as a target for heavy ion irradiations (*invited* G. Severin, MSU, FRIB, USA)
9:30–9:50	Isotope production at PSI (R. Dressler, PSI, Switzerland)

Samples of Exotic Radionuclides



Sources

Targets

Radiations

Radioactive Ions

Radioactive beam
Radioactive Samples

α- and γ- standard

Nuclear data measurements:
Half-life measurement
Decay branching fractions
Emission intensity

Interaction of radiation with matter
Nuclear industry
Nuclear medicine

PRL **114,** 041101 (2015) PHYSICAL REVIEW LETTERS week ending 30 JANUARY 2015

Settling the Half-Life of ^{60}Fe: Fundamental for a Versatile Astrophysical Chronometer

A. Wallner,[1,2] M. Bichler,[3] K. Buczak,[2,3] R. Dressler,[4] L. K. Fifield,[1] D. Schumann,[4] J. H. Sterba,[3] S. G. Tims,[1] G. Wallner,[5] and W. Kutschera[2]
[1]*Department of Nuclear Physics, Australian National University, Canberra, Australian Capital Territory 2601, Australia*
[2]*VERA Laboratory, Faculty of Physics, University of Vienna, 1090 Vienna, Austria*
[3]*Atominstitut, Vienna University of Technology, 1020 Vienna, Austria*
[4]*Biology and Chemistry, Paul Scherrer Institute (PSI), 5232 Villigen, Switzerland*
[5]*Institute of Inorganic Chemistry, University of Vienna, 1090 Vienna, Austria*
(Received 21 August 2014; published 28 January 2015)

Samples of Exotic Radionuclides

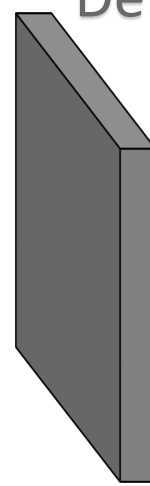
Sources

Targets

Samples of Exotic Radionuclides

Targets

Detector



Particle beam

Synthesis of new elements

(Super Heavy Elements)

Nuclear physics/ chemistry

Cross section measurement

Nuclear astrophysics

Nuclear industry

Thursday, 29.09.2022

Session: Isotope production (chair: G. Sibbens)

9:50–10:10	A Missing link: towards the preparation of a 32Si target for nuclear astrophysics experiments (M. Veicht, EPFL & PSI, Switzerland)

Friday, 30.09.2022

Session: Stable targets II (chair: B. Lommel)

9:30–9:50	Production of PbSe targets for neutron capture cross section studies (N. Chiera, PSI, Switzerland)

Nuclear structure

Fundamental Science

Nuclear physics

Wednesday, 28.09.2022

Session: High power targets (chair: D. Schumann)

9:50–10:10	The PSI Meson Target facility and its upgrade IMPACT-HIMB (D. Kiselev, PSI, Switzerland)
10:10–10:30	IMPACT-TATTOOS as part of the infrastructure roadmap Switzerland initiative: Challenges of the design concepts (R. Eichler, PSI & Univ. Bern, Switzerland)

Synthesis radionuclides for Nuclear medicine applications

Thursday, 29.09.2022

Session: Medical application (chair: E. Maugeri)

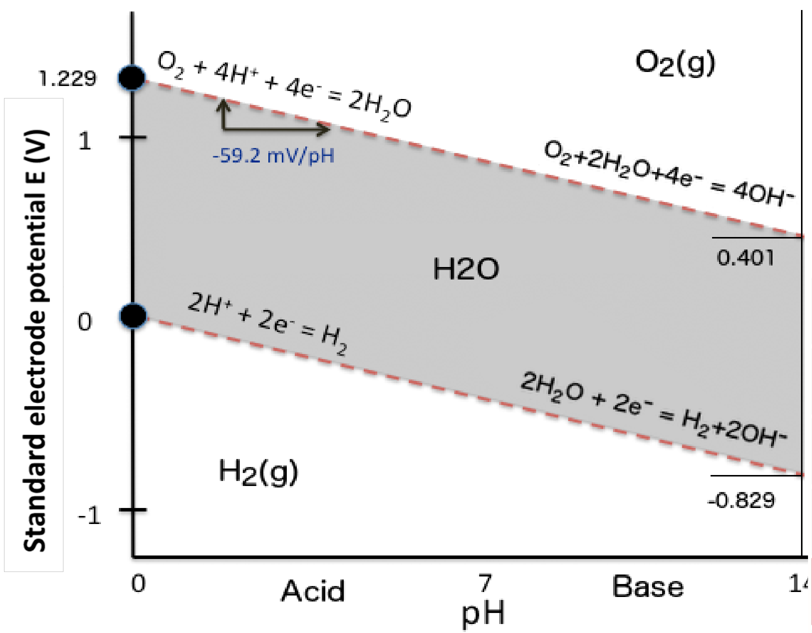
11:20–11:40	Target preparation for radionuclide development towards medical application at Paul Scherrer Institut (Z. Talip, PSI, Switzerland)

Target production: Molecular Plating

NUCLEAR INSTRUMENTS AND METHODS **16** (1962) 355–557; NORTH-HOLLAND PUBLISHING CO.

Electrochemical window

From +1.229 to -0.829



MOLECULAR PLATING: A METHOD FOR THE ELECTROLYTIC FORMATION OF THIN INORGANIC FILMS

W. PARKER

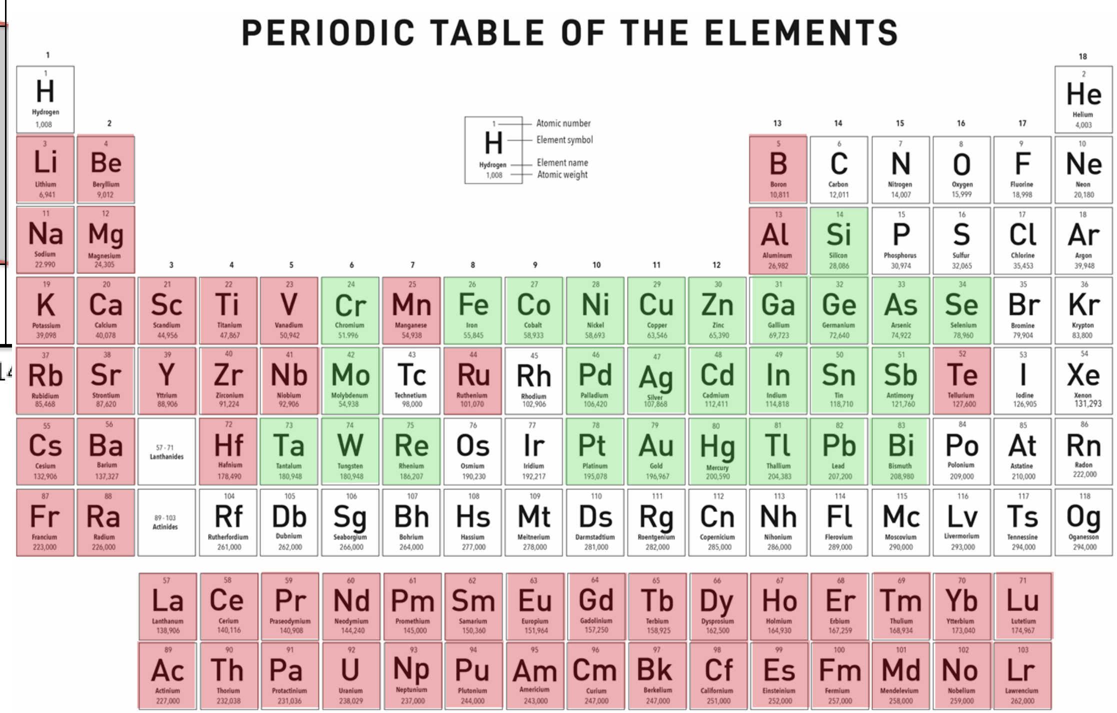
Dept of Physics, Chalmers University of Technology, Gothenburg, Sweden

and

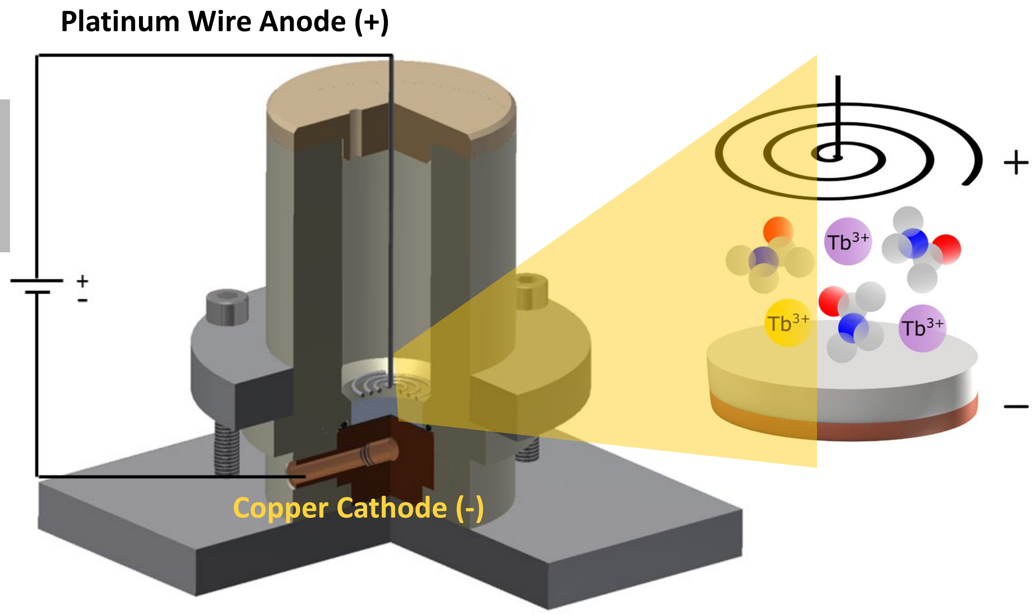
R. FALK

Nobel Institute for Physics, Stockholm 50, Sweden

Received 7 June 1962



Target production: Molecular Plating



- organic solvent,
- starting material: neutral salt, such as $Me(NO_3)x$
- high voltage (100–600 V), low current (few mA)
- **90-95% yield**

$$2\ H_2O_{(l)} + 2e^- \rightarrow H_{2(g)} + 2\ OH^-_{(aq)}$$

$$x\ OH^-_{(aq)} + Me^{x+}_{(aq)} \rightarrow Me(OH)_{x\ (aq)} \downarrow$$

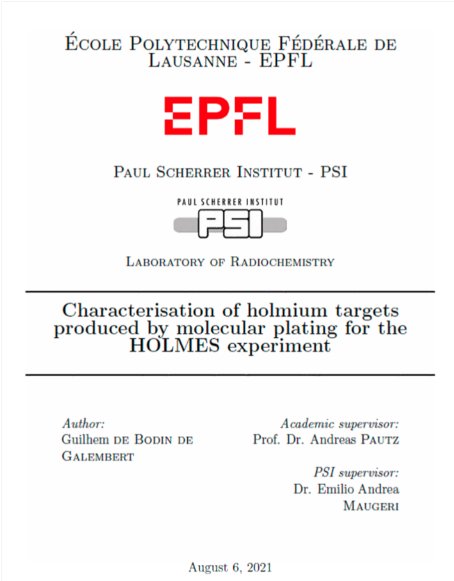
but…

Me^{3+} can also react with other anionic species resulting from electrolysis of the organic solvent resulting into a complex speciation

- **Co-deposition of other elements**

Target characterization: SEM

5 µL of $^{nat}Ho(NO_3)_3 \cdot 5H_2O$ in 0.01 M HNO_3 [0.128 mg/µL]
5 µL 330 Bq of ^{166m}Ho diluted in 0.01 M HNO_3



École Polytechnique Fédérale de Lausanne - EPFL

EPFL

Paul Scherrer Institut - PSI

Laboratory of Radiochemistry

Characterisation of holmium targets produced by molecular plating for the HOLMES experiment

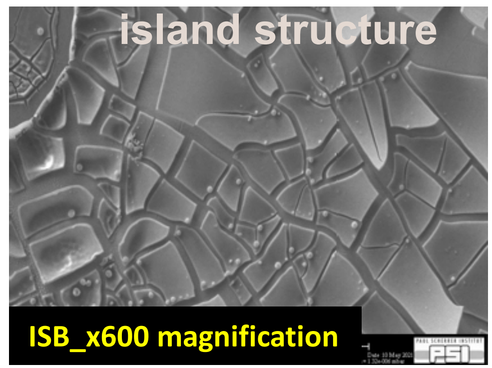
Author:
Guilhem de Bodin de Galembert

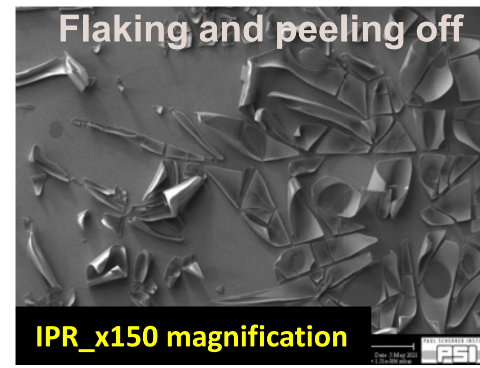
Academic supervisor:
Prof. Dr. Andreas Pautz

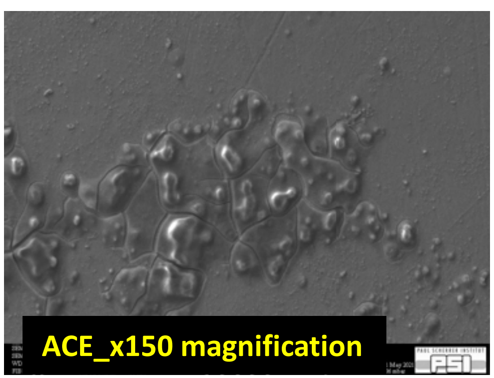
PSI supervisor:
Dr. Emilio Andrea Maugeri

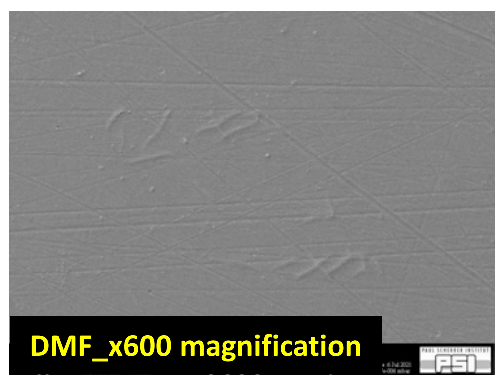
August 6, 2021

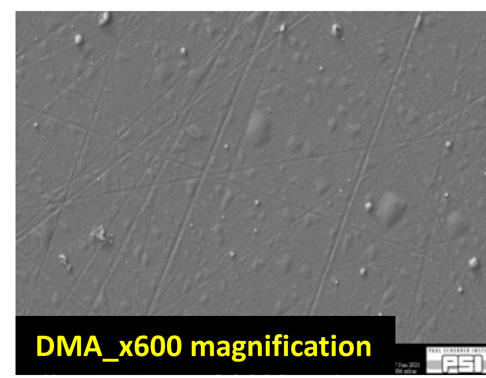
Solvent	Dielectric constant at 20 °C [-] [29]	Vapour pressure at 25 °C [kPa] [30]
Isobutanol	17.93	1.53
Propan-2-ol (Isopropanol)	20.18	5.78
Acetone	21.01	30.80
Ethanol	25.3	7.87
Methanol	33.0	16.94
N,N-Dimethylformamide (DMF)	38.25	0.44
N,N-Dimethylacetamide (DMAc)	38.85[4]	0.17









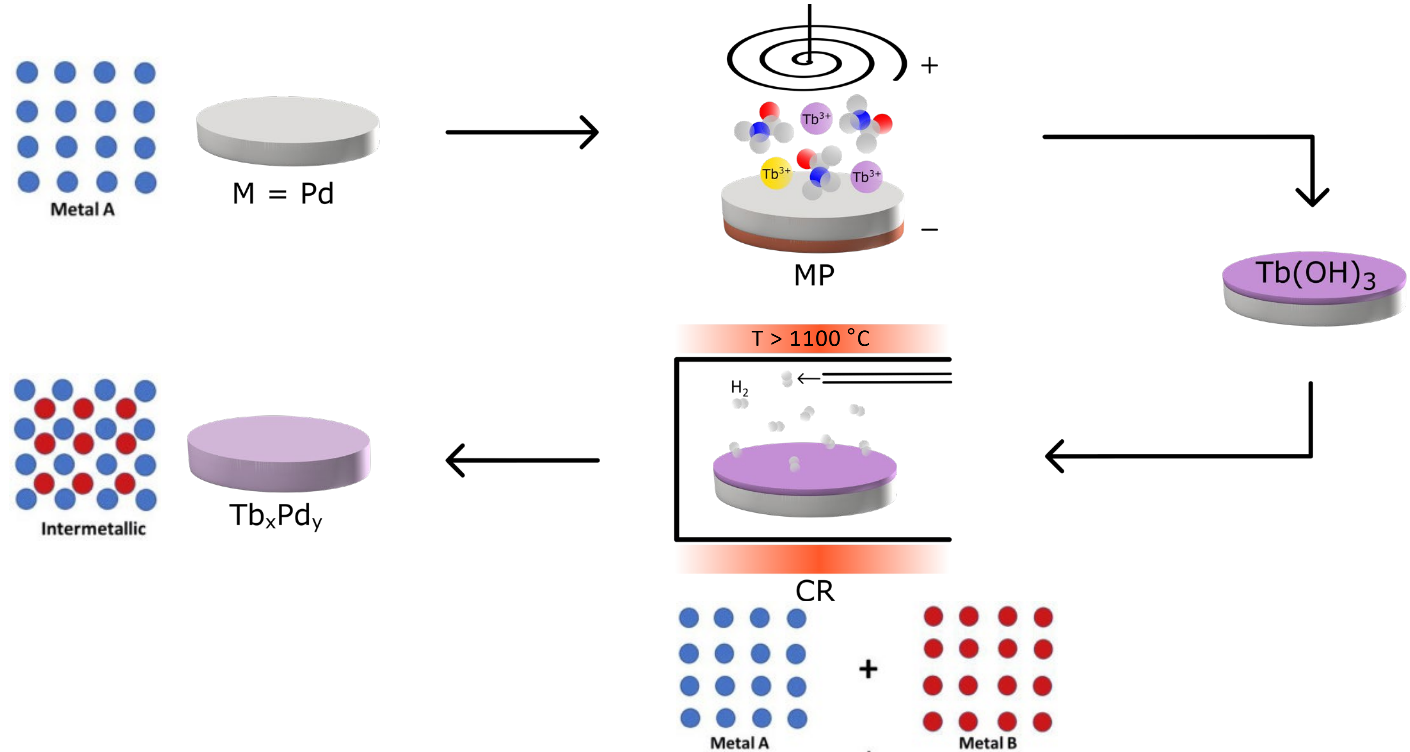


➢ **Less volatile solvent allow obtaining more uniform and thinner targets**

Dr. E. Müller Manager of Electron Microscopy Facility at PSI (EMF)

PAUL SCHERRER INSTITUT

Targetry production: Molecular Plating + Coupled Reduction



Many advantages over molecular plated samples

- High thermal conductivity
- High electrical conductivity
- High chemical stability
- High mechanical stability

….for samples that need to withstand high stress level

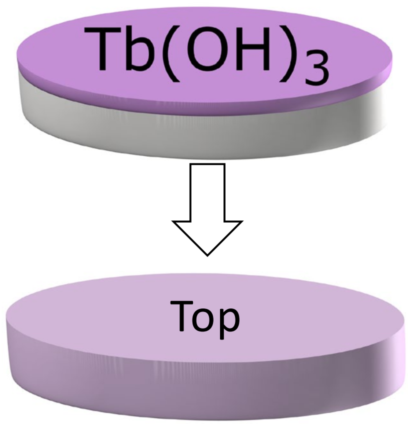
Monday, 26.09.2022

8:30–9:00	Registration (Foyer of the Auditorium)
9:00–9:30	Welcome: A. Pautz (Head of the NES department), C. Stodel (President of INTDS), D. Schumann (conference chair)
Session: Target characterization (chair: K. Eberhardt)	
9:30–9:50	Targetry of rare isotopes at PSI (E. A. Maugeri, PSI, Switzerland)
9:50–10:10	Thickness and uniformity analysis of thin and heat resistant targets (V. Capirossi, DISAT, INFN, Italy)
10:10–10:30	Analysis of thin Tb/Pd intermetallic targets prepared by the coupled reduction reaction (N. Cerboni, PSI, Switzerland)

Target characterization: SEM/ α-spectroscopy/ Auto-radiography

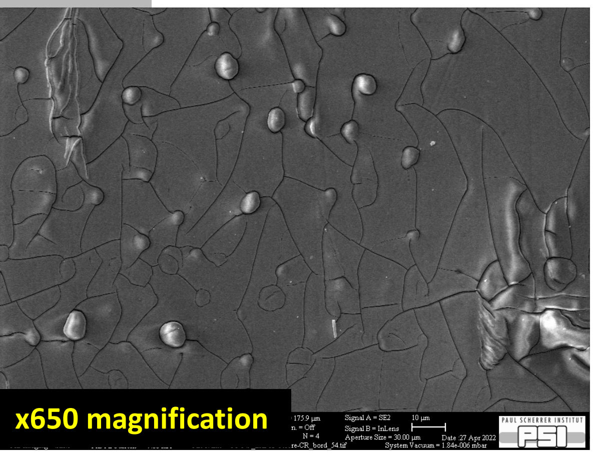
^{149}Tb (10 MBq) as alpha emitting tracer

Sample before CR

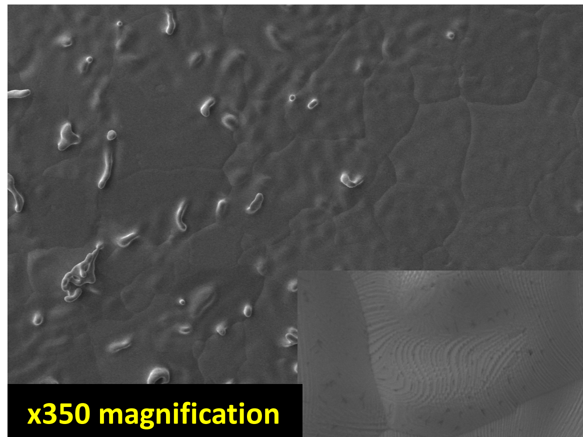


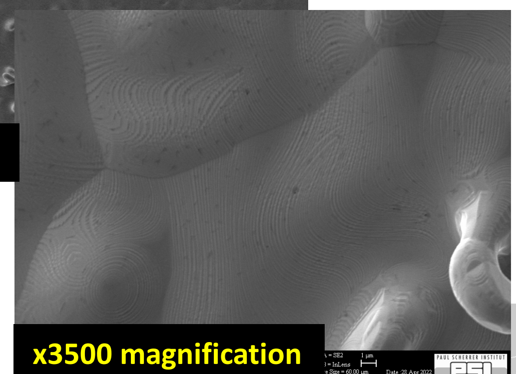
Sample after CR

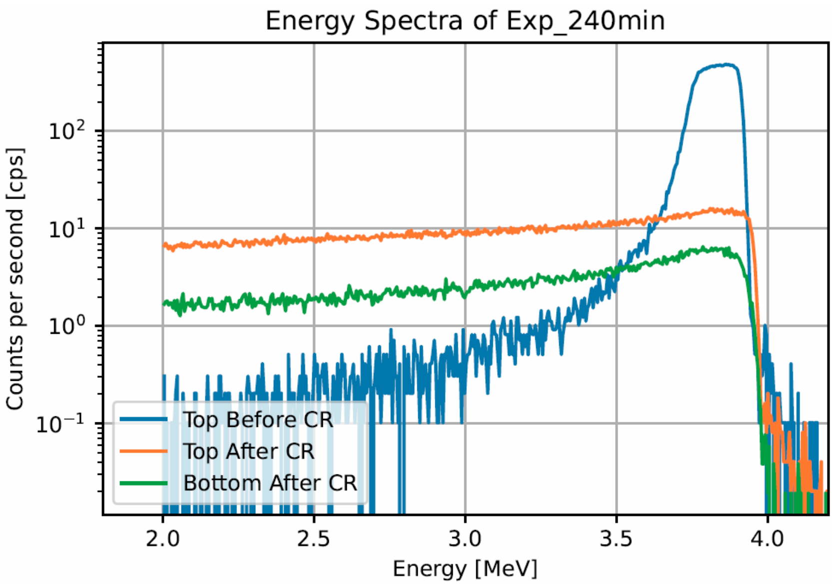
Before CR (Exp_5min)

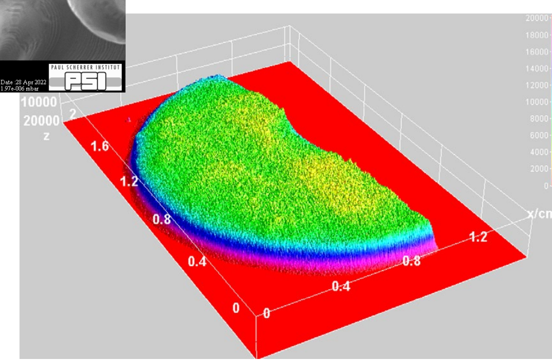


After CR (Exp_5min)



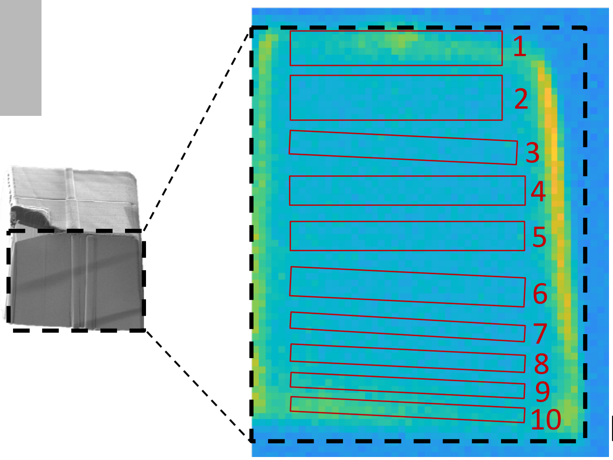






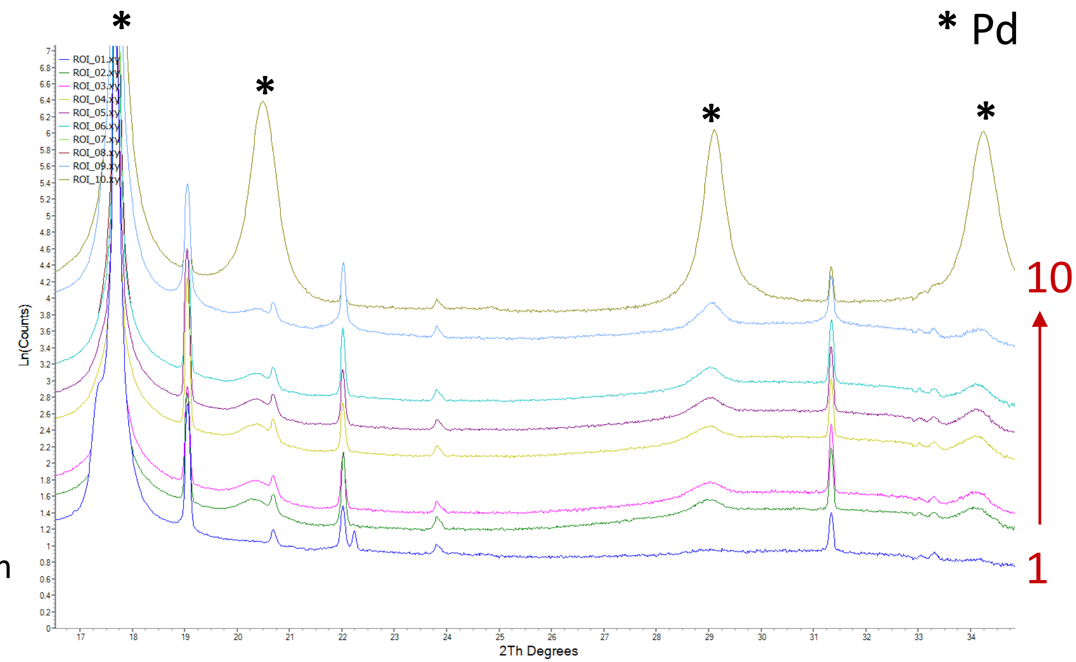
Transmission XRD at SLS-PSI

25 µm



top

bottom



- Pd XRD pattern visible over whole thickness
- Additional XRD pattern → possibly caused by intermetallic

Dr Grazyna Makowska Material Scientist, microXAS group & Advanced Nuclear Materials group

Target characterization at PSI

gamma spectroscopy

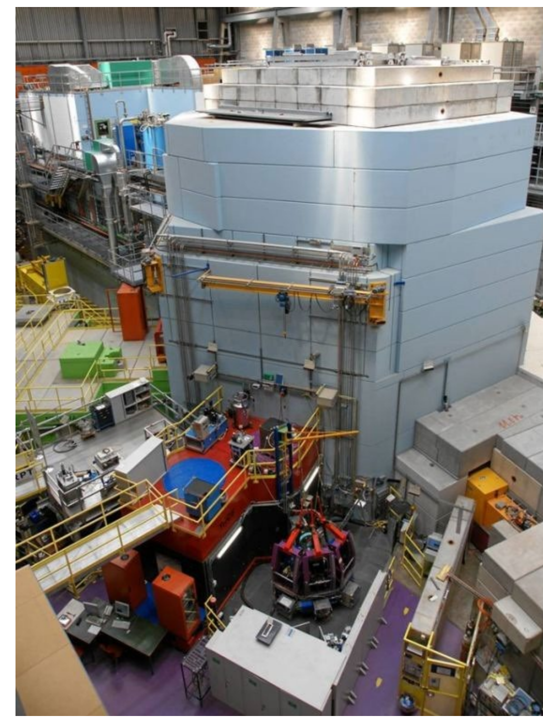
HPGe detector Canberra GmbH

alpha spectroscopy

liquid scintillation counter

TriCarb CA2110 scintillation counter

Neutron Activation Analysis



Inductively coupled plasma mass spectrometry (**ICP-MS**)

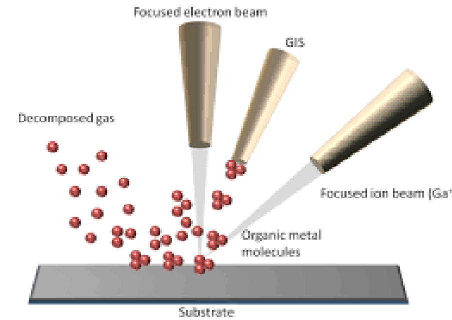
Element 2, Thermo Fisher Scientific,

Inductively Coupled Plasma Optical Emission spectroscopy (**ICP-OES**)

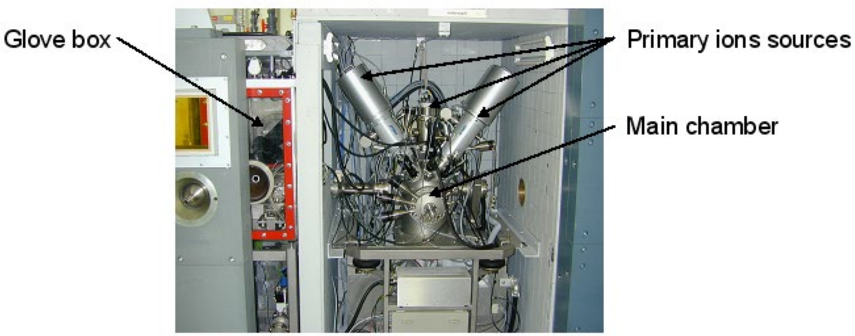
Target characterization at PSI

Scanning Electron Microscopy/EDX

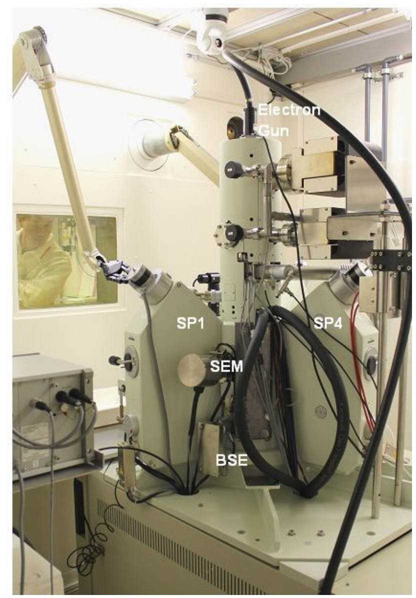
Transmission Electron Microscopy



Focused ion beam



Secondary Ion Mass-Spectrometer



Electron Probe Microanalysis

Thanks to Dorothea Schumann for paving the way for recognition of targetry and, more generally, of chemistry in a "physicists world"

My thanks go to

- Noemi Cerboni
- Guilhem Galembert
- Balàzs Szekér
- Grazyna Makowska
- Elisabeth Müller
- Dressler Rugard
- Eichler Robert
- Tiebel Georg