Institut für Kernchemie

Actinide targets for superheavy element production

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- Target production
- Target characterization
- New developments
- Future tasks
SHE production with actinide targets

Target thickness: 500 µg/cm²

Requirements:
• Chemical purification prior to deposition (if necessary)
• Recovery of used target material (sooner or later…….)
• Small and simple set-up
• High deposition yield

Target production techniques:
• Painting
• Sputtering (²³⁸U)
• Molecular Plating

• E114 ⇒ _2⁴⁴Pu^(48Ca,xn)_
• E115 ⇒ _2⁴³Am^(48Ca,xn)_
• E116 ⇒ _2⁴⁸Cm^(48Ca,xn)_
• E117 ⇒ _2⁴⁹Bk^(48Ca,xn)_
• E119 ⇒ _2⁴⁹Bk^(50Ti,xn)_
• E120 ⇒ _2⁴⁸Cm^(54Cr,xn)_
• E120 ⇒ _2⁴⁹Cf^(50Ti,xn)_
Rotating target wheels for high beam intensities

**Backings:**
- Ti-foils (2 µm) or C-foils
- Foils are glued onto Al-frame

**TASCA target wheel @ GSI:**
- Target area: 6 cm²
- 4 targets per wheel
- 12 mg per wheel @ 500 µg/cm²

**Beam intensities:**
- DC-beam: 1-2 pµA
- Pulsed beam (25% duty cycle): 1 pµA ≈ 4 pµA (Maximum)
Actinide deposition by Molecular Plating

**Diagram:***
- Ultrasonic stirrer
- Cooling water
- Backing: 2μm Ti-foil cleaned with HCl, water, isopropanol
- PEEK-cell
- Actinide compound, dissolved in isobutanol
- Voltage: 100 V - 1500 V
- Deposition time: 3-6 hours

**Caption:**
Cell design according to H. Haba [RIKEN], TASCA05, Oslo, Oct. 2005
Deposition of actinides by MP

- $^{244}\text{Pu}$: 250 kBq
- $^{248}\text{Cm}$: 600 kBq
- $^{243}\text{Am}$: 24 MBq
- $^{249}\text{Cf}$: 550 MBq
Molecular Plating

- Deposition Yield: up to 90% for actinides
- Thickness: 500-1000\(\mu g/cm^2\) possible in a single deposition step
Standard target characterization techniques

**Deposition yield:**
- $\alpha$-particle spectroscopy
- $\gamma$-spectroscopy
- Neutron Activation Analysis

**Layer homogeneity:**
- $\alpha$-particle spectroscopy
- Radiographic Imaging

Properties of actinide layers produced by MP

Studies on layer growth mechanism:
- Scanning Electron Microscopy (SEM) \( \Rightarrow \) \( \mu \text{m}\)-resolution
- Atomic Force Microscopy (AFM) \( \Rightarrow \) 10-100 nm-resolution

Chemical composition:
- X-ray Fluorescence (XRF)
- Photoelectron Spectroscopy (XPS)

[A. Vascon et al., Nucl. Instr. and Meth. A 655 (2011) 72]
• **Polymer-assisted deposition (PAD):**

  Metal-oxide mixed with polymer solution. Spin-coating of silicon substrate with metal-organic film. Target thickness up to 600 $\mu$g/cm$^2$ possible. No irradiation tests with actinide elements so far.


• **Electrodeposition using Ionic Liquids (IL):**

  Ionic organic salts that are liquid at room temperature and serve as solvent for metal ions. Electrodeposition of U from IL already performed.
• **Superhydrophobic surfaces:**

Modification of a substrate with self-assembled monolayer (SAM) of alkyl chains. Homogenous deposition of metal-oxide/nitrate from aqueous solution by simple evaporation of single drops. No irradiation tests with actinide elements so far.

Alternative target production techniques III

- **Intermetallic targets:**

  Molecular Plating of a lanthanide/actinide compound on a Pd backing. Subsequent reduction by heating the target in a hydrogen atmosphere. Formation of intermetallic Ac-Pd phases. First in-beam irradiation tests performed.

  [I. Usoltsev et al., contribution to TAN 11]
Tasks

• Target development for high intensity beams:
  - Explore limits of current target technology
  - Search for alternative backing materials
  - Develop new methods target production
    ⇒ Beam time needed

• Study interaction of target material with backing (Ti) under long irradiation conditions with high intensity beams
  ⇒ Beam time needed

• Availability of facilities where targets (non-irradiated and irradiated) can be characterized with modern analytical techniques e.g. XRF, XRD, XPS, SEM, AFM

• Design of standard target wheel that can be applied at different accelerator facilities
INTDS 2012
26th World Conference of the International Nuclear Target Development Society
Targets for Accelerator-Based Research
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Topics:
- Preparation Techniques for Thin Films and Foils
- Stripper Foils
- Radioactive Targets
- High Power Targets
- Liquid and Gas Targets
- Isotopic Enrichment and Materials
- Target Characterization
- Targets and Coatings for Medical Radioisotope Production

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