Requirements for Pu NIF targets

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High-precision Pu targets are required on NIF

- Targets are \( (b)(3) \) many layers with thicknesses < 1 mm
- Mounted outside a hohlraum
- Indirect drive experiment
A shot campaign of 10 targets/year for 10 years is being evaluated

- Mass of Pu in each target = \( (b)(3) \) thick
- Ripples or steps on one surface
- Targets also have conformal heat shield and tamper
  - Heat shield must be molded or deposited
  - Tamper can be glued
Proposed experiments use $\alpha$-phase pure Pu metal

- Minimal oxide/hydride layer (if any)
  - $\alpha$-Pu oxidizes more rapidly than $\delta$-Pu
- Grain size approximately 10 $\mu$m
  - Ability to control grain size desired
- After rippled pattern is created, sample cannot be heated above 125° C
  - $\alpha \rightarrow \beta$ phase transformation (11% density change)
ES&H requirements at NIF require that targets are fabricated from Pu-242 or Pu-244

- The Site-Wide Environmental Impact Statement allows only “specially prepared plutonium” without an inner containment system at NIF
- Experiments on Pu-239 (weapons-grade) would require an extremely expensive inner containment vessel
- Pu-242 and Pu-244 will be permitted for experiments on NIF without complete containment
  - Best practice: capture as much material as possible
  - Any material lost to the NIF target chamber counts against an experimental activity limit

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Relative radioactivity of available material</th>
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<tbody>
<tr>
<td>$^{239}\text{Pu}$</td>
<td>1</td>
</tr>
<tr>
<td>$^{242}\text{Pu}$</td>
<td>$1/14$ (8 grams available)</td>
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<tr>
<td>$^{244}\text{Pu}$</td>
<td>$1/64$ (1 gram available)</td>
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The proposed fabrication path for Pu targets involves many processing and metrology steps.

1. Input: $^{242}$Pu metal
   - Receive purified “ingots” from B151

2. Form a blank
   - Re-melt metal, form near-net shape
   - Grain size refinement, polishing

3. Shaping operations
   - Manufacture parts with diamond turning lathe (coining?)

4. Layering and metrology
   - Apply materials to back and front
   - Polishing and interferometry

5. Assembly
   - Assemble final package

6. Ship to experimental site
   - Release part in a container for transport

Not to scale
Metrology and material characterization are essential throughout the fabrication process

- Ripple height, quality
  - Interferometry (Veeco, Zygo)
- Pu thickness
- Density
- Heat shield thickness
- Stack thicknesses (including glue thicknesses)
Ideally, fabrication would occur in a single laboratory, but we are investigating options for utilizing existing facilities at LLNL

- Workspace requirements
  - No (or minimal) contamination with Pu-239
  - Dry, oxygen-free workspace
  - Meets ES&H requirements for Pu
    - Containment vessels could be utilized to control contamination in clean equipment

- Essential equipment
  - UHV furnace
  - Interferometer
  - Polishing equipment
  - Method for fabricating ripples
  - Deposition system (depends on target materials)
  - Assembly space
ES&H requirements vary depending on each fabrication process

- Machining and polishing likely require a Type III workplace (glovebox)
- Depending on location, other steps can occur outside glovebox
  - Containment vessels
  - Hood
  - Example: metallography (imaging) in Superblock occurs in the open laboratory
Challenge for working group: fabricate Pu targets for NIF utilizing existing LLNL equipment in multiple locations, or propose alternative fabrication techniques

- **Summary of processing steps**
  1. Melt Pu “ingot” from B151
     - Refine grain size
  2. Create rippled pattern on surface
  3. Apply heat shield and tamper
  4. Assemble physics package on hohlraum