Techniques for Increasing Foam, Plastic, and Foil Yield*

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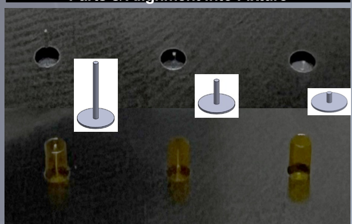
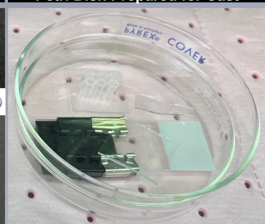
RESORCINOL FORMALDEHYDE FOAM

Bulk CHI rods (3 at% Iodine) were cast on mandrels and machined into rods with table-tops. The tables had a 1.05 mm OD and the rods were 0.15 mm in OD with varying lengths (1.8, 0.75, 0.3 mm). Kapton tubes (also 1.05 mm OD) were cut to 1.8 mm in length. To center and align the CHI tables to the Kapton Tubes, a fixture was laser cut to snugly hold the assembly during the casting of Resorcinol Formaldehyde Foam (RF). Binder clips held the fixture to a glass slide, and a second slide was used to level off the RF on top of the tubes. The RF cured in the oven, then the fixture and parts were cut free. Contact Radiography (CR) was used to show rod alignment to the tubes.

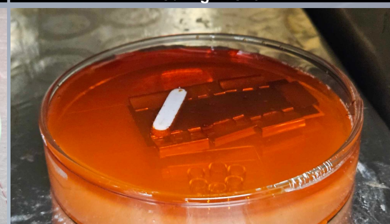
Parts & Alignment into Fixture



Petri Dish Prepared for Cast



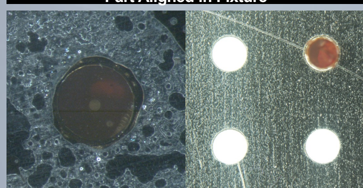
RF Curing in Oven



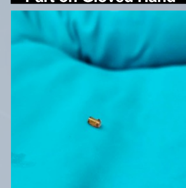
Removal of Parts

Freeing Fixture

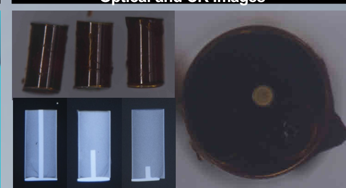
Part Aligned in Fixture



Part on Gloved Hand



Optical and CR Images



RF Casting Tips & Future Tests

Fixture Design
- A maximum of 10 µm of space is needed between the tubes and the fixture holes.
- Fixture holes should be spaced 3x the length of the tube apart (~6mm) for sufficient working room for unobstructed tweezer access.
- Extend width of the fixture beyond that of the glass slide to allow for space to clamp the fixture to the slide.

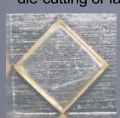
Casting Techniques
- Place rods into the fixture first, then place the Kapton tubes. Check tube-rod alignment prior to casting with a microscope. Fixture should preserve alignment.
- Top glass slide should be cut to size to cover the tubes, but not be obstructed by the clamps.
- A non-magnetic weight should be used to hold down the top glass slide that levels the liquid RF in the tubes.

Other Notes
- Previous RF orders had the CHI table fixed inside the Kapton tube – the concern here was that the rods and tubes were often not aligned to the same vertical axis. By seating the table outside the tube, the vertical axis of the rod stayed more aligned to the walls of the tube.
- There is still room for improvement to the centering of the table and rod to the center of the tube.

PLASTICS & SiO_2 AEROGEL

CD & CD2 Plastic Foils

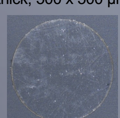
Deuterated plastics can be synthesized and heat-pressed to desired thicknesses before die-cutting or laser-cutting to shape.



NeutronTime-J, CD square, 100 µm thick, 500 x 500 µm

MTW Product, CD square, 20 µm thick, 500 x 500 µm

TNSAion, CD circle 100 µm thick, 1.4 mm OD

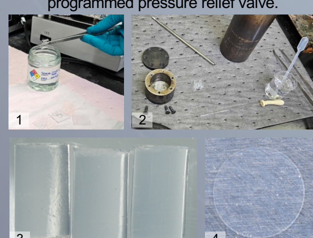


Titan JLF Neutrons CD circle, 20 µm thick, 3 mm OD

CD2 275 µm thick foils for Magnetic Recoil Spectrometer

SiO_2 Renewed Capability

The PARR reactor vessel utilizes a temperature-driven process regulated by a programmed pressure relief valve.

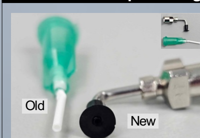


Process Images

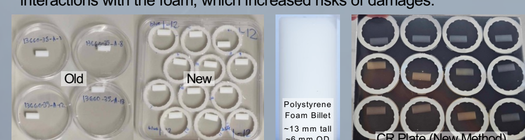
1. PAMS coating of molds to facilitate the release of cured SiO_2.
2. Progressive layering of molds and reactant solution within the PARR reactor chamber.
3. FMS synthesized 3 mm OD SiO_2 billets to be machined by the Center for Precision Machining (CPM).
4. Final parts produced are SiO_2 Aerogel disks that are 160 µm thick with a 3 mm OD.

GACH FOAM

Simple Changes → Increased Part Yield (⇧12.5%)



- Old: The green, plastic vacuum tip (~1 mm) tended to jab into and dent the foam ends.
- New: The wider, rubber vacuum tip (~5 mm OD) allows the operator to be more delicate when picking up the foams, as the rubber end can give way instead of the foam and distribute the suction power across its end.
- Old: In individual petri dishes (54 mm OD), foams would reorient themselves due to static or air flow. Sometimes the lid would be placed back down onto a foam at an angle and squish the part. For CR, the operator had more direct interactions with the foam, which increased risks of damages.



- New: Somar Rings (3 cm OD) with XRF sample support windows allow a group of 12 foams to be held in a single tray (12 cm x 12 cm). Here, the foam does not cling to the container. When the foams need to be moved onto a CR plate (12.6 cm x 10 cm), the operator can grab the Somar Rings without interacting directly with the foams. Also, the Somar Rings' 2.3 cm ID allows for the vacuum tip to reach in and pick up the foam from one of its flat ends.

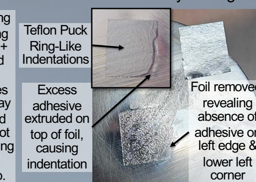
BERYLLIUM FOILS

Typical Be Foil orders start with a laser cut foil at a given thickness that then gets polished down to the desired thickness and smoothness. Most orders are for 25 µm or 40 µm 3 mm OD circles, with a thickness tolerance of +/-2 µm. Other geometries may be 2-5+ mm OD circles, or 2x2-4x4 mm² squares, with thicknesses usually between 25 and 280 µm. Less often, there are requests for foils that are only 5 µm ±1 µm thick – these are super thin foils. Tactics for super-thin foil polishing are elaborated below.

Obvious Mounting Defects → Immediately Retry

While reducing a foil's thickness is the end goal of polishing, the mounting of the foil (~12.5 mm x 12.5 mm) to a polishing puck (57.15 mm OD) is critical in achieving a flat foil whose opposing faces are completely parallel. This is especially true for super thin foils (<10 µm thick). The thinness of a Be foil under 10 µm allows the foil to bow and curve to the shape of the adhesive or FOD (foreign objects & debris) between the foil and the polishing puck. Polishing the foil while these features exist results in pits or holes. When bubbles or FOD is visually observed after a mounting attempt, there is no need to perform a WYKO measurement, and the foil can immediately undergo another mount.

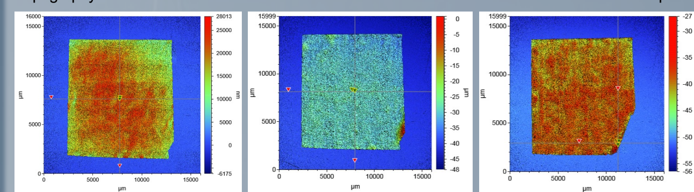
First mounting attempt using an Acetone + Crystalbond Spray. Microbubbles from the spray and adhered FOD were not extruded during the press-cooling step.



Lessons:
- Using less adhesive tends to reduce foil surface variation.
- Use wooden edge (not end) of a cotton swab to spread the adhesive more evenly before placing the foil and use the cotton end to press smooth the Be Foil while the adhesive is in a flow state.
- Wipe excess adhesive before arbor-pressing.

White Light Interferometry (WYKO) Data Needed to Observe Subtle Flaws

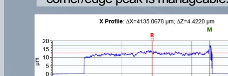
Only WYKO analysis can confirm that a mounted foil is indeed sufficiently flat. Below, common topography variations are noted for a ~12.5 mm x ~12.5 mm hand-cut Be foil after mount attempts.



1st Attempt: Top right corner is too low (green). The adhesive needs to be spread thinner in the higher (red) areas by massaging raised areas with a cotton swab or by removing and cleaning the foil for remounting the to a new spread of adhesive.

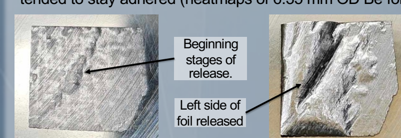
3rd Attempt: Pinched bottom right corner, raised. The foil may have got caught and folded up while the underlay of adhesive was being smoothed, or the adhesive was not completely melted when the foil was pushed with tweezers.

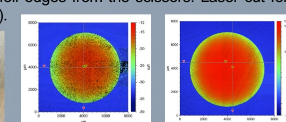
5th Attempt: Corner bend cut away. The ~5 µm corner/edge peak is manageable.



Clean, Laser Cut Edges

Attempts to polish ~12.5 mm x ~12.5 mm hand-cut Be foils often led to releasing of the foils during polishing. This is likely due to microtears on the foil edges from the scissors. Laser cut foils tended to stay adhered (heatmaps of 6.35 mm OD Be foil).





Mounted and Polished Foil with Laser Cut Edge. 800 grit and 6 µm Diamond Paste Polishing Steps.

Final Notes for Maximizing Super Thin Foil Polishing Yield (33%⇨66%)

- Typical foil orders (25/40 µm) tend to have the best results from removal of ~7 µm of material per side, whereas for super thin foil orders (5 µm), the less material removed the better.
- Smaller removal amounts lead to less stress in the foil and fewer polishing steps that could rip the thin, fragile foil apart. 2 µm of foil removal is ideal for super thin foils.
- For super thin foils, even with a near-perfect mount, excessive removal using 800 grit sandpaper may cause the foil to tear release. Instead, use new polishing pads & 6 µm Diamond Paste.
- Future tests should explore exchanging 800 grit sandpaper with 15 (or 30) µm Diamond Paste: the polishing pads for DP tugs less on the foil compared to sandpaper, but 6 µm DP struggles to remove more than 2 µm of Be between steps. Trials by 15 or 30 µm DP may show increased removal amount while remaining delicate toward foil edges.

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