ADDITIVE MANUFACTURING OF PURE Nb AND Cu FOR PARTICLE ACCELERATOR APPLICATIONS

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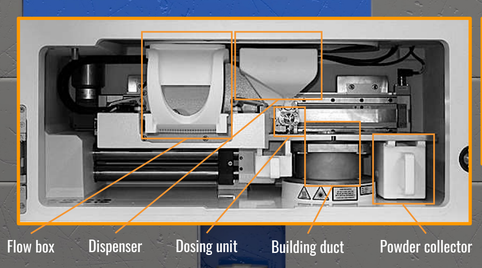
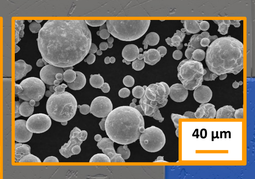
Laser Bed Powder Fusion

is a technique that involves spreading a powder bed onto a platform and melting it with a laser. A dispenser holds the powder, and a recoater blade creates precise layers on the platform. After each layer is exposed, the platform moves down for the next layer. Excess powder is collected in bins called "collectors."



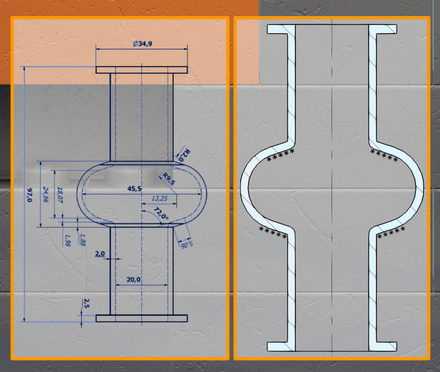


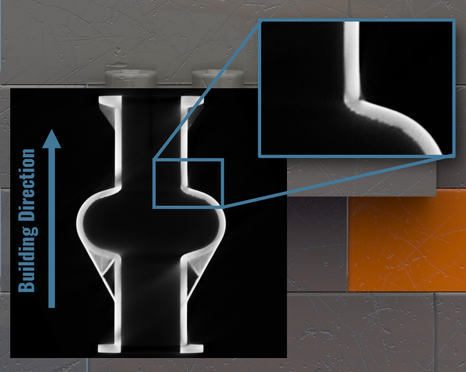
Prototypes

Nb “big cavity” Nb “small cavity” Cu cavity “T1” & “T2”

Down skin optimization

Additive Manufacturing poses challenges, including poor surface quality on downward-facing surfaces in LPBF. Niobium's critical angle was found to be around 30°-35°. This study examined down-skin parameters for the Nb prototypes and developed innovative contact-free supports to mitigate these issues.





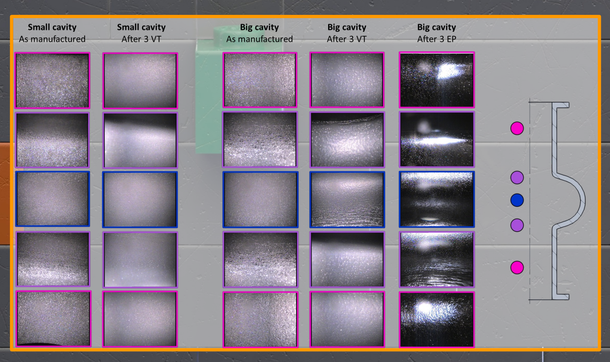
Testing

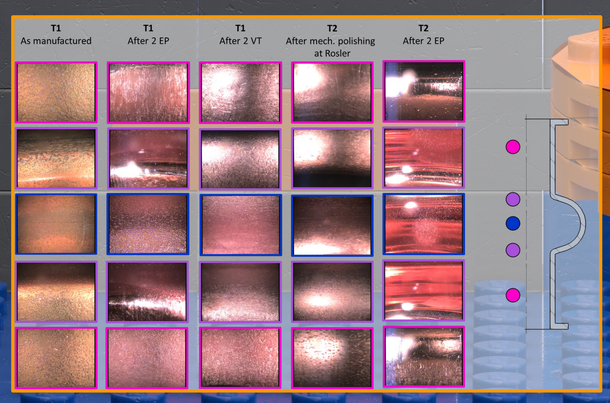
All cavities underwent RF resonance testing at room temperature, demonstrating excellent reproducibility. Leak tests were performed before and after each mechanical and chemical treatment. A sample Nb specimen, printed using Additive Manufacturing, was subjected to RRR (Residual Resistivity Ratio) testing at 300K and 10K, as well as critical temperature testing using the inductive method. The results showed an average frequency of 6 GHz (±0,14%), a Tc of 9.15 ± 0.1K, and an RRR of 8.

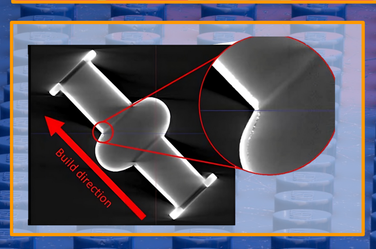
Treatments

Vibro-Tumbling (VT) and Electrochemical Polishing (EP) were employed as surface treatments to enhance the internal surface finish of prototypes. The Nb cavities underwent three stages of vibro-tumbling, followed by an additional three stages of electropolishing (EP) treatment for the "big cavity." As a result, the surface exhibited some pitting of various sizes, but overall, it became reflective and displayed noticeable smoothing on both macro and micro scales.

For the Cu cavities, mechanical treatments were carried out at Rösler before the VT and EP processes. In the case of cavity "T1," the electrochemical process was performed prior to vibro-tumbling. During these processes, a total of 210 µm of material was removed over a duration of 147 minutes. Subsequently, EP was conducted, but it led to a leak at the iris of the cavity. As for cavity "T2," the process was reversed, starting with EP. In this case, 94 µm of material was removed through EP, but a leak was once again identified at the iris. CT scans revealed a vulnerable area in the internal fillet (iris) of the down-skin region. Therefore, the same approach and improvements applied to the Nb cavities will be implemented to reinforce that specific area.







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