

Development of beam window with a large diameter, a thin wall thickness and a large proof pressure for COMET experiment through additive manufacturing

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We have developed beam windows for J-PARC COMET beamline for its Phase- α . The developed windows composed of the Ti-6Al-4V 0.5 [mm] thin sphere made by AM are now installed and achieve 5×10^{-5} Pa in the experimental apparatus.

Objective

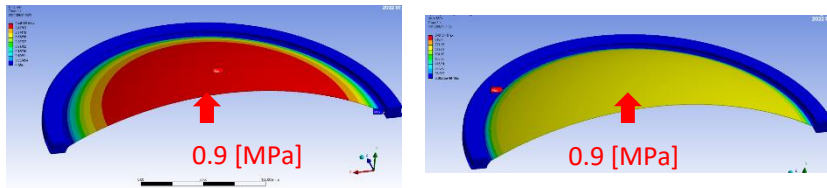
Vacuum windows withstanding 0.15 MPa pressure are needed to develop with;

Requirements: high transmission efficiency with minimizing the nuclear heat generation by beam energy loss.

- material density: low
- thickness: thin, as possible
- mechanical strength: robust enough to withstand against such high and rapid increasing pressure until rupture disks work for LHe quenching over 0.8 [MPa]

- After R&Ds, **employed a spherical shape on to the beam passing area**, instead of a conventional thin and flat shape.

On our case, the ratio of thickness ($t_{0.5}$) to curvature radius (270) is chosen considering the yield stress of the material.

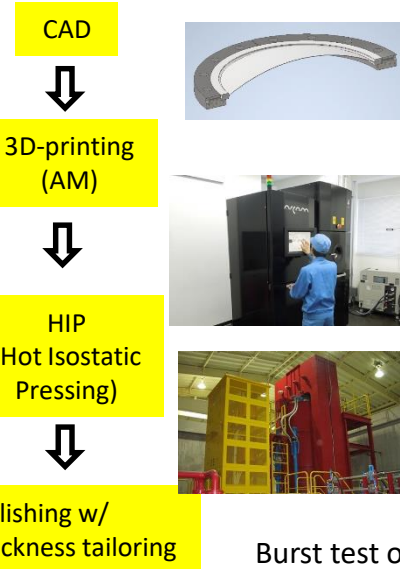


Simulated **0.9 [MPa] pressurized** condition and found the window withstands;

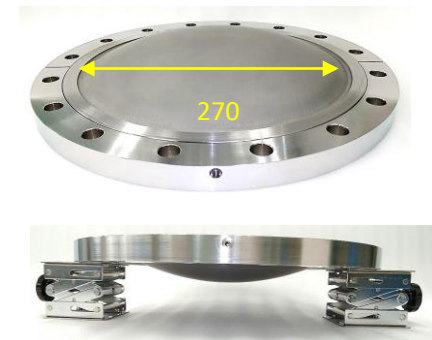
- Deflection: 0.48 [mm]
- vM stress: 320 [MPa] (**safety factor roughly 3** for 0.2% proof stress, 890)

- To obtain the desired dimensions with the required performance, **Additive Manufacturing (AM/ 3D printing)** was chosen as the preferred fabrication process, made of Ti-Al6-V4.

Manufacturing Steps

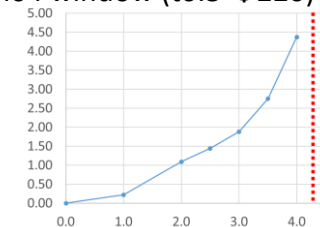


Produced windows



We produced a dome of 270 / 220 [mm] to mate with the rotational flange.

Burst test of Ti64 window ($t_{0.5}$ - $\Phi 220$)



Measured displacement of the dome apex