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## ABSTRACT:

### Radial and Unidirectional Freeze Cast Ceramics and Implications on Transport Paths

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Freeze casting is a materials processing technique in which a suspension (typically ceramic, or polymer particles in a solvent) is directionally frozen to template a porous structure. As the solvent crystallizes, particles are rejected and concentrated between growing crystals, forming a segregated architecture. Subsequent sublimation of the frozen solvent (e.g., via freeze-drying) leaves behind a highly anisotropic porous scaffold. The pore morphology and alignment are governed by parameters such as freezing rate, temperature gradient, and suspension composition. Freeze casting is widely used to fabricate materials with controlled porosity for applications in tissue engineering, filtration, and thermal insulation.

We have studied several porous ceramics (ZrO<sub>2</sub>, TiO<sub>2</sub>, HfO<sub>2</sub>, CeO<sub>2</sub>), all of them being promising candidates to be used as target materials in the production of radioactive isotopes. For this purpose, a controlled pore architecture becomes crucial for optimizing the extraction/release of the produced radioisotopes. A cylinder geometry is typical for nuclear ion beam targets. For an optimized yield, a core region of high, but not full theoretical density, is ideally embedded in a much lighter foamy structure, enabling fast ion diffusion over long distances. These ions are then fed into the secondary ion beam to be utilized in nuclear physics.

In this contribution we show our results on samples prepared using both radial and unidirectional freeze casting, employing PTFE (poly-tetra-fluoro-ethylene, Teflon®) as well as brass molds and varying solid loadings (10-20 vol%). The results reveal that the mold type and the solid content significantly influence pore morphology and pore size distribution. While samples with lower solid content (10 vol%) generally exhibit elongated pores with thin walls (Teflon® mold) and even finer pores with thinner walls (brass mold), a higher solid content (15% to 20 vol%) leads to nearly square pores with thick walls (Teflon®) and oval pores embedded in long and radial walls (brass). Across all configurations, an increasing solid content results in higher density and reduced porosity. The radial

architecture is particularly advantageous for enhancing ion diffusion, underlining its potential utility in isotope production applications. The mechanism of ion diffusion is not yet completely elucidated and leaves us with open questions and promising challenges.