3D Printing of Sol-Gel Synthesized BGO Nanoparticle Ceramics for Radiation Detection

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Bismuth germanate ($Bi_4Ge_3O_{12}$, BGO) is a widely used inorganic scintillator owing to its high density, large effective atomic number, good stopping power for γ-rays, and stable scintillation properties, making it valuable for radiation detection and medical imaging applications. However, the conventional fabrication of BGO single crystals via high-temperature growth is time-consuming, costly, and limited in terms of shaping complex geometries [1]. Polycrystalline ceramics prepared by cold pressing and sintering offer a cost-effective alternative; however, they can only be formed into certain geometries [2].

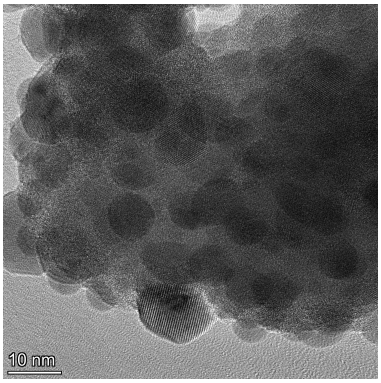

Fig.: HR-TEM image of the sol-gel synthesized BGO nanoparticles

In this work, we report on the synthesis of BGO nanoparticles via a sol-gel route and their use as feedstock for additive manufacturing of BGO ceramic scintillators. The sol-gel process enables precise control over composition and particle size at relatively low temperatures, producing fine and homogeneous nanopowders suitable for advanced shaping and densification. These nanoparticles were formulated into printable pastes and 3D-printed into dense ceramic structures using a layer-by-layer additive process, followed by optimized thermal sintering to achieve high relative density and controlled microstructure. The scintillation performance of the 3D-printed BGO ceramics is systematically compared with that of a conventionally grown BGO single crystal and a cold-pressed ceramic. Key metrics evaluated under γ-ray excitation will be presented at the conference. These results demonstrate the feasibility of using sol-gel-derived nanoparticles and 3D printing to fabricate BGO scintillators, unlocking new opportunities for customizable detector designs in nuclear instrumentation and medical imaging.

[1] Vaithianathan V., et al., Materials chemistry and physics **74.2** 121 (2002).

[2] Macedo, Zélia Soares, et al., Journal of the American Ceramic Society **87.6** 1076 (2004).