Transparent Ceramics Scintillators and Quick Material Search

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Scintillators with higher gamma-ray sensitivity are required to various fields such as medical imaging, astronomy, and gamma-ray detection efficiency (gamma-ray stopping power, σ) depends on effective atomic number (Z_{eff}) and density (ρ); σ is proportional to ρ $(Z_{\text{eff}})^{a}$, where a is 4-5. Positron emission tomography (PET) camera with scintillation materials is used in medical imaging, and these scintillator is required to have high gamma-ray sopping power and short decay time. Ce-doped Lu_2SiO_5 (Ce:LSO) is conventional scintillator, because Lu has a high atomic number of 71, good attenuation length of 1.16 cm at 511 keV and fast decay time of around 40 -50 ns. Meanwhile, this crystal has intrinsic background noise from ^{176}Lu, and Y-admixed Ce:LSO, Ce:$(Lu,Y)_2SiO_5$, is also the standard materials in medical imaging to suppress this intrinsic background. Here, the effective atomic number for Ce:$(Lu,Y)_2SiO_5$ is around 62, while this scintillator still has intrinsic background.

Hafnium has a high atomic number of 72, and intrinsic background is negligible. $SrHfO_3$ doped with Ce (Ce:SHO), for example, are attractive scintillation material due to a high density of 7.65 g/cm3, a high effective atomic number of around 60 and no intrinsic background. Since Ce:SHO and other Hf-containing materials have high melting temperatures of over 2500°C, we prepared transparent ceramics by the spark plasma sintering (SPS) process [1,2]. The scintillation decay time for Ce and Al-doped $SrHfO_3$ was estimated to be faster (21.6 ± 0.9 ns) than that for Ce:$(Lu,Y)_2SiO_5$, and Ce:SHO can be the next-generation materials for the PET camera.

The SPS process enable us to obtain the transparent samples within a few hours, and quick material search is realized. Also, other techniques are applied to material search. In this paper, I review Hf-based and high-effective-atomic number scintillators and their growth techniques.

[1] S. Kurosawa et al., (2013) Radiat. Meas., 56, 155,
[2] H. Chiba, S. Kurosawa et al., (2016) Radiat. Meas., 90, 287

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