Material design and fabrication of a novel optical guiding crystal scintillator

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[Introduction] Scintillating fibers were widely used for radiation detection applications such high energy physics, medical imaging, space observation and so on due to its long shape with flexibility, wavelength shifting and light guiding performance like optic fibers. In general, scintillating fibers consist of a polystyrene-based plastic scintillator core and a polymethyl methacrylate clad. The generated scintillation light can be light guided along the fiber. The refractive indices of polystyrene and polymethyl methacrylate are 1.59 and 1.49@nD, respectively, and they are totally reflective and light guiding at a critical angle of 69.6 degrees in the fiber. However, because the core is a plastic scintillator, energy discrimination and pulse counting are difficult, and there is the problem of low density and low sensitivity. In addition, because the refractive index difference is small, when scintillator light is emitted in all directions inside, there is a problem of a large light component transmitted to the side. Up to now, our group have developed eutectic scintillators (fig.1-left). The eutectic crystals have a structure in which scintillator crystal fibers of several μm diameter are arranged in a matrix and have excellent position-resolving performance against x-rays and charged particles [1-3]. However, it was extremely difficult to grow the eutectic crystals enough large or long size, and it was impossible to grow them as a single fiber.

[Results] In this study we proposed a novel optical-guiding crystal scintillator (OCS). It consists of halide single crystal scintillator core and glass clad. The refractive index of the halide single crystals is higher than the glass in this system. Generated scintillation light above the critical angle is totally reflected at the interface with the glass and optically waveguided like optical fibers and the scintillating fivers (fig.1-right). In OCS, the molding of the cladding and the crystal growth of the scintillator core are performed in the same process. By adjusting the fabrication conditions, the fiber system can be tuned from a few microns to several hundred microns in diameter. The thickness ratio of the core to cladding is also variable by changing the thickness of the glass material. As cladding, quartz glass and borosilicate glass have been tested as available, and halide crystals with melting points below their softening points can be used as the core. The glass and scintillator materials that were prototyped in this study are listed in Table 1. Tl:CsI, Eu:SrI_2, $CeBr_3$, etc. were examined as scintillator cores, and borosilicate glass were used as cladding to construct OCS fibers. OCS was not limited to single fiber but could also be formed into bundles for high resolution radiation imaging.

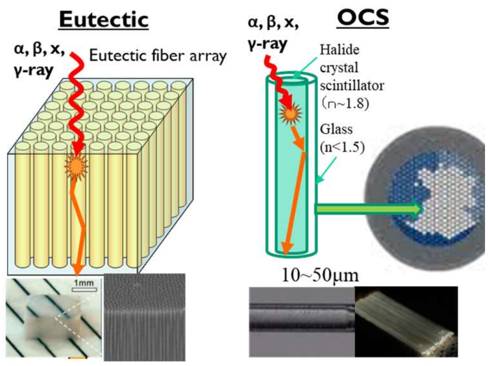

Fig. 1. Schematic of the structures of the reported eutectic scintillator (left) and developed OCS (right)

References

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