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Optimization of dopant and scintillation fibers diameter of GdAlO3/a-Al2O3 eutectic for X-ray phase imaging detector

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X-ray phase imaging techniques has been developing for the last decade because of its attractive potentials [1–7]. X-ray phase imaging provides three images such absorption, differential-phase, and visibility-contrast images. This future causes to higher resolution density variations in the sample than that conventional absorption-contrast X-ray imaging. Medical and biological imaging is the main target of X-ray phase imaging, and several trials using synchrotron radiation sources and laboratory sources have been made. In X-ray Talbot-Lau interferometry, single or mulch absorption gratings between a sample and X-ray generate detector differential-phase, and visibility-contrast images. The absorption gratings generate Moire fringes and differential-phase, and visibility-contrast images are obtained from analysis of the spatial frequency of the Moire fringes. However absorption gratings absorbed the transmitted X-ray and sensitivity is degraded. So exposure dose can become a problem in medical and biological imaging.
Recently submicron-diameter phase-separated scintillator fibers (PSSFs) were reported and they possessed both the properties of an optical fiber and a radiation-to-light conversion. The PSSFs were fabricated using a directionally solidified eutectic (DSE) system. Our group reported high-resolution X-ray imaging using Ce doped GdAlO3(GAP)/a-Al2O3 eutectic[9,10]. In this study, Tb and Eu doped GAP/a-Al2O3 eutectic scintillator was grown by the micro pulling down (□-PD) method with varius growth rate. Radiomuninescence intensity, decay time and scintillation fibers diameter were evaluated for X-ray imaging detecrtor.
1˜15mol% Tb and Eu doped GAP/□□-Al2O3 eutectics were grown by the □-PD method. Tb3+ and Eu3+ 4f4f emission were observed in 470-700nm and 580-750nm ranges , respectively. Tb 8mol% and Eu 5mol% samples showed 5.5 and 4.4 times higher emission intensity than Ce doped one. Diameter pf scintillation fibers were 2.43-0.38mm for growth rate of 0.07-3.0 mm/min in the grown Tb 8mol% doped GAP/a-Al2O3 eutectics. The best contrast transfer function@122lp/mm of 0.28 was archived at the sample of growth rate at 0.3mm/min. The grown eutectic wafers were mounted on a CMOS sensor (SONY, 2.5μm pitch, 2080x1552pizels, 5.2x3.9mm sensitive area) with a fiber optic plate (FOP, Hamamatsu J5734, 3□m fiber diameter). By using this sensor, a prototype of X-ray Talbot-Lau imaging system was developed. Absorption, differential-phase, and visibility-contrast images were simultaneously obtained without absorption grating. Comparing to X-ray Talbot-Lau imaging system using CsI scintillator and a absorption grating, 2 time higher signal difference-to-noise ratio was achieved at the same radiation dose of 10mGy. This is the first result of direct X-ray phase imaging. Details on eutectic growth, detector design and X-ray phase imaging will be showed in the presentation.

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