Growth of 2 inch diameter LiI:Eu In Carbon Coated Crucible And Effect Of Post Growth Thermal Treatment On Scintillation Light Yield

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In LiI:Eu single crystal isotopically enriched with ^{6}Li is used as thermal neutron detector owing to the large cross section (940 barn) of ^{6}Li for thermal neutrons. LiI is a hygroscopic material and Li has the tendency to react with the the quartz crucible which leads to sticking of the crystal to crucible wall and cracking of crucible during the cooling cycle of crystal growth. Thus the growth of large diameter LiI:Eu single crystal is challenging. To address this problem different groups have used glassy carbon crucible and pre melting of growth charge etc. [1,2]

Here we report the successful growth of 2-inch diameter single crystal of LiI:Eu (doping 0.2 mol %) using the Bridgman technique as shown in Figure 1 (A) and (B). To solve the sticking problem of LiI:Eu with crucible, carbon film was coated in the inner walls of the quartz crucible. Use of carbon coated crucible for LiI is reported for the first time and this is an economical and easy process as compared that what is reported in the literature [1,2]. Single crystal of LiI:Eu was grown with two different translation rate 2.5 mm/hr (Crystal-I) and 1 mm/hr (Crystal-II). Core formation was observed in Crystal-I grown with high translation speed even for low concentration of Eu because of constitutional supercooling [Figure 1(A)]. No core formation was observed in Crystal-II which is grown with lower translation rate. Both the grown single crystals were crack free but dense in color. The coloration in LiI:Eu can be ascribed to excess of iodine in the lattice. The scintillation measurement with ^{137}Cs gamma source using these crystals shows low light yield. For improving the transparency and scintillation light yield post growth thermal treatment approach was used. Grown single crystals were annealed at 400 ^{o}C for 10 hrs under running vacuum (10^{-3} mBar). Transparency of single crystals was remarkably improved (Figure 1(C)) and scintillation pulse height improves approximately two times as compare to yield before annealing for both Crystals I and II. Improvement in transparency may be ascribed to reduction of excess of iodine form the LiI matrix due to vacuum annealing.

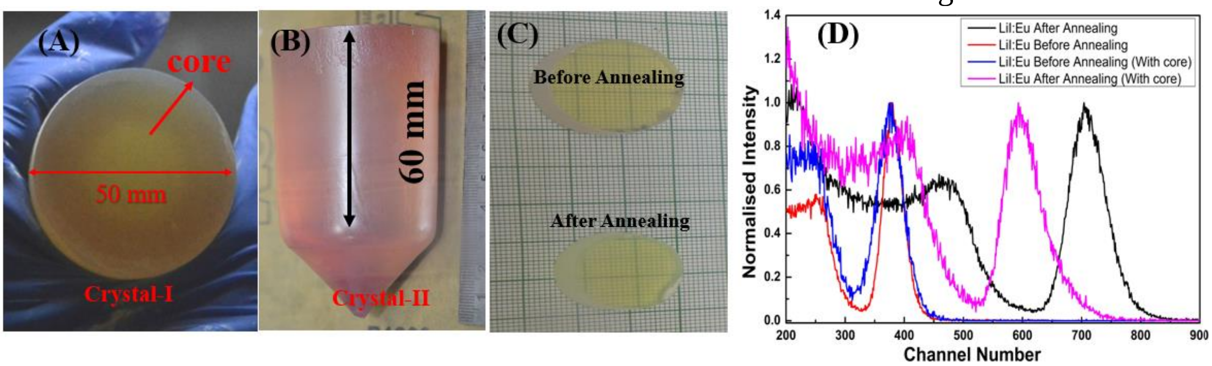

Figure 1. LiI:Eu single crystals grown at (A) 2.5 mm/hr. (B) 1 mm/hr. (C) Disc of Crystal-II before and after heat treatment. (D) Gamma Spectra for Crystals I & II before and after heat treatment.

References

[1] Lynn A. Boatner, et al. "Improved lithium iodide neutron scintillator with Eu^{2+} activation: The elimination of Suzuki-Phase precipitates". Nucl. Instrum. Methods Phys. Res. A, Accel. Spectrom. Detect. Asso. Equip. 854 (2017): 82-88.
[2] Lynn A. Boatner, et al. "Improved Lithium Iodide neutron scintillator with Eu^{2+} activation II: Activator zoning and concentration effects in Bridgman-grown crystals Nucl. Instrum. Methods Phys. Res. A, Accel. Spectrom. Detect. Asso. Equip. 903 (2018): 8-17.