$LaBr_3$:Ce -^{6}LiBr composite crystal for dual gamma-neutron detection application, crystal growth and characterization.

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The direct objective of the study was to create scintillation material for dual gamma-neutrons inheriting high energy resolution known for $LaBr_3$:Ce crystals processing also a very short decay time coupling with the property of neutron detection through ^{6}Li co-doping.
The fundamental question has been pointed out by practical applications: Could gamma-neutron dual detection material with excellent energy spectrum discrimination capability be proposed? Meaning that the energy resolution (at ^{137}Cs isotope source) must be equal or better than 3.0% [1].
It is well known from phase diagram studies that $LaBr_3$-$CeBr_3$–LiBr are not forming phases [2] and therefore are decomposing into eutectics when solidifying, so doping of $LaBr_3$ matrix by Li is usually limited by filling in the interstitial positions in the host crystalline matrix where ^{6}Li concentration is too low to support neutron detection capability.
The materials composed from eutectic mixed phases compounds are usually suffering for the optical opacity [3] limiting the use of such compounds for scintillation application.
An alternative solution has been proposed and successfully carried out to incorporate Li into $LaBr_3$ host matrix. Vertical Bridgman technique has been applied when growing $LaBr_3$:Ce crystals in ^{6}LiBr flux.
$LaBr_3$ crystals have a hexagonal crystallographic symmetry belonging to the space group 176 (P^{63}/m). The crystal growth has been carried out in "c" <0001> crystallographic direction by using an oriented seed.
The grown crystals are containing thin fiber-like ^{6}LiBr inclusions aligned in <0001> crystallographic direction in $LaBr_3$ hexagonal host matrix. The crystal singularity has been supported by using of an oriented seed. The presence of inclusions with a uniform alignment is limiting the scintillation light dispersion and keeping good optical transmission in the emission range for grown crystals and manufactured detectors.
The grown $LaBr_3$:Ce-^{6}LiBr composite crystals containing [Li] > 3% molar are demonstrating neutron detection capability keeping the advantage of very good energy resolution of $LaBr_3$:Ce crystals below 3.0% at 662 keV gamma source and good enough FoM = 1.66 (Figure of Merit) parameter for neutron/gamma discrimination.
The new discovered approach for creation of composite anisotropic crystals with incorporation of inclusions originated from eutectics under the form of aligned fibers is opening a practical way for creation of new optical and scintillation materials.

References

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