DOI:10.16553/j.cnki.issn1000-985x.2000.s1.003

闪烁晶体——辐射探测用单晶

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Scintillating Crystals: Single Crystals for Radiation Detection

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Phosphor converts excitation energy into light, resulting in lumminescence. The luminescence caused by radiation is called scintillation. Since the discovery of the scintillation in NaI:Tl crystal in 1948, a series of materials with profound scintillating characteristics have been developed and have found wide applications for radiation detection in different fields such as nuclear physics, high energy physics, medical diagnostic imaging, geophysics exploration, clandestine explosive finding and many industrial measuring systems.

Inorganic scintillating crystals have superior characteristics over their organic counterparts and some kinds of ceramics, glasses and powders that do have their scintillation effects. We will confine ourselves mainly to inorganic scintillating crystals in this presentation..

After brief introduction, more details will be given on oxide and halide scintillating crystals with a few examples on which we had done R & D works in recent years such as bismuth germanate(BGO), lead tungstate(PWO), barium fluoride (BaF_2), thallium doped cesium iodide(CsI:Tl) etc. In this part, we will also describe on crystal growth technology for scintillating crystals in Shanghai Institute of Ceramics. We had developed an unique modified Bridgman method with multicrucible growth furnace that can scale up the yield to meet with the requirements of mass production and to lower the production cost. Moreover, we have successfully developed a non-vacuum Bridgman method to grow large size CsI:Tl crystals which are usually grown by Kyropoulos method in vacuum or inert gas atmosphere. It is expected that this new method can be used to grow other halide scintillating crystals in ambient atmosphere.

The artificial crystals are precious products only in rather small quantities except artificial quartz and synthetic diamond. However, in recent years, owing to the rapid development of radiation detection, particularly the requirements of experiments in high energy physics(HEP) enable the scintillating crystals, for example, BGO, CsI:Tl and PWO to rank among the products in tons level too. For HEP applications, one crucial requirement for scintillating crystals is to be radiation hard when they are used in hostile environment of high radiation dose. Otherwise the crystals will be spoiled resulting in the coloration, deterioration of both transmission and light yield that is so called radiation damage in the crystals. In the last part of this presentation, the mechanism of radiation damage of both oxide and halide scintillating crystals are discussed. For example, we suggested that oxygen vacancy is the cause of radiation damage of BGO crystal. With this view point, we succeeded in developing a new BGO crystal that is Eu doped BGO with high radiation hardness. Through Transmission Electron Microscopy(TEM)and Energy Dispersion Spectrometry(EDM) study on lead tungstate crystals, we found that the radiation hardness of PWO crystals in which the oxygen vacancies were reduced after oxygen annealing can be enhanced and concluded that the radiation damage is due to the formation of F centers which came from oxygen vacancies in most oxide scintillators. For barium fluoride and some other halide crystals, the oxygen and hydroxyl impurities will play an important role in the damage of the crystals we concluded.

Key words: scintillation crystal; radiation detection; NaI:Tl; BGO crystal; PWO crystal; BaF_2; C_sI:Tl