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Characterization of impurities in cubic boron nitride crystallites with thermoluminescence and ionoluminescence

C. Manfredotti[*], **A. Lo Giudice, C. Paolini, E. Vittone, F. Fizzotti,** and **R. Cossio**

Experimental Physics Department, University of Torino, via Pietro Giuria 1, 10125 Torino, Italy

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IonoLuminescence (IL) and ThermoLuminescence (TL) techniques have been used in order to characterize the defects induced by doping due to different precursors in cubic boron nitride (c-BN) growth. Crystallites of dimensions of the order of 10–40 µm obtained by HPHT (High Pressure and High Temperature) method were used. Protons microbeams of 2 MeV – corresponding to a penetration depth of 26 µm in c-BN – with a spot diameter of few µm, in connection with an ellipsoidal mirror characterized by a large light collection efficiency and a 0.25 m monochromator, allowed to acquire wide area luminescence spectra. We observed that IL spectra for samples characterized by a large Mg content, as obtained by PIXE (Particle Induced X-ray Emission) analysis, displayed three peaks at 1.95 eV, 3.2 eV and 3.9 eV respectively, while in samples with a large Ca content a fourth peak appeared around 1.7 eV. Even if the number of available samples was relatively low, a fair correlation was observed between the total area under the peaks at 1.7 and 1.95 eV and the total Ca content (up to 25 ppm) on one side and between the total area under the peak at 3.9 eV and the total Mg content (up to 100 ppm), even if this peak appeared with a much smaller intensity also in all the other samples. Moreover, TL measurements were carried out from RT up to 400 °C with a standard Harshaw TL reader after the exposure of samples to some Gy doses from a collimated α-particle ^{241}Am source. Specimens obtained by a Mg-based precursor did not show any thermoluminescence, while samples obtained by a Ca-based precursor showed a large and very reproducible TL spectrum. From the initial rise TL method, coupled to a preheating in order to separate the contributions from different traps, three series of centres were found out at 0.21, 0.35 and 0.6 eV. Samples obtained without a Ca-based precursor probably have a level at 0.45 eV instead of at 0.35 eV and, likely, there is also another level at 0.52 eV in Ca-doped platelets.

1 Introduction

Boron nitride is a synthetic material, which exists in several different forms: cubic (c-BN), graphite-like hexagonal (h-BN), lonsdaleite-like wurtzitic (w-BN), disordered turbostratic (t-BN) and rhombohedral (r-BN) [1]. Among these isometric compounds, cubic boron nitride, which has a diamond-like zinc blend structure, is characterized by a number of highly desirable mechanical, thermal, electrical and optical properties.

It is second in hardness only to diamond and it is then a natural candidate for hard, protective coatings. Moreover, it does not react readily with ferrous metals [2]; this fact, together with the high resistance to oxidation (at temperatures as high as 1300 °C), makes it attractive also for tooling applications. The energy bandgap of boron nitride, varying between 5.4 and 7.0 eV at room temperature, is the highest among all the covalent-bonded materials known so far. This bandgap is suitable for ultraviolet (UV) detectors and UV light emitting diodes operable at wavelengths in the deep UV regime [3, 4] for optical

[*] Corresponding author: e-mail: manfredotti@to.infn.it, Phone: +00 39 011 6707306, Fax: +00 39 011 6691104