An Influence of X-Ray Irradiation on Mid-Bandgap Luminescence of Boron Nitride Epitaxial Layers.

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Boron nitride has been known since its first synthesis in 1842 but nowadays has become one of the most intensively studied material for modern optoelectronics. One of the reasons is that its hexagonal form (h-BN) suits very well as a substrate for graphene and other two-dimensional materials. This useful feature is even further strengthened by a large band gap of BN (equal to about 6.4 eV) which allows using it as a transparent substrate for blue optoelectronics.

There are a few reasons which directed us towards the studies presented in this paper. First, some epitaxial layers grown at the Faculty of Physics exhibit a broadband photoluminescence (PL) with a spectrum covering almost full range of the visible light. The PL is tentatively attributed to defects and it is interesting to verify whether X-ray photons influence the PL; and if they do, are the changes temporary or permanent. This could shed some light on the nature of defects involved in the PL. Second, it was found that irradiation of BN layers with electrons lead to changes in Raman or PL spectra and it was our aim to verify whether similar changes can be produced with X-ray photons. Third, we wanted to check whether epitaxial boron nitride could be used as a dosimetric material working on the principle of optically stimulated luminescence (a dosimetric method which relates changes of luminescence intensity to absorbed dose of radiation). Once boron nitride - based devices become reality in future electronics, dosimetric properties of this material could be addressed to estimate radiation doses absorbed by people in massive nuclear or radiation accidents.

Measurements were carried out at room temperature on a few samples of epitaxial BN grown on sapphire by a MOCVD technique. The samples were grown at different intensity of ammonia flow and were characterized with a Raman spectroscopy. To observe an influence of X radiation on the PL, we irradiated samples with a collimated beam of X-rays generated by a Cu_{K_α} X-ray tube for a few periods of T_R equal to 1.5 hour. After each irradiation time, the X-ray beam was shut and a laser beam exciting the PL (wavelength of 488 nm, power of about 100 mW) was simultaneously set on for the period of 30 min. A luminescence integration time was set to 1 min for each spectrum, so a time evolution of the luminescence could be traced with a step of 1 min.

No structural changes of the layers were found after irradiation with X-rays. We observed that X-rays change the intensity of the PL in the whole registered spectral range between 550 nm and 900 nm in an approximately uniform manner. We observed that the spectrum of the PL returns to its pre-irradiated form after a few minutes of laser excitation.

In conclusion, we have shown that the PL from epitaxial layers of boron nitride is sensitive to X-ray irradiation produced with a standard X-ray tube (working at 35 kV with the current of 30 mA) generating photons with the energy of about 8 keV. Thus, we have also proved that this material shows a potential for dosimetric applications.