# Study of the Correlation Between Occurrence of Defect-Induced Yellow Luminescence and Growth Parameters of Boron Nitride

**Aleksandra K. Dąbrowska , Krzysztof Pakuła , Mateusz Tokarczyk, Johannes Binder, Grzegorz Kowalski, Andrzej Wysmołek, Roman Stępniewski**

*Faculty of Physics, University of Warsaw, Pasteura 5, 502-093 Warsaw, Poland*

The most widely studied form of boron nitride is $sp^2$–hybridized BN. It is a wide-bandgap material with interesting optical and structural properties. Due to the energy gap about of 6 eV [1] it is a good candidate for deep UV optoelectronic applications. The specific crystallographic structure of $sp^2$-BN groups it together with graphene and into the whole family of layered, two dimensional materials (2D). Van der Waals heterostructures, formed of atomic layers of these materials [2] can perform various functions – from light emitting structures to transistors. In recent years the technology of boron nitride growth by Metal Organic Vapour Phase Epitaxy (MOVPE) on $Al_2O_3$ substrate has been developed and understood enough to obtain well ordered, epitaxial layers. Further research is underway to improve the quality and properties of the material. One of the issues that requires explanation is the nature of the defect responsible for yellow luminescence that were assigned to presence of the carbon in the layer [3].

The defect-induced luminescence, excited by a 532 nm laser line, is characterized by a wide spectrum and bleaching during exposure. It usually consists of the three bands at about 590 nm, 640 nm and 690 nm. A correlation between growth parameters and the intensity of the luminescence was studied. It can be stated that the luminescence is associated with ammonia deficiency. The intensity of the luminescence increases with ammonia flow decreasing, total pressure decreasing or when a flow-rate modulation epitaxy (FME) method is used. This method involves an alternating addition of ammonia and boron precursor (TEB) to reactor, so that at a certain time there is no nitrogen precursor on the surface. A further development of this method, which led to disappearance of this kind of luminescence, will be discussed. The surface morphology of the samples was studied by Scanning Electron Microscopy. It has been noted that there are no relations between the layer morphology and the yellow luminescence.

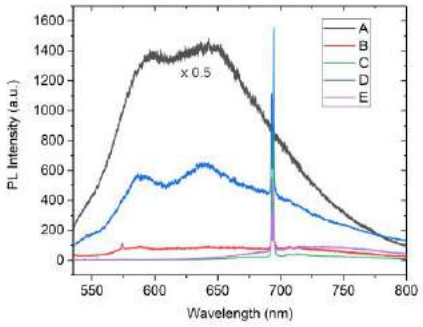


Fig.1. Photoluminescence spectra of boron nitride grown in different conditions. Samples A, B, C were grown in continuous mode with correspondingly increasing pressure in reactor and increasing ammonia flow. Samples D and E were grown by modified FME method. Sharp emission structure around 693 nm is due to $Cr^{3+}$ in sapphire substrate.

The defects responsible for the yellow luminescence associated with an ammonia deficiency could be boron interstitial or impurities like hydrogen or carbon built-in the boron nitride structure. Further research will allow to finally determine the nature of these defects.

[1] K. Watanabe et al., *Phys. Stat. Sol.* (a) 201, No. **11**, 2561–2565 (2004)
[2] F. Withers et al., *Nature Materials* vol**. 14,** 301-306 (2015)
[3] D. Chugh et al., *2D Mater.* **5** (2018) 045018