Advantages and Prospects of Boron Nitride Grown by Two Stage Epitaxy

Aleksandra K. Dąbrowska, Mateusz Tokarczyk, Grzegorz Kowalski , Johannes Binder, Rafał Bożek, Jakub Iwański, Roman Stępniewski, Andrzej Wysmołek

Institute of Experimental Physics, Faculty of Physics, University of Warsaw, Pasteura 5, 02-093 Warsaw, Poland

Sp^2 – hybridized boron nitride (BN) combines the properties of classic nitrides (extraordinary resistance to external conditions and wide bandgap) with a two – dimensional nature [1]. Such a combination yields BN material with tremendous versatility of applications (i.e. deep UV light source, insulating barrier in van der Waals heterostructures, protective layer etc.) [2]. The Metal Organic Vapour Phase Epitaxy (MOVPE) is one of the most promising growth methods in terms of the production of large-scale, uniform BN with a relatively high growth rate, compatible for use in commercial devices..

The BN growth is carried out on sapphire substrates with triethylboron (TEB) and ammonia as precursors of boron and nitrogen, respectively. The proposed new growth mode - two stage epitaxy - allows to avoid the chaotic nucleation on the substrate, characteristic for Flow-rate Modulation Epitaxy (FME) by introducing a thin (a few nanometers), pre-ordered, Continuous Flow Growth buffer layer [3]. This new growth method leads to the formation of boron nitride with an almost ideal lattice constant and to the reduction of the concentration of point like defects in the structure. Interestingly enough, in depth studies revealed the correlation between the properties and growth conditions of the CFG stage with structural properties and smoothness of the whole two stage sample (Fig. 1). In this communication the influence of the nitridation, temperature, pressure and the growth time on the properties of the two stage samples is discussed.

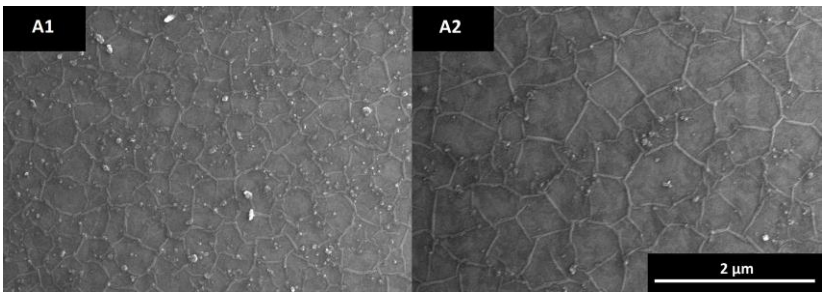

Figure 1 *Scanning Electron Microscopy (SEM) image of the two stage samples grown in the same conditions but annealed and stabilized before the growth in nitrogen (A1) and hydrogen (A2).*

A further tunning of the two stage method and preparing the perfect buffer can have a huge impact on improving the smoothness and both – structural and optical properties of the achieved boron nitride layer. Obtaining a material comparable to bulk BN on the large scale is within the scope of our possibilities and will bring us closer to practical applications.

[1] K.S. Novoselov, A. Mishchenko, A. Carvalho, A.H. Castro Neto, Science 353, 6298, aac9439 (2016)
[2] A.F. Rigosi, A.L. Levy, M.R. Snure, N.R. Glavin, J. Phys. Mater. 4, 032003 (2021)
[3] A.K. Dabrowska, M. Tokarczyk, G. Kowalski, J. Binder, R. Bożek, J. Borysiuk, R. Stępniewski, A. Wysmołek, 2D Mater., 8, 015017 (2021)

Acknowledgement: This work has been partially supported by the National Science Centre under grant no. 2019/33/B/ST5/02766