KONWERSATORIUM INSTYTUTU FIZYKI UMCS

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Wafer-scale Hexagonal Boron Nitride on sapphire – Growth, Polytypes, Properties and Applications

Hexagonal boron nitride (h-BN) is a two-dimensional (2D) material and a member of the III-nitride family that has recently attracted great interest due to its versatile range of applications. One of the most prominent examples is the use of h-BN as a substrate for other 2D materials. The lack of dangling bonds, the atomically flat surface and the homogenous dielectric environment lead to a significant improvement of the electrical and optical properties of adjacent 2D materials and render h-BN the prototype 2D-insulator for van der Waals (vdW) heterostructures that consist of stacks of many different 2D materials. However, most of the work on vdW heterostructures is so far based on exfoliated flakes of h-BN. It is clear that the bottleneck for industrial applications of 2D materials will be the possibility to fabricate high-quality large-area layers.

In the first part of my presentation I will address this issue and show results on the growth of epitaxial h-BN on sapphire by metalorganic vapour-phase epitaxy (MOVPE) [1-5], which is currently regarded as one of the most promising growth techniques. Particular emphasis will be placed on our recent findings in homoepitaxial growth, specifically the growth of BN on hBN flakes [1]. In this work, we demonstrate that various non-centrosymmetric polytypes, such as bBN (Bernal Boron Nitride with AB stacking), can be grown epitaxially even on an hBN flake used as the substrate. By measuring photoluminescence in the UV range, we further demonstrate the ability to distinguish hBN from rBN (rhombohedral BN with ABC stacking) by analyzing the carbon-dimer-related defect band at 4.1 eV, which exhibits a significant energy shift of approximately 50 meV between different polytypes [6].

The last part of my talk will focus on the applications of our MOVPE-grown h-BN, which include the large-area growth of $MoSe_2$ using our wafer-scale h-BN as a substrate to obtain centimeter-sized epitaxial van der Waals heterostructures [7,8], photonic applications such as the growth of purely BN-based Bragg mirrors [9], hBN as membrane leading to polarisation-dependent Raman enhancement [10] and hydrogen generation and storage applications enabled by the radiolysis of interfacial water, leading to the formation of hydrogen-filled bubbles of epitaxial BN [2].

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[2] J. Binder, et al. *Nano Letters*, 23, 1267 (2023)
[3] M. Tokarczyk et al. *2D Materials*, 10, 025010 (2023)
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[5] K. P. Korona et al. *Nanoscale*, 15, 9864 (2023)
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[7] K. Ludwiczak et al. *ACS Appl. Mater. Interfaces*, 13, 47904 (2021)
[8] K. Ludwiczak et al. *ACS Appl. Mater. Interfaces* 16, 49701−49710 (2024)
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[10] J. Rogoża et al. Nanoscale 17, 3053 (2025)

Uprzejmie zapraszam wszystkich pracowników, doktorantów i studentów Instytutu Fizyki.

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