hBN bubbles – a way of deterministic activation of single-photon emission from defects in hBN?

P. Tatarczak, J. Binder, A. K. Dąbrowska, J. Iwański, M. Tokarczyk and A. Wysmołek

University of Warsaw, Faculty of Physics, ul. Pasteura 5, 02-093 Warsaw, Poland

Email: Piotr.Tatarczak@fuw.edu.pl

Hexagonal boron nitride (hBN) is a wide band-gap (~6 eV), two-dimensional semiconductor which is used in many van der Waals heterostructures. hBN has been shown to host defects that act as single-photon sources [1]. Local deformation could be used as an effective tool for deterministic activation of quantum light emission on demand [2].

We address this issue by creating bubbles in our large-area hBN layers grown by MOVPE on sapphire substrates [3,4]. Stable, hydrogen-filled bubbles are created via interfacial water hydrolysis, induced by electron beam irradiation. Mapping photoluminescence (PL) measurements were performed to study statistically their impact on the optical properties of hBN in various spectral ranges. The total PL intensity is enhanced on bubbles (Fig. 1b) – at first glance, one can think that it is only due to some microcavity effects in bubbles [5]. However, it is clear that some new spectral lines, not observed on flat hBN, appear on bubbles (Fig. 1c). These defect-related transitions, activated by bending hBN, are candidates for single-photon emission. Measurements at helium temperature also reveal sharp spectral lines present only on bubbles. Additionally, bubbles create a non-uniform strain distribution, which can tune the energy of the emitter. Since bubbles are created via electron irradiation of the material in precisely selected locations, this method seems to be a promising tool to deterministically locate and activate single-photon emission from defect states on demand.

Acknowledgement: This work has been partially supported by the National Science Centre Poland under decisions no. and 2020/39/D/ST7/02811 and 2022/45/N/ST7/03355

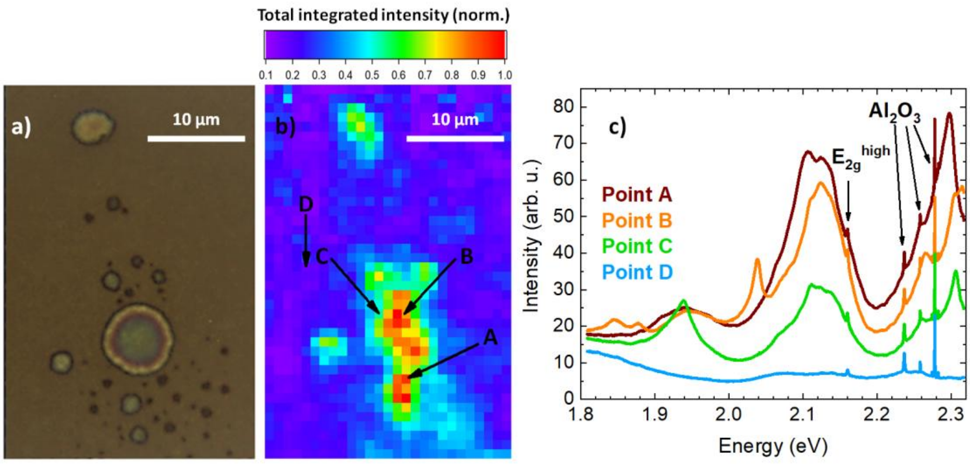

Fig. 1. PL mapping measurements on hBN bubbles at room temperature with 532 nm excitation: a) optical image, b) map of total integrated intensity, c) spectra at given points: A, B, C – on bubbles, D – on flat hBN

[1] T. T. Tran et al., Nature Nanotech, **11**, 37 (2016)
[2] N. V. Proscia et al., Optica **5**, 1128 (2018).
[3] J. Binder et al., Nano Lett., **23**, 1267 (2023)
[4] A. K. Dąbrowska et al., 2D Mater., **8**, 015017 (2021)
[5] H.Y. Lee et al., Nat Commun **13**, 5000 (2022)