

# Features of using Ni and Ni-Cr systems as solvents for h-BN crystallization under high N<sub>2</sub> gas pressure

B. Sadovyi<sup>1,2</sup>, P. Sadovyi<sup>1</sup>, A. Nikolenko<sup>3</sup>, V. Strelchuk<sup>3</sup>, B. Turko<sup>2</sup>, S. Porowski<sup>1</sup> and I. Grzegory<sup>1</sup>

<sup>1</sup> Institute of High Pressure Physics PAS, Sokolowska street, 29/37, 01-142 Warsaw, Poland

<sup>2</sup> Ivan Franko National University of Lviv, Dragomanova street, 50, Lviv, 79005, Ukraine

<sup>3</sup> V. Lashkaryov Institute of Semiconductor Physics NASU, pr. Nauky 45, Kyiv, 03028, Ukraine

Hexagonal BN (h-BN) is a compound very similar to graphite regarding arrangements of its constituent atoms in the crystal lattice. It is a hexagonal graphite-like structure (h-BN) where the monoatomic BN layers forming a strongly bound honeycomb pattern (like in graphene) are inter-bonded with weak van der Waals forces. This material has great potential to be used in 2D electronics, deep UV emitters and detectors, and as a new platform for quantum systems. However, at present, the obtained h-BN crystals have lateral dimensions of about 1 mm, which is a limiting factor in further research. Therefore, the development of h-BN crystallization is of great importance for the advancement of new technologies.

This work presents a new possibility of obtaining h-BN single crystals using well-known Ni or Ni-Cr solvents but under high N<sub>2</sub> gas pressure, not under atmospheric pressure. The reference from which we started was an already existing method that implies to use of the Ni-Cr solvent for synthesis of boron nitride [1]. In our approach, the growth process is carried out under high nitrogen pressure in a gas-pressure reactor at N<sub>2</sub> pressure of 1000 bar. In this case, the pre-homogenized (1000 bar, 1450 °C, 2 h, Ar atmosphere) Ni<sub>50wt%</sub>-Cr<sub>50wt%</sub> alloy or pure Ni were used as the solvents for boron and nitrogen, sources of components – crystalline B and N<sub>2</sub> gas. Boron and the solvent were placed in an alumina crucible. The growth process included four stages: (i) heating (1200 °C/h), (ii) dissolution of B and N in the solvent (1450 °C, 1 h), (iii) growth in temperature gradient (60 °C/30mm, 45 h) in case of Ni-Cr solvent or slow cooling (4 °C /h) from 1450 to 1380 °C in case of pure Ni solvent, and finally (vi) cooling by quenching. As a result, the h-BN single crystals grew on the top surface of the metallic solvent (insert on Fig. 1). The total area of the grown crystalline layer was several tens of mm<sup>2</sup>, and the thickness of the layers for different cases was in the range 5-25 μm. The crystals were examined using optical and scanning electron microscopy, XRD, EDX, micro-Raman (Fig. 1), photoluminescence and absorption spectroscopy.

Comparison of h-BN layers properties obtained with different solvents will be shown and discussed. The results of Raman measurements showed that the new h-BN crystals were of a very high crystalline quality (FWHM of E<sub>2g</sub> Raman mode was 7,8 cm<sup>-1</sup>). Additionally, the micro-Raman study confirmed the uniformity of the properties within an individual single crystal. Suggestions for further development of this approach will also be discussed.

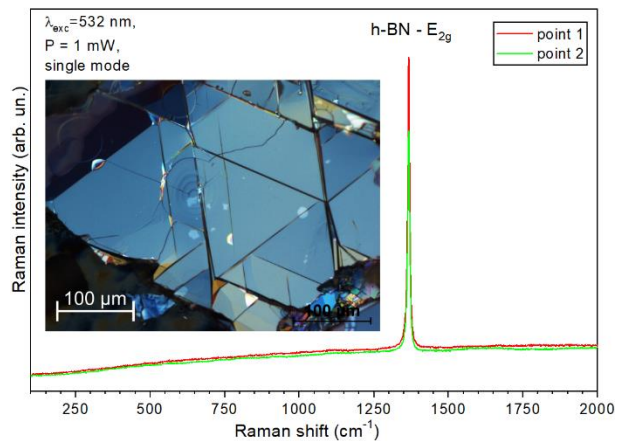


Fig. 1: micro-Raman spectra of h-BN crystals which are shown in the insert