Hexagonal boron nitride (h-BN) is a material known since 1842 when it was synthesized in the laboratory of the British chemist W. H. Balmain. Thanks to its unique properties such as layered structure, high thermal conductivity, heat resistance, chemical inertness, and mechanical strength it has been widely used in industry (e.g. in solid lubricants). It is composed of boron and nitrogen ions forming strong bonds with a honeycomb structure within the layer and weak bonds between the layers, creating a three-dimensional crystal with a wide indirect bandgap of ~6 eV corresponding to a deep UV spectral range, unlike semi-metallic graphite or graphene with a similar structure.

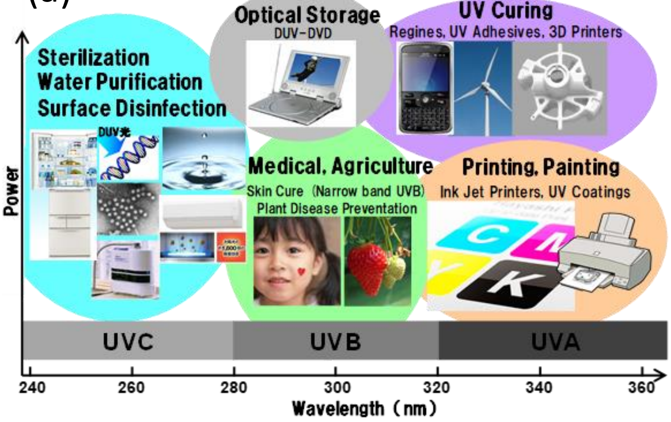
A new era of interest in h-BN began about 20 years ago, when advances in growth techniques improved the material quality, and large-sized single crystals were grown, opening up applications in electronic and optoelectronic devices. The pioneering works of Japanese scientists (Watanabe et al.) revealed the high efficiency of deep UV emission of h-BN at room temperature and led to the design of the first h-BN-based device with emission in the deep UV range. However, the physical mechanisms behind h-BN luminescence remain still a subject of debate.

Additionally, currently grown h-BN bulk crystals or epitaxial layers are rich in different defects. Many of them act as bright emitters with various photon energies from 5.5 eV down to ~1.5 eV creating so-called single photon sources with extreme thermal stability which are important building blocks of optical quantum technologies. However, to fully control and develop on-demand unique applications of h-BN, the nature of radiative recombination centers should be identified. Despite intensive experimental and theoretical research, this is still one of the unresolved issues and none of the currently proposed defects assignments are conclusive.

The project "**Comprehensive study of radiative recombination centers in hexagonal boron nitride single crystals using high-pressure and time-resolved spectroscopy supported by theoretical analysis**" is devoted to an innovative and unique approach to resolving the mystery of optically active centers whose emission is observed in photoluminescence of h-BN crystals. Thus, the main objective of the project is the complex investigation of the luminescent properties of point defects in h-BN crystals. This will be achieved by the correlation of growth parameters (i.e. pressure, temperature, the composition of the growth solution) with the crystal quality and defect structure followed by the temperature-dependent optical measurements at ambient and high hydrostatic pressures including spectrally- and time-resolved photoluminescence and the advanced theoretical modeling to receive a precise description and complete understanding of the observed effects.

The final result of the project will be the new knowledge on growing high-quality h-BN crystals, the energy structure of selected impurities in the h-BN host, and their impact on optical properties of the investigated material leading to a better understanding and improved control of occurring emission properties, which cannot be sufficiently controlled at present. These results will allow the design of h-BN crystals with given emission properties required for specific applications, e.g. in developing novel efficient deep-UV optoelectronic devices.

(a)




(b)

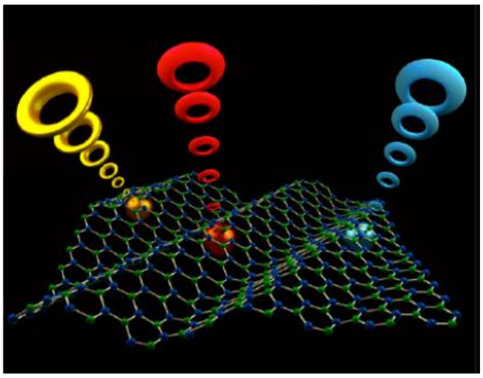


Fig.1. (a) Applications of UV emitters [source: A. Yadav, H. Hirayama, E.U. Rafailov, Light Emitting Diodes, in *Nitride Semiconductor Technology*, F. Roccaforte & M. Leszczynski (eds), Wiley-VCH Weinheim 2020, pp. 253-300], (b) illustrative image of bright single photon sources with various possible photon energies [source N.R. Jungwirth, B. Calderon, Y. Ji, M.G. Spencer, M.E. Flatté, G.D. Fuchs, Nano Lett. **16**, 6052 (2016)].