Optical properties of hBN layers

Annick Loiseau[1]
Léonard Schué[1,2], Ingrid Stenger[2], Alexandre Plaud[1,2], Frédéric Fossard[1], Lorenzo Sponza[1]
Claudio Attaccalite[3], François Ducastelle[1]
Julien Barjon[2]

[1]*LEM, Onera – CNRS, U. Paris Saclay, 29 Av. de la Division Leclerc, Châtillon, France*
[2]*GEMaC, Université de Versailles-CNRS, U. Paris Saclay, 45 Av. des Etats Unis, Versailles, France*
[3]*CINaM, Aix Marseille University - CNRS, Campus de Luminy, Marseille, France*

Annick.loiseau@onera.fr

hBN layers meet a growing interest for deep UV LED [1], and has become a strategic material for the fabrication of van der Waals heterostructures. Stacked with graphene and/or transition metal dichalcogenides, it can reveal the best of their physical properties [2, 3]. However, hBN optoelectronic properties remain much less characterized and understood than other 2D materials.

In this talk, we review recent advances made thanks to the development of appropriate spectroscopies in the UV range - cathodoluminescence (CL) at 4K, angular resolved Low loss EELS [4, 5] and Raman spectroscopy [6] - combined with ab initio simulations and tight binding modelling [7]. Thanks to these tools, a h-BN characterization metrics has been developed on the basis of their original optical properties, governed, in the energy range 5.5 – 6 eV, by strong excitonic effects easily trapped at structural or chemical defects [8]. We shall discuss the interplay between structure, defects and spectroscopic properties and how these properties can be further exploited for sample benchmarking [8,9].

Beyond this effort, the talk will also address the recent experimental advances made for the understanding of the high luminescence observed although bulk hBN is an indirect band gap material [1, 10]. The efficiency of radiative recombinations has been measured on a reference single crystal [11] using temperature - dependent cathodo-luminescence and compared to that diamond and ZnO crystals [12]. These measurements confirm the existence of tightly bound excitons in hBN, and will be discussed in the light of recent theoretical ab initio calculations of the exciton dispersion [12, 13].

References

[1] K. Watanabe, T. Taniguchi and H. Kanda, Nature Materials, 3 (2004), 404
[2] C. R. Dean et al., Nature Nanotechnology, 5, 722 (2010).
[3] F. Cadiz et al., Phys. Rev. X, 7, 021026 (2017).
[4] A. Pierret et al, Phys. Rev. B, 89 (2014) 035414.
[5] P. Jaffrennou el al., Phys. Rev. B **77** (2008) 235422
[6] I. Stenger et al., 2D Materials, 4, 031003 (2017).
[7] T. Galvani et al., Phys. Rev. B, 94 (2016), 125303
[8] L. Schué et al., 2D Materials, 4, 015028 (2017).
[9] L. Schué et al., Nanoscale, 8 (2016), 6986
[10] B. Arnaud, S. Lebègue, P. Rabiller and M. Alouani, Phys. Rev. Lett., 96 (2006), 026402
[11] K. Watanabe and T. Taniguchi, Int. J. Appl. Ceram. Technol., 8 (2011), 977
[12] L. Schué et al, under preparation (2018)
[13] L. Sponza, H. Amara, F. Ducastelle, Annick Loiseau, and C. Attaccalite, Phys. Rev. B, 97 (2018), 075121