Structural and optical characterisation of h-BN layers

Léonard Schué[1,2], Aurélie Pierret[1], Frédéric Fossard[1], François Ducastelle[1], Julien Barjon[2] and Annick Loiseau[1]

[1]*LEM, ONERA-CNRS, 29 avenue de la Division Leclerc, Châtillon, France*

[2]*GEMAC, Université Versailles – CNRS, 45 avenue des Etats-Unis, Versailles, France*

[*]frederic.fossard@onera.fr; Téléphone : 0146734595;

1. INTRODUCTION

Hexagonal boron nitride is a wide band gap semiconductor (~ 6.5 eV), which meets a growing interest for graphene engineering [1]. In particular electron mobility of graphene is shown to be preserved when graphene is supported by a h-BN film. We attempt to have a better comprehension of the optical and electronic properties of thin BN layers, in correlation with their structural properties and to better know how electronic properties of graphene can be impacted by underlying BN layers.

Until recently, these properties were poorly known due to both the scarcity of crystals and suitable investigation tools. This situation has changed thanks, first, to the development of dedicated cathodoluminescence (CL) experiments running at 5K and adapted to the detection in the far UV range [2], and second to the avaibility of high quality single crystals [3].

2. RESULTS

The main issue when studying emission properties of large bandgap materials, is obviously the large photon energy required to create electron hole pairs. We used a cathodoluminescence setup (Figure 1) combining both the imaging capabilities of a SEM and the response of an achromatic spectroscopic chain of acquisition up to 6.5 eV (190 nm). This setup allows us to study the basic optical properties of hBN with a nanometric resolution and experiments can be performed as a function of T, down to the liquid helium temperature. Moreover since a spectrum can be recorded for each position of the probe, it is possible to build hyperspectral datacubes.

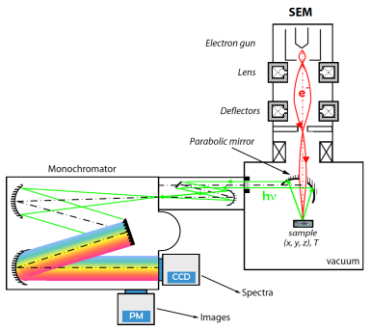

Figure 1. scheme of the cathodoluminescence setup exhibiting a SEM coupled with an UV optimized spectrometer

h-BN has been shown to display optical properties, governed, in the energy range 5.2 – 6 eV, by strong Frenkel-type excitonic effects [2, 4]. In this work, we investigate by CL the luminescence properties of hBN samples synthesized by three different processes (HPHT, PDCs and a commercial powder). We observe in CL spectra the same features of the S series, in the energy range 5.7 – 6 eV as presented on figure 2. This reveals the intrinsic origin of these excitonic recombinations unlike the D series previously attributed to excitons trapped on defects such as dislocations or grain boundaries and observed at lower energy (5.2 – 5.7 eV) [5].

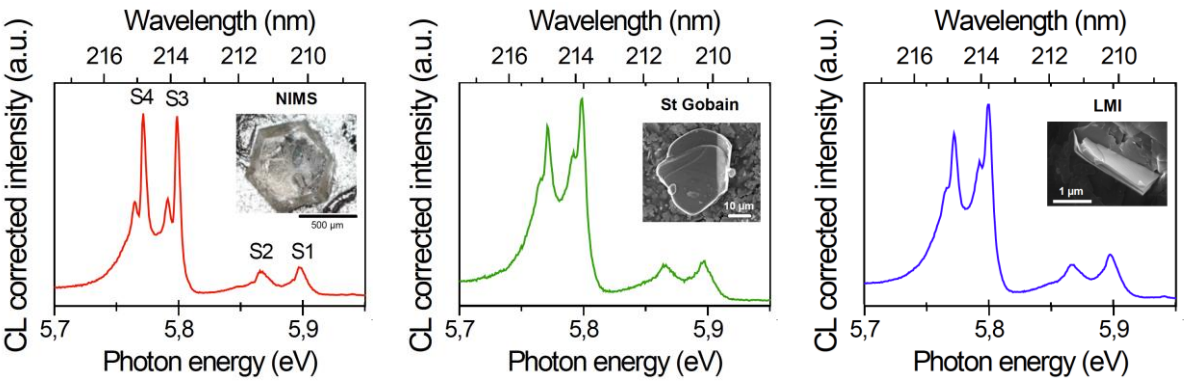

Figure 2. cathodoluminescence spectrum of hBN for samples obtained by different techniques : (left to right) high temperature/pressure single crystals, powders and Polymers Derived Ceramics.

Besides, thin hBN layers have been obtained by mechanical exfoliation from small crystallites of a commercial powder and a single crystal. We performed CL measurements on several flakes with various thicknesses from 100L to 6L and observed a significant effect of the confinement on the luminescence of hBN, especially in the energy range 5.7 – 6 eV previously mentioned. Indeed, CL spectra exhibit S series with different features depending on the hBN thickness. This strongly suggests that this signal (S series) could arise from distinct contributions that we will discuss.

The research leading to these results has received partial funding from the European Union Seventh Framework Programme under grant agreement n°604391 Graphene Flagship.

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