Experimental characterisation of a µPECVD process for the deposition of hexagonal boron nitride

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Hexagonal boron nitride (h-BN) is a material with remarkable properties, widely applicable in fields such as electronics, optoelectronics and spintronics. Its hexagonal crystal structure, similar to that of graphene, allows for the formation of Van der Waals heterostructures, making it a key material for the development of advanced devices [1]. The use of Microplasma Enhanced Chemical Vapor Deposition (µPECVD) is one of the promising techniques for producing thin h-BN films. This method is based on a special plasma discharge known as Micro Hollow Cathode Discharge (MHCD). MHCD consists of two molybdenum electrodes separated by dielectric layer (alumina), with a hole of few hundred microns in diameter drilled through the three layers. This discharge is operated in a gas mixture of nitrogen and argon in a 1:1 ratio at 30 mbar pressure and powered with a negative pulsed high voltage (500 ns pulse width at -1 kV). On the other side of the MHCD Boron tribromide (BBr_3) and hydrogen (H_2) is injected to form homogeneous boron nitride with an hexagonal structure. The MHCD can dissociate the nitrogen molecule which is difficult to split (binding energy of 9.6 eV), thus providing the atomic nitrogen needed to form boron nitride. This is induced by different microplasma mechanisms involving reactive species such as argon and nitrogen metastables or energetic electrons. These are then drawn into a low-pressure (≈1 mbar) chamber containing a third electrode, which is located on a substrate holder 3 cm away from the MHCD and biased with a DC positive voltage. The substrate holder is heated to 800°C to facilitate deposition on various substrates such as silicon, copper or sapphire. The h-BN growth parameters are highly dependent on substrate temperature, pressure, gas composition and the position of the holder [2]. This study aims to investigate the deposition process of h-BN by µPECVD for different deposition times (between 30 minutes and 5 hours). To identify the atomic vibrations of h-BN and confirm its presence Raman spectroscopy was used. Furthermore, time-integrated and time-resolved ICCD (Intensified Charge-Coupled Device) imaging provided information about the discharge dynamics/structure during the deposition (figure 1). Finally, optical emission spectroscopy (OES) was employed which allowed us to detect emissive species in the deposition chamber and assess their role in the deposition process. Overall, these techniques provide a better understanding of MHCD conditions affecting the growth of h-BN thin films and the mechanisms responsible for its formation.

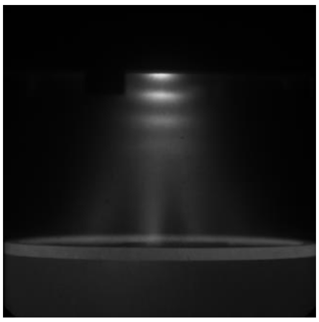

Figure 1: time-integrated ICCD image of the plasma during *h*-BN deposition

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Mots clés : Microplasma, Nitrure de bore hexagonal, µPECVD,diagnostics optiques, ICCD résolu en temps, spectroscopie d'emission, Raman.

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