Canadian Association of Physicists

Association canadienne des physiciens et physiciennes

Contribution ID: **2700** Type: **Oral not-in-competition (Graduate Student) / Orale non-compétitive (Étudiant(e) du 2e ou 3e cycle)**

Assembly and Characterization of MoS2/HBN heterostructures for Opto-electronic devices

Monday 3 June 2019 13:30 (15 minutes)

2D transition-metal dichalcogenides (TMDs) exhibit unique optical and electronic properties that make them highly appealing to the scientific community. Like graphene, they have strong in-plane bonds and weak out-of-plane bonds, allowing for easy fabrication of complex single layer structures or molecular heterostructures. In particular, MoS2 is a TMD semiconductor that displays emerging photoluminescence (PL) through its transition from exhibiting an indirect bandgap in its bulk form to a direct bandgap at few- to monolayer thickness. Although it holds great potential for use in novel nanoelectronics and optical devices, there is still much variability in the reported PL and electron mobility across studies involving 2D MoS2. This necessitates a better understanding of its excitonic properties. In this work, we report on our exfoliation and membrane transfer technique: a modified mask aligner and dry PDMS transfer for assembly of heterostructures. We developed simple optical methods to quantify layer number, which we compare with Raman spectroscopy, Atomic force microscopy, and PL spectrum analysis. We then compared the PL spectrum between layer number, h-BN encapsulated samples, and exfoliated vs. grown MoS2 via chemical vapour deposition (CVD). We found red shifted PL peaks with increasing layer number and in CVD-grown MoS2, indicative of crystal purity or structural differences for exfoliated devices. Also, PL intensity increased with decreasing layer number as well as with h-BN encapsulation. We further discuss the lithographic process used to integrate monolayer samples into a bottom-gated field effect transistor, followed by preliminary data.

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Session Classification: M2-11 Materials synthesis and characterization II (DCMMP) | Synthèse et caractérisation de matériaux II (DPMCM)

Track Classification: Condensed Matter and Materials Physics / Physique de la matière condensée et matériaux (DCMMP-DPMCM)