hBN-encapsulated Group-VI TMDC van der Waals Heterostructures: Fabrication and Optical properties

Mitsuhiro Okada¹, Yusuke Kureishi¹, Kenji Watanabe², Takashi Taniguchi², Hisanori Shinhohara¹, Ryo Kitaura¹

¹ Department Chemistry and Institute for Advanced Research, Nagoya Univ., ² NIMS
E-mail: noris@nagoya-u.jp, r.kitaura@nagoya-u.jp

1. Introduction
Two-dimensional (2D) semiconductors, including MoS₂, WS₂, MoSe₂, etc., have provided a fascinating opportunity to explore optical properties in 2 dimensions. In particular, van der Waals (vdW) heterostructures composed of these 2D semiconductors, such as WS₂/MoS₂, offer a novel platform for optical physics, where strong inter-layer interaction drastically alters optical transitions. To explore the intrinsic properties of TMDC vdW heterostructures, high-quality samples are indispensable. Here, we report preparation and optical properties of high-quality vdW heterostructure (WS₂/MoS₂) which are fully encapsulated by hexagonal boron nitride (hBN) (Fig. 1).

2. Results and Discussion
We synthesized monolayer MoS₂ and WS₂ by chemical vapor deposition method and prepared thin hBN flakes by mechanical exfoliation method. hBN-encapsulated heterostructures (hBN/WS₂/MoS₂/hBN) were prepared with the polymer-assisted dry-transfer method. Figure 2 shows PL spectrum of a (hBN/WS₂/MoS₂/hBN) sample measured at room temperature under ambient condition. As clearly seen, PL peaks arising from A-exciton of WS₂ and MoS₂ appear at 1.98 and 1.87 eV, respectively. In addition to the A-exciton peaks, new emissions can be seen at 1.4-1.7 eV. This new feature, which is decomposed to three peaks, is observed in heterostructure samples, being assigned to interlayer excitons. The interlayer excitons in WS₂/MoS₂ vdW heterostructures were observed in previous papers, giving a single broad peak at around 1.4 eV. [1] In contrast, the observed interlayer PL peak gives more detailed spectral features, which might originate from high-quality (clean interface and surface flatness) of our sample.

3. Conclusions
We have successfully fabricated hBN-encapsulated WS₂/MoS₂ vdW heterostructure by the dry transfer method. Appearance of the sharp interlayer exciton peak clearly demonstrates that the quality of the fabricated is high. The results obtained in this work indicate the importance of hBN encapsulation in investigation of intrinsic physical properties of TMDC and its vdW heterostructures.

Fig. 1 A structure model of the fabricated heterostructure.

Fig.2 PL spectrum of hBN-encapsulated WS₂/MoS₂ vdW heterostructure.

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References