## Optical identification of grain boundaries of monolayer MoS<sub>2</sub>

Jeongyong Kim

Center for Integrated Nanostructure Physics, Institute for Basic Science, Sungkyunkwan University, Suwon 440-746, Korea Department of Energy Science, Sungkyunkwan University, Suwon 440-746, Korea E-mail address: j.kim@skku.edu

## 1. Introduction

Monolayer molybdenium disulfide (MoS<sub>2</sub>), one of promising 2 dimensional transition metal dichalcogenide materials, is mono-atomic semiconducting layer with visible wavelength emission, being actively studied for novel device application.<sup>1</sup> However the CVD process where grains are separately grown from multiple scattered seeds is inevitably subjected to grain boundaries (GBs) between micro-size MoS<sub>2</sub> grains, which was shown to affect the electrical and optical properties of MoS<sub>2</sub> devices. Optical method of GB visualization of large area MoS<sub>2</sub> would be convenient for the large-area and non-invasive inspection capability and also contribute to the understanding of the physical nature of GB in MoS<sub>2</sub>. photoluminescence (PL) variation on GBs were also reported to occur on the GBs of MoS<sub>2</sub> where PL reduction or enhancement were observed.<sup>2</sup> While the PL variation along the GBs could provide a convenient optical visualization of monolayer MoS<sub>2</sub>, can really cause the PL variation that is spatially extensive enough to be detected by routine micro-PL imaging having a few hundreds nanometer spatial resolution. To answer this question, not only PL imaging also other characterization on the GBs must be carried out.

## 2. Results and Discussion

Another experimental approach that may elucidate the origin of PL variation along GB is the use of nanoscale PL imaging which can provide the more precise estimation of intrinsic spatial extension of spatial PL variation around the GB. Here we used NSOM PL imaging with ~100 nm spatial resolution and showed that NSOM PL imaging can identify the nanoscale structural defects, as small as ~20 nm in size, such as GBs or ad-layers of CVD grown monolayer MoS<sub>2</sub>, which were not distinguished by conventional confocal PL imaging. We also found that combined with correlated scanning electron microscopy(SEM) imaging, observed PL quenching on GBs MoS<sub>2</sub> is caused mostly due to actual physical damages on GBs<sup>3</sup>



Figure 1. Photoluminescence images of a polycrystalline monolayer MoS2 by confocal (a), near-field (b) and electron (c) microscopy

## References

- [1] K. F. Mak et al. 105, 136805 (2010).
- [2] A. M. van der Zande, et al. Nat. Mater., 12, 554-561 (2012)..
- [3] Y. Lee et al Nanoscale., DOI: 10.1039/C5NR02897C