Plasmonic Enhancement of Photoluminescence Intensity in Liquid Exfoliated WS_2 – Silver Island Film Hybrid Structure

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Hybrid structures, composed of semiconductors and metallic nanoparticles are a group in which plasmon excitation allows for tailoring the optical response of semiconductor [1]. One of the vast possibilities is to use the plasmon excitation to enhance the photoluminescence response of the semiconductor.

Since graphene discovery in 2004, 2D materials focus much attention of the scientific community. Various atomically flat materials are investigated; among them transition metal dichalcogenides (TMD) monolayers form a distinct family of 2D semiconductors with open and direct bandgap, exhibiting photoluminescence at room temperature [2]. Advances in liquid exfoliation of 2D materials and subsequent size selection allows for the preparation of monolayer-enriched dispersions with well-defined size [3]. Such materials are promising candidates to study optical properties as well as fabricate hybrid structures due to the possibility of solution processing.

In this work we report the enhancement of PL intensity of liquid exfoliated WS_2 monolayers, coupled with Silver Island Film (SIF). The hybrid structure was prepared by drop-casting WS_2 on SIF, prepared by reduction of silver nitrate with glucose.

To quantify the enhancement and its spectral dependence, WS_2 PL was measured for three excitation wavelengths (405, 485 and 532 nm) on SIF and on glass. In order to collect statistically significant data, 400 emission spectra for each excitation and substrate was acquired by mapping a 200 μm x 200 μm sample region with 10 μm step for each substrate. Spatial resolution equals to 2 μm. The experiment was carried out at temperature of 7 K.

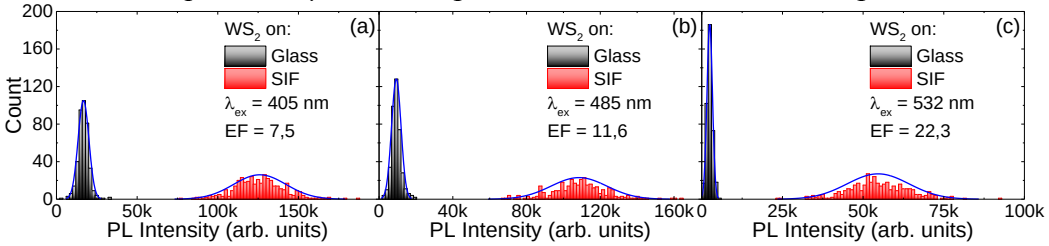

Fig.1. Intensity distributions of monolayer WS_2 PL measured on glass (black bars) and SIF (red bars) for excitation of (a) 405 nm, (b) 485 nm and (c) 532 nm.

This measurement allowed to calculate the enhancement factor; it varies between 8, and 22. Spectral dependence of the EF suggests presence of effects beyond excitation rate enhancement – e.g. Purcell effect. Significant broadening of PL intensity distribution on SIF is observed, revealing SIF inhomogeneity, that is well known from literature.

[1] R. Jiang et al., *Adv. Matt.* **26** (2014), 5274.
[2] Q. H. Wang, et al., *Nat. Nanotechnol.* **7** (2012), 699.
[3] C. Backes et al., ACS Nano 10 (2016), 1589.