Tuning the spontaneous emission of monolayer WSe_2 by optical environment control – cavity coupling and substrate manipulation

Hyunseung Lee[1] and Jieun Lee[1]

[1] *Department of Physics and Department of Energy Systems Research, Ajou University, Suwon, 16449, Korea.*

Atomically thin layer of transition metal dichalcogenides (TMDs) such as monolayer WSe_2 exhibit direct bandgaps ranging from visible to near-infrared with strong exitonic effect [1]. Thanks to its optical characteristics, these materials can be used for integrated functional devices such as light emitting devices, photodetectors and optical modulators. In these applications, device performances can be improved by engineering the material thicknesses and doping levels, applying external fields, or modulating optical environment. In particular, tailoring the optical environment has been demonstrated by coupling monolayer TMDs to various types of optical microcavities such as Bragg reflectors or photonic crystals [2-4].

In this work, we utilize microspheres on planar substrates to manipulate the emission properties of monolayer WSe_2. First, we show the enhancement of the photoluminescence (PL) emission which is controlled by the size of the coupled microsphere which ranges from 2 to 7 μm. Time-resolved PL measurement supports the cavity-induced emission rate enhancement of monolayer WSe_2 coupled to a microsphere. The PL enhancement is further increased by increasing the thickness of the oxide layer between the microsphere and silicon substrate, which is supported by finite-time domain method (FDTD) simulations. Both microsphere coupling and substrate manipulation provide convenient pathways to modulate 2D material-based photonic devices.

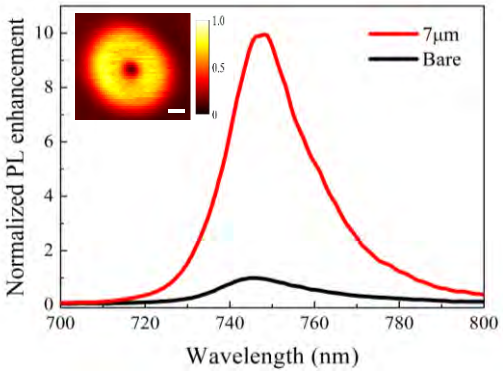

Figure 1 PL enhancement of monolayer WSe_2 coupled to a 7 μm diameter microsphere. Inset scale bar : 2 μm .

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[+] Author for correspondence: jelee@ajou.ac.kr