Title of the Presentation: Atomic-Layer-Confined Multiple Quantum Wells Enabled by Monolithic Bandgap Engineering of Transition Metal Dichalcogenides

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Short Biography:

Yoon Seok Kim received his B.S. ('15) from the Department of Materials Science and Engineering of Yonsei university. Then, he moved to his Ph. D of KU-KIST graduate school in Korea University. His research interests are classical and non-classical optical properties of TMDs and integration into the photonic circuits.

Abstract:

Two-dimensional (2D) semiconducting transition metal dichalcogenides (TMDs) have attracted enormous attention because of exceptional optical properties such as large exciton binding energy, and strong light-matter interaction at the ultimate thickness limit. Such remarkable properties make them promising for high-performance light-emitting devices such as LEDs, LASERs, and single-photon emitters. However, high efficiency in the luminescence of those 2D semiconductors is inherently limited to monolayer regime due to indirect-to-direct bandgap transition and intrinsic high quantum yield should be realized for practical applications. In addition, constructing a quantum well structure with type I band alignment is difficult because most TMDs form the type II heterojunctions. Consequently, securing the large active volume and confining the excitons in 2D semiconductor heterostructures still remain a huge challenge. Here, we demonstrate the novel approach to fabricate atomic-layer-confined multiple quantum wells (MQWs) via monolithic bandgap engineering of TMDs and artificial van der Waals stacking. A fundamental building block of QWs, the WO_X/WSe_2 hetero-bilayer with type-I band alignment, was prepared by monolithic oxidation of the WSe_2 bilayer, followed by stacking the blocks into the MQWs. Unlike the case of stacking monolayers only, the photoluminescence (PL) characteristic was not quenched in this MQWs, and the super-linear increases of PL with the number of QWs were achieved. This is presumably because the WO_X layer acts as a quantum-barrier layer between two adjacent monolayers, allowing to preserve the direct bandgap nature of monolayers even in the staked heterostructure. By examining the band structure of WO_X/WSe_2, we found that the hetero-bilayer WO_X/WSe_2 constitutes the quantum well for efficient exciton confinement and radiative recombination. Furthermore, the quantum-confined radiative recombination in MQWs was verified by a large exciton binding energy of 193 meV and a short exciton lifetime of 170 ps. This work paves the way toward monolithic integration of 2D superlattices for novel quantum optoelectronics.