MATERIALS RESEARCH SOCIETY

SESSION QN03.05: Photonic Properties and Devices I

Session Chairs: Deep Jariwala and SungWoo Nam

Tuesday Afternoon, April 23, 2019

PCC North, 100 Level, Room 129 A

1:30 PM QN03.05.01

Enhancement and Control of Circularly Polarized Emission in Monolayer Heterogeneous WS2 with a Plasmonic Chiral Metasurface Wei-Hsiang Lin1, Pin Chieh Wu1,

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Controlling the circular polarization of light is a key aspect for the development of functional nanophotonics for emerging applications. Monolayer transition metal dichalcogenides (TMDCs) are excellent candidates for spintronic, valleytronic and optoelectronic devices because the two inequivalent valleys in the Brillouin zone can give rise to valley-polarized photoluminescence (PL) under excitation with circular polarized light (CPL). However, the atomic monolayer thickness is a significant challenge for WS2 photoluminescence emission due to its weak light-matter interaction. We investigated the feasibility of enhancing the light-matter interaction in monolayer WS2 by means of the exciton-plasmon interaction with spin-orbit coupling of light. This objective was achieved by designing and fabricating plasmonic spiral rings with subwavelength dimensions on a hybrid substrate for WS2, and by synthesizing high-quality WS2. Specifically, we developed controlled growth of heterogeneous domains in CVD-grown monolayer WS2 single crystal on SiO2/Si substrate using tungsten oxide and sulfur precursors at T=850 degree C. Spatially resolved PL, Raman, X-ray photoelectron spectroscopy and Kevin

probe force microscopy images revealed the formation of homojunctions in these single crystals which imply a direct correlation between the chemical stoichiometry and optoelectronic heterostructure. The WS2 were integrated with a plasmonic spiral ring metasurface with subwavelength sized elements, designed to enhance the light-matter interaction. Our plasmonic chiral metasurface consisted of a gold back reflector, a 20-nm-thick SiO2 dielectric layer followed by a monolayer heterogeneous WS2 layer on which we fabricated a gold spiral array. By optically pumping the plasmonic chiral metasurface/WS2 heterostructure with CPL and measuring the resulting spatially resolved CP emission (Pcirc) at room temperature and low temperature (80K), we found the optical chirality of WS2 was enhanced by more than 10 times relative to WS2 layers. Additionally, by proper designs of the dimensions of the chiral metasurface structure, a linearly-polarized incident light can be converted to circularly-polarized light. These results suggest a new pathway of manipulating the valley-polarized PL emission in 2D materials via plasmonic chiral metasurfaces, which may be further applied to the development of valley-polariton optoelectronic devices.