Direct Correlative Nanoscopy Imaging of 2D Materials

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2D transition metal dichalcogenides (TMDCs) materials are considered of very high potential semiconductors for future nanosized electronic and optoelectronic devices. An information-rich nanoscale characterization technique is required to qualify these materials and assist in the deployment of 2D material-based applications. Scanning Probe Microscopy (SPM) is a powerful technique to image physical properties of 2D materials, such as topography, conductivity or other electrical properties. Combining SPM and Raman in a single instrumentation is extremely powerful as it makes imaging of both chemical and physical properties possible. As Raman is diffraction limited, only plasmon enhanced Raman and photoluminescence spectroscopies yield correlated electrical and chemical information down to the nanoscale.

In this talk, we will report on Tip-Enhanced Photoluminescence (TEPL) and Tip-Enhanced Raman spectroscopy (TERS) data obtained on single crystal WS2 and WSe2 flakes directly grown on SiO2/Si. TEPL and TERS images will be correlated with contact potential difference and capacitance maps as results of Kelvin force probe microscopy acquisition. In addition, we will show the sensitivity of electronic properties (related to Fermi level and charge accumulation) upon light illumination.

Beside these semiconductor/dielectric (SiO2) interfaces, probing TMCD/metal interfaces is also essential to integrate TMCDs in 2D or 3D complex structures of devices. We will show results from WS2 on silver and WSe2 and MoS2 on gold. Such transferred surfaces exhibit nanoscale inhomogeneities observed in correlated CPD and Raman maps.

Finally, TEPL together with AFM topography data on a lateral single layer WS2/WSxSe1-x/WSe2 heterostructure grown on SiO2/Si will be presented: nanoscale PL response variations are observed beyond the smooth nano-resolution topography.