TERS: New Method for Nanoscale Characterization of 2D Materials - from Graphene to TMDCs.

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Recent advances in tip-enhanced Raman scattering (TERS) instrumentation, availability of commercial highly enhancing probes and development of dedicated TERS imaging modes have brought TERS characterization to the level of an everyday analytical method that can provide important information on structural and electronic properties of different materials at the scale of a few nanomenters.

We report the results of TERS characterization of 2 classes of 2D materials: graphene and its derivative and two members of transition metal dichalcolgenides (TMDCs) class- MoS_2 and WS_2. We discovered that the gap mode TERS signal of these 2D materials becomes dramatically enhanced over wrinkles and creases, as well as over nanopatterns imprinted into flakes using a sharp diamond probe.

Resonant Raman spectra of TMDCs contain additional peaks normally forbidden by selection rules. TERS maps of few-layer-flakes of MoS_2 show that the spatial distribution of Raman intensity across the flake varies for different peaks, specifically, the lower energy component of the complex resonant 465cm^{-1} peak is significantly decreased at the edges of the flakes. TERS and tip-enhanced photoluminescence (TEPL) characterization of WS_2 grown on Si/SiO2 show that, similar to the case of MoS_2 flakes, the properties are not uniform across the flake: there exists a narrow, 150-200 nm wide, area along the edges of the flakes with decreased and blue shifted photoluminescence and in the same time enhanced TERS response, both of which indicate decreased charge carrier density in the vicinity of the flake outer edges.

Based on these results, we argue that TERS and TEPL can be an extremely useful tool for nanoscale characterization of the 2D materials.

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