Wide-field microscopy of STM-induced luminescence in 2D semiconductors

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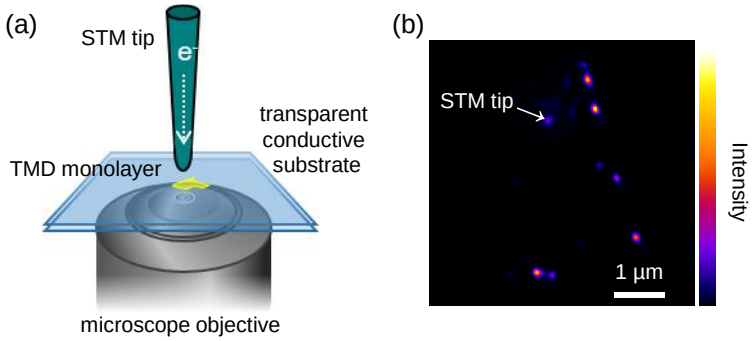
The diffusion of charge carriers and excitons (bound electron-hole pairs) and their interactions with defects play a key role in the electroluminescence properties of two-dimensional (2D) semiconductors. Understanding and controlling these processes is crucial for the performance of future devices based on these materials. Recently, the electroluminescence properties of monolayer transition metal dichalcogenides (TMDs) have been mapped at the nanoscale by recording light induced by the tunneling current under the tip of a scanning tunneling microscope (STM) scanned over the sample [1-6]. However, scanning imaging techniques such as STM-induced luminescence in photon-mapping mode provide no information on the diffusion of charge carriers and excitons, as they are not sensitive to the spatial distribution of emission around the excitation source. To address this issue, we combine tunneling current excitation under the tip of an STM (for extremely local excitation), wide-field optical microscopy (to image the spatial distribution of the emission), and deconvolution of optical microscopy images using an iterative Richardson-Lucy algorithm (to achieve spatial resolution beyond the diffraction limit) [7].



(a) Schematic of the experiment, combining an STM head and an inverted optical microscope. (b) Deconvolved optical microscopy image of the STM-induced luminescence of a WS_2 monolayer, showing the emission of hot spots several micrometres away from the STM tip [7].

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