Local Electrical Excitation of Excitons in 2D Semiconductors and of Surface Plasmons in Metallic Structures

Elizabeth Boer-Duchemin
Institut des Sciences Moléculaires d'Orsay (ISMO), Université Paris-Saclay, Orsay, France
Elizabeth.Boer-Duchemin@universite-paris-saclay.fr

We use a biased tunnelling junction to locally and electrically excite surface plasmons and excitons. The tunnelling junction used may be between the tip of a scanning tunnelling microscope (STM) and a conducting plasmonic sample[1], between an Au nanoantenna and a gold film[2], or between an STM tip and a conducting substrate on which has been deposited a monolayer of a transition metal dichalcogenide (TMD) material[3-5]. Our setup combines ambient scanning probe microscopy (STM/AFM) with an inverted optical microscope, leading to wide-field imaging capabilities. More precisely, thanks to *real plane* imaging, we can determine from where on the sample the collected light is emitted, while through *Fourier plane* analysis the emission angle of the light is known, thus providing a powerful tool for the interpretation of the physical phenomena at play. In plasmonics we have used this technique to produce a directional nanosource of light[6], and a cylindrical vector beam[7]. In the area of exciton physics, thanks to this technique we have studied exciton diffusion, the orientation of the transition dipole moments, and the controlled quenching of luminescence [3-5].

References

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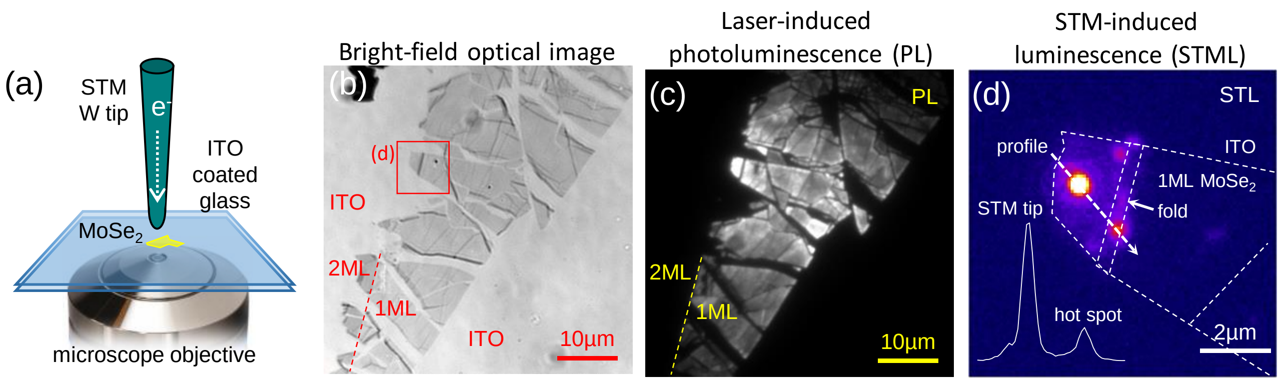

Figure 1: STM-induced generation of excitons in 2D semiconductors. a) Experiment: tunnelling current flows between the tungsten STM tip and the biased sample, which is a mechanically exfoliated $MoSe_2$ flake on ITO on glass. b) Monolayer and bilayer regions are identified with difficulty using transmission optical microscopy. c) Monolayer and bilayer regions are easily identified using laser-induced photoluminescence. d) STM luminescence is induced locally; the bright spot in the image at the tip location demonstrates that most of the created excitons recombine close to the excitation position. Note that others diffuse in the flake and recombine at a "hot spot".