Low-Loss EELS Study of Monolayer MoS_2 and the Effects of Ion-Implantation

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After the initial burst of research caused by the discovery of graphene, other 2D materials have since entered the spotlight [1]. Transition Metal Dichalcogenides (TMDs) show unique properties for nano-electronics and nano-optoelectronics, due to their transition from indirect to direct band gaps when going from bulk to monolayer [2-4]. Their fascinating optical properties have launched research into 2D TMDs as potential materials for single photon emitters [5], nanoscale waveguides [6,7].

Electron Energy Loss Spectroscopy (EELS) in the Scanning Transmission Electron Microscope (STEM) offers a tool for highly resolved, localized analysis of the chemical composition and electronic structure [8]; in particular low-loss EELS is suited to extract information about the latter. Low-loss spectra of mechanically-exfoliated 2D MoS2 were obtained using a monochromated double aberration-corrected Titan Themis microscope. By using a monochromator, we are able to obtain a high enough energy resolution to observe EEL spectra properties in the energy range below 1 eV. This will reveal the local optoelectronic properties of MoS2, e.g. the nature of its plasmons and exitons.

Samples of MoS2 were implanted with Se and Au ions via low-energy ion implantation at 10 eV, in the University of Gottingen. Observed changes in the low loss spectra of MoS2 reflect the effects on the electronic bandstructure imparted by the foreign atoms implanted into the lattice. We furthermore used a combination of Electron Dispersive X-ray Spectroscopy (EDX/S), High Angle Annular Dark Field (HAADF) imaging, and EELS to reveal the positions of the implanted ions in the MoS2 lattice or as adatoms on the 2D surface. These observations are important in order to obtain an understanding of the effects of implantation in 2D materials for the future development of 2D technologies.

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