E-beam assisted etching and patterning of few-layer molybdenum disulfide

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Abstract

Transition metal dichalcogenides have attracted a huge interest since the isolation of graphene. This interest is based in the fact that these materials develop different properties when their thickness is reduced down to the monolayer or few-layer regime [1]. Among all of them, molybdenum disulfide (MoS_2) is especially interesting because as a bulk it is a semiconductor with an indirect band-gap in the near-infrared region of the spectrum, and this band-gap blue-shifts when reducing the number of layers, resulting in a direct band-gap semiconductor which emits in the visible (1.85eV) when its thickness is reduced to a single layer [1, 2, 3].

During the last years, many different techniques for fabricating MoS_2 single layers have been developed, such as mechanical exfoliation [2, 3], XeF_2 plasma etching [4] and many others [5, 6].

In this work we use mechanical exfoliation to deposit MoS2 flakes on a SiO_2/Si substrate and use an electron beam with a XeF_2 flow to locally etch specific regions of the flake (Fig. 1) without using masks or electron beam lithography resists.

We also created point defects using a focused ion beam and visualized on-line the growth of hexagonal holes (Fig. 2) while using the SEM while keeping the XeF_2 flow. This is consistent with the results obtained in [4] using a XeF_2 plasma and graphene as a masking layer.

Using this method we are able to pattern the exfoliated MoS_2 and to selectively etch the material with arbitrary shapes and a good lateral resolution. This will allow us to design complex structures with controlled thicknesses, giving us the possibility to fabricate different kinds of devices such as photonic crystals, quantum dots or transistors.

References

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Figures

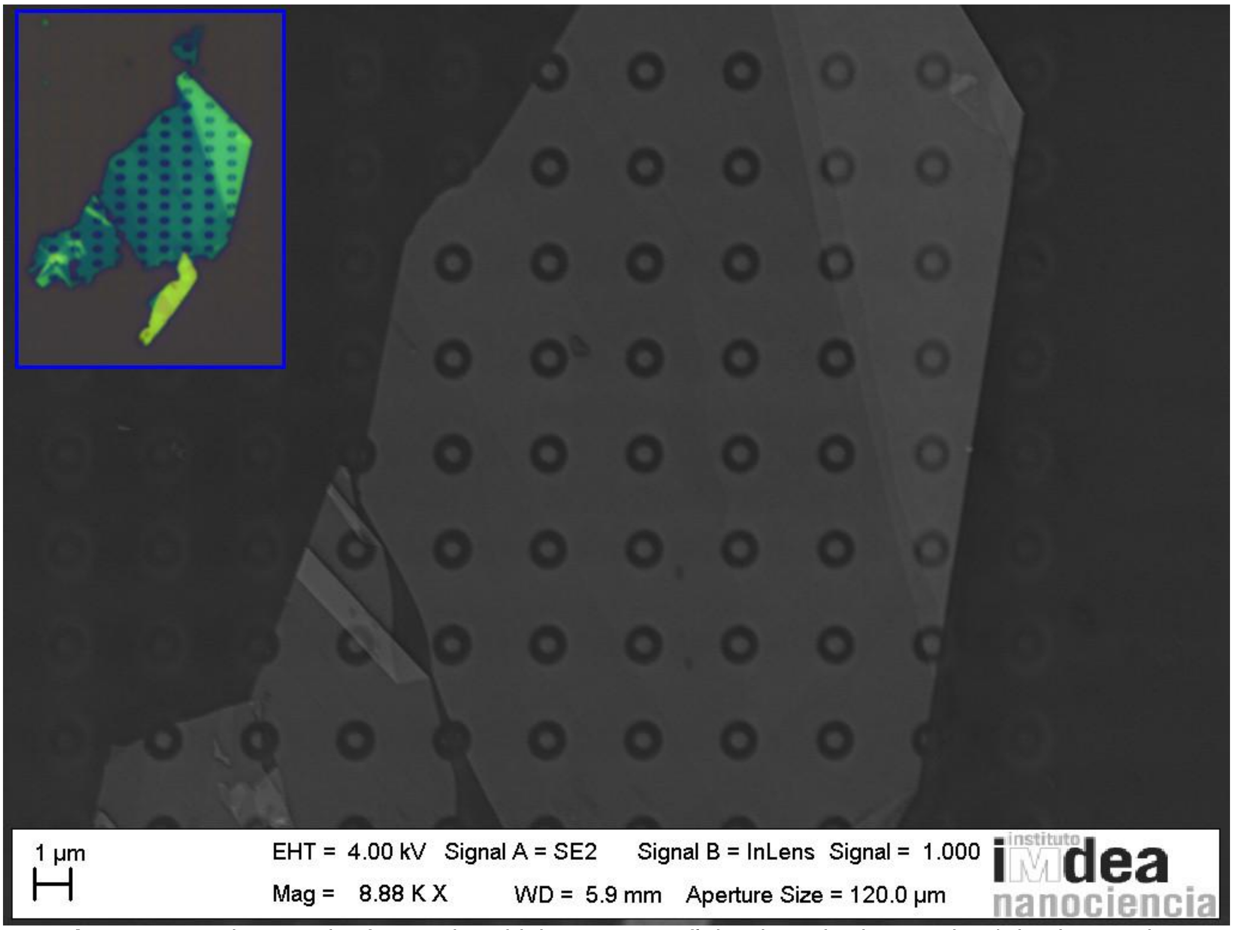

Fig. 1: SEM micrograph of a varying-thickness MoS_2 flake deposited on a SiOx/Si substrate by mechanical exfoliation and patterned using the proposed method. Inset: Optical microscope image of the same flake.

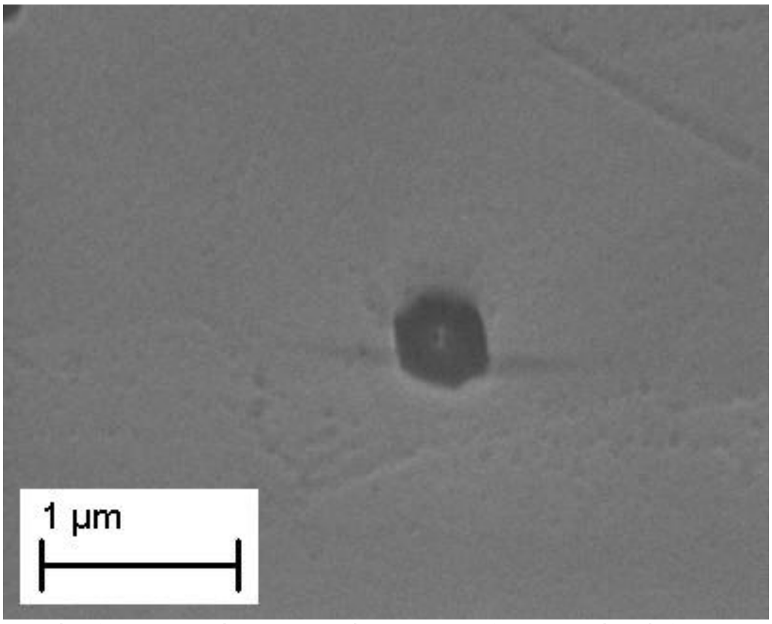

Fig. 2: SEM micrograph of a 500nm hexagonal hole grown from a point defect created with a focused ion beam.