Growth of molybdenum sulphide ultra-thin films and their characterization

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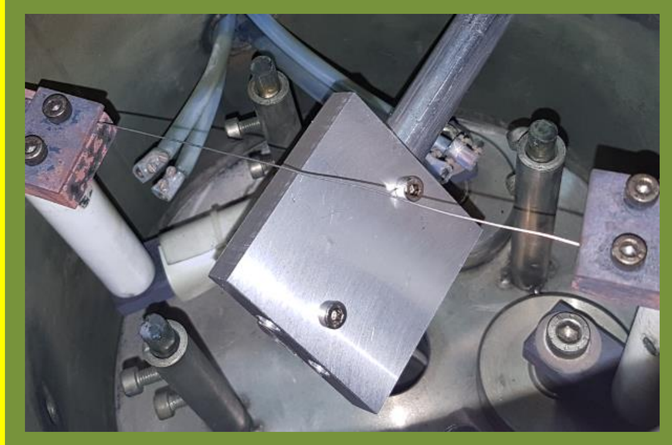
Abstract

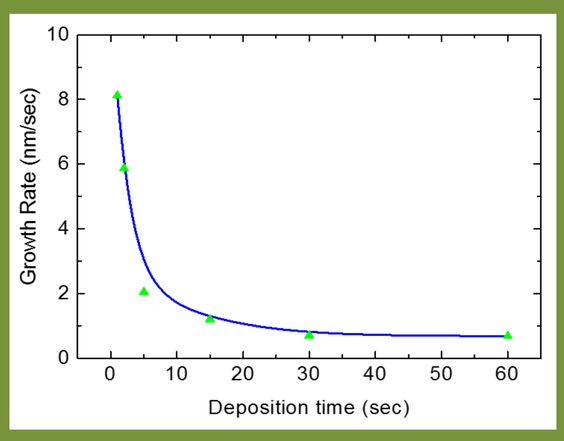
In this work a simple method for depositing molybdenum sulphide films, with thicknesses from a few monolayers to some nanometers, is described. The grown films were amorphous and deposited very easily by heating a molybdenum wire under vacuum at low filament temperature (400 °C) in an ambient composed by H_2 and H_2S. The deposited films were subjected to thermal and microwave annealing in order to be crystallized and were characterized with various techniques to investigate their morphological and structural properties.

MoS_2 film deposition

- The films are deposited very easily compared to other methods by a heated molybdenum filament, covered by a native oxide, at low pressure (1,5 Torr).
- MoO_3 (native oxide) yields MoS_2 according to the reaction: $2MoO_3 + 4H_2S \rightarrow 2MoS_2 + 4H_2O + O_2$ $\quad T_{filament} \geq 400°C$
- The rotated shutter system enables the deposition of MoS_2 ultra thin films with thicknesses from a few monolayers to some nanometers.
- The samples remained at room temperature rendering the deposition method suitable for using organic and plastic substrates, too.

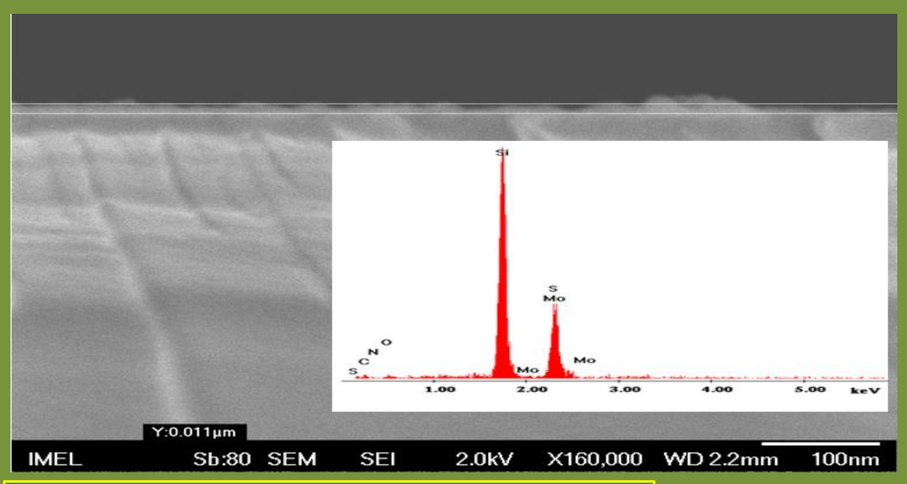


The rotated shutter system.

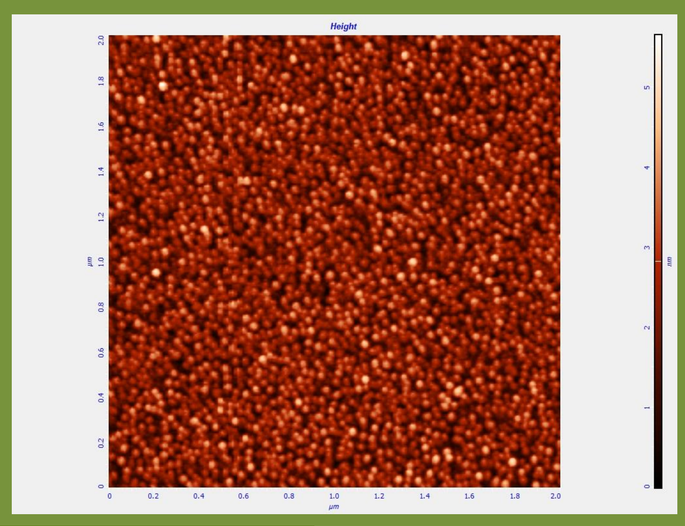


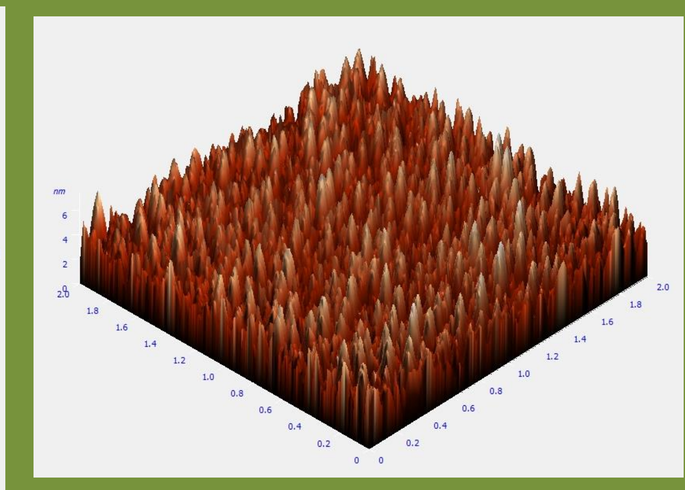
Time variation of growth rate.

MoS_2 film characterization

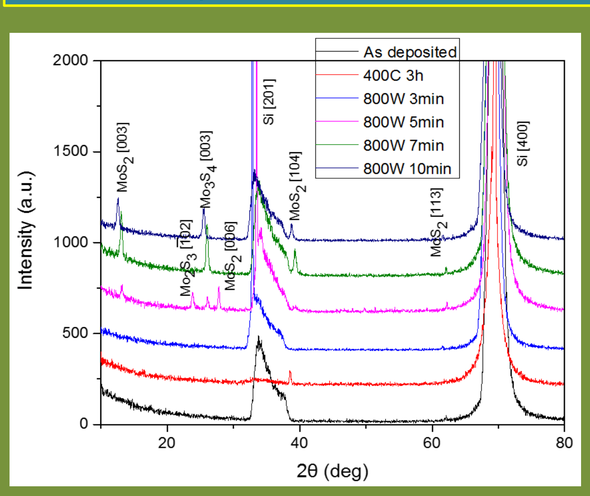


SEM micrographs and EDXS spectra of MoS_2 thin films deposited at 400 °C filament temperature.

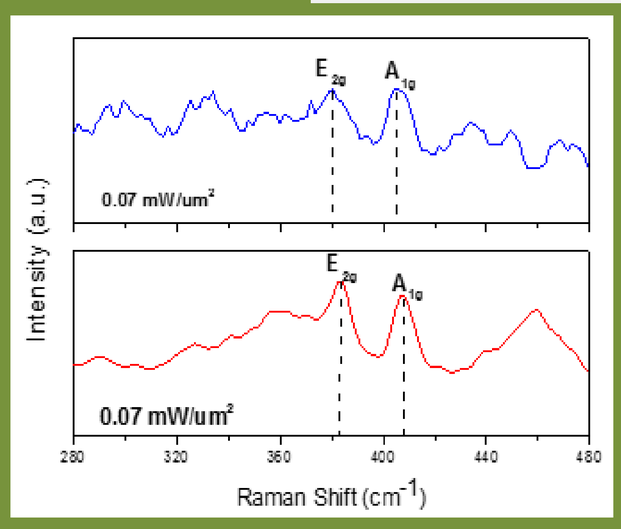




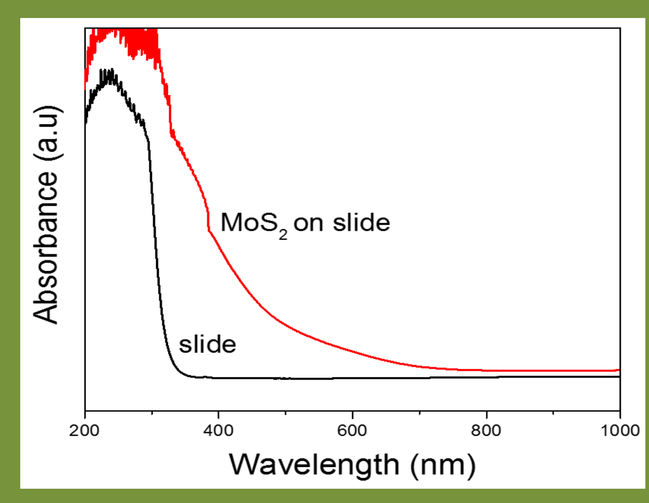
AFM images of a MoS_2 film with a roughness of 1 nm.



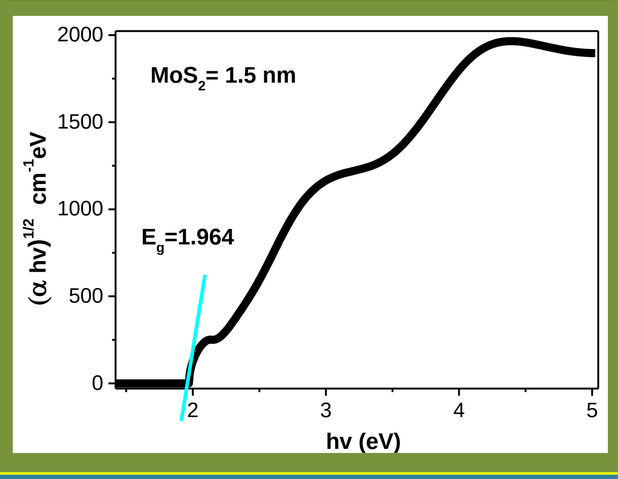
XRD patterns of the deposited films as a function of the adopted post-deposition treatments.



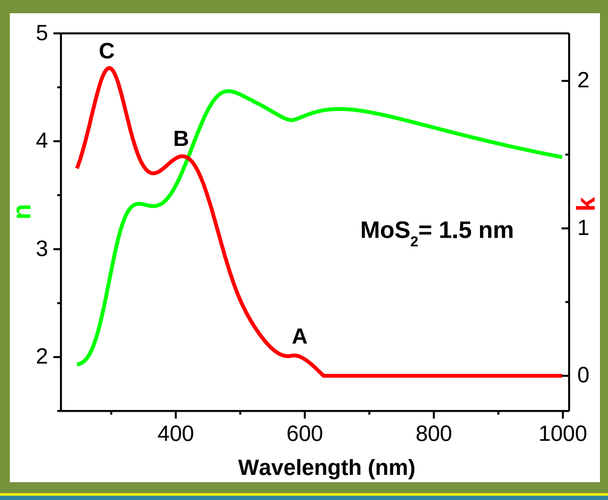
Raman spectra of MoS_2 thin films grown at 400 °C filament temperature before and after annealing treatment.



Absorption spectra of a MoS_2 thin film deposited on a microscope slide.



Tauc plot of a MoS_2 thin film grown at 400 °C filament temperature.



Wavelength variation of the real and imaginary parts of the refractive index of a MoS_2 film deposited with a filament temperature of 400 °C.

Conclusions

Summarizing, a simple method for depositing MoS_2 ultra thin films at room temperature was presented. The as-deposited films were amorphous and were characterized with respect to their morphology and chemical composition. As shown by SEM and AFM measurements, the obtained samples are smooth and homogeneous. At variance with conventional thermal treatments, microwave annealing yields MoS_2 films exhibiting a better atomic ordering as shown by XRD and Raman measurements. The rotated shutter system contributes to the control of film thickness from a few monolayers to some nanometers.

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