Thermal Stability of Monolayer MoS_2 Flakes under Controlled Atmosphere

A. Madonia[1], E. Sangiorgi[1], G. Laurella[1], S.E. Panasci,[2] E. Schilirò,[2] F. Giannazzo,[2] F. M. Gelardi[1], M. Cannas[1], S. Agnello[1,2]

[1]Department of Physics and Chemistry Emilio Segrè, University of Palermo, antonino.madonia@unipa.it
[2] Consiglio Nazionale delle Ricerche - Istituto per la Microelettronica e Microsistemi (CNR-IMM), Strada VIII 5, Catania, Italy

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INTRODUCTION

Bi-dimensional materials are a novel category of solid-state structures renowned for their enticing mechanical and electronic properties.[1] Among these, MoS_2 is one of the most investigated members thanks to its stability and its bulk counterpart being largely abundant in nature. Such semiconductor, belonging to the transition metal dichalcogenides family, presents a thickness dependent band-gap which gives — in the case of monolayer MoS_2 — strong light-absorption capabilities and intense photoluminescence.[2] Such properties as well as its high charge carrier mobility have allowed for the development of optoelectronic devices such as transistors, diodes, photodetectors and light emitting devices.[3]

Nonetheless, several issues are yet to be faced before considering a more widespread usage of this bi-dimensional semiconductor. In particular, because of its sensitivity to the environment and of the interactions occurring with its substrate, MoS_2 is often subject to ageing effects leading to alterations in its mechanical, optical and electronic properties.[4] In this context we have studied the effects that thermal treatments carried out in a controlled atmosphere of O_2, Ar, N_2 as well as air have on the properties of monolayer MoS_2 flakes deposited on a gold substrate. By means of characterization techniques such as Raman and optical spectroscopy we have explored the material's stability and the reversibility of the aging processes. It was found that changes in the stress displayed by the material's crystalline structure induced during the production or by aging in room atmosphere are tuned by the treatment in the given controlled atmosphere and retained after going back to ambient temperature in a permanent way. Additionally, the characteristic exciton emission bands of monolayer MoS_2 are found to shift in position and their relative intensities are found to change both depending on selected gas and aging time. Such studies are aimed at further understanding the structural and electronic effects that processes such as aging and interactions with the external environment have on monolayer MoS_2.

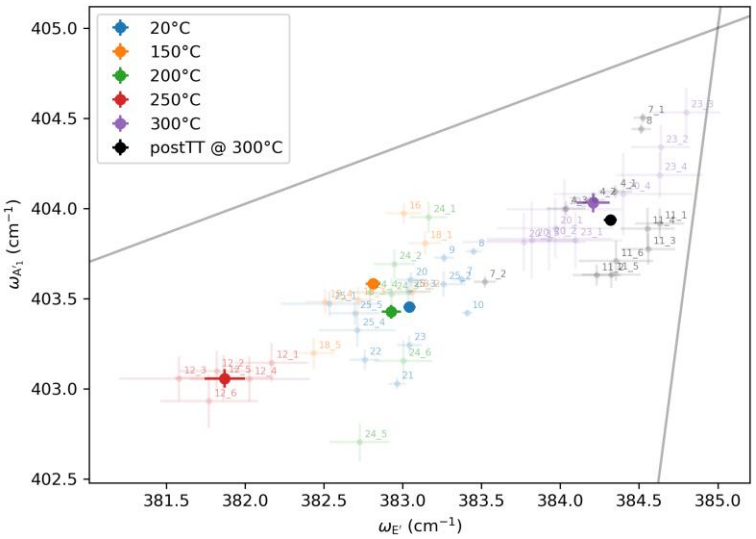

Figure 1 – Strain-doping map of a monolayer MoS_2 flake treated at different temperatures for 2 hours in a controlled Ar atmosphere.

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