Graphene/ Mo_2C vertical heterostructures: Low temperature chemical vapor deposition growth and electrocatalytic properties on HER and OER.

Dr. Stefanos Chaitoglou
Tatiana Giannakopoulou, Antonios Vavouliotis, Athanasios Dimoulas

Institute of Nanoscience and Nanotechnology, National Center for Scientific Research "DEMOKRITOS", 15310, Athens, Greece
s.chaitoglou@inn.demokritos.gr

Thin 2D Mo_2C/graphene vertical heterostructures have attracted significant attention due to their potential application as electrodes in hydrogen evolution reaction (HER) and energy storage. Common drawback in the chemical vapor deposition synthesis of these structures is the demand for high temperature growth, which should be higher than the melting temperature of the metal catalyst. The most common metallic catalyst is Cu, which has a melting temperature of 1084 ˚C. Here, we report the growth of thin, ~ 200 nm in thickness, semitransparent micrometer-size Mo2C domains and Mo_2C/graphene heterostructures at lower temperatures using liquid Sn-Cu alloys. Results demonstrate the capability to grow continuous nanometer-thin Mo_2C films at temperatures as low as 880 ˚C, without sacrificing the growth rate. Mo2C films are proven to be efficient electrocatalyst for hydrogen evolution reaction (HER). Moreover, we demonstrate the beneficial role of graphene overgrown on Mo_2C in reducing the HER overpotential values. We also evaluate the electrocatalytic efficiency of Mo_2C/ graphene on oxygen evolution reaction. Finally, we discuss on the enhanced electrocatalytic performance of the heterostructure when we apply a ´´flipped´´ transfer method which permits to reverse the vertical order of the heterostructure, allowing Mo_2C to stand on graphene [1-3].

References

[1] D Geng et al 2017 Advanced Materials 1700072
[2] S. Chaitoglou et al 2018 J Cryst. Growth 495 46-53
[3] S. Chaitoglou et al 2018 Nanotechnology in press https://doi.org/10.1088/1361-6528/aaf9e8

Figures

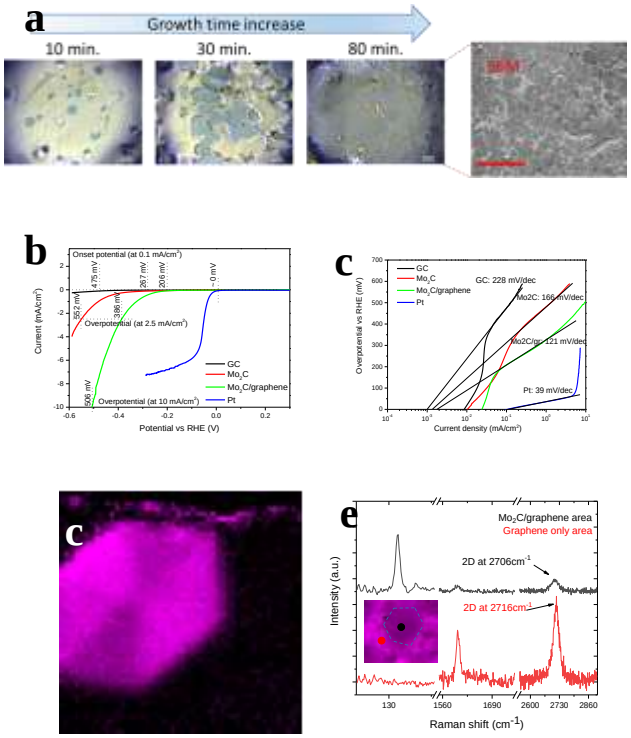

Figure 1: a) OM images of Mo_2C domain nucleation and film growth. After 80 min, the domains reach the coalescence phase to form a continuous film. On the right end, a SEM image of the continuous Mo_2C film is demonstrated. b, c) Electrochemical performance of Mo_2C/graphene rode. Polarization curves and Tafel plots of Mo_2C and Mo_2C/graphene electrodes. d, e) Raman mapping of Mo_2C domain for Raman shift between 130-155 cm^{-1} and Raman spectrum from zone covered with Mo_2C/graphene (black line) and graphene-only (red line).