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INTRODUCTION

Chemical vapour deposition (CVD) is known as the most promising route for industrially applicable wafer scale graphene synthesis. The CVD process mainly relies on the decomposition of a gaseous carbon source on a metal catalyst at high temperatures. Due to the e.g. inhomogeneous out-diffusion of carbon and metal groove formation, uniform graphene synthesis is still challenging. A new promising catalyst for uniform mono and multi-layer graphene (MLG) synthesis with high temperature stability is Mo<sub>2</sub>C, having noble metal like catalytic properties and low cost[1,2].

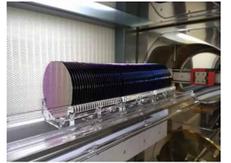
Unlike traditional graphene catalyst materials, Mo<sub>2</sub>C is not directly deposited but is formed by a rapid transformation of a Mo layer directly after exposure to CH<sub>4</sub> at high temperature. The properties of the initial Mo layer, such as purity and density, are critical for the formed Mo<sub>2</sub>C structure and also the subsequent graphene nucleation. Previously, the number of graphene layers showed to be different for Mo foils and thin films[2] but the influence of the Mo properties is not investigated. In this work, the relation is studied between graphene growth and the properties of the as deposited Mo layers before CVD, in particular the effect of Mo oxygen content and density.

PROCESS FLOW AND RESULTS

## Dry oxidation of Si wafers



SiO<sub>2</sub> (300 nm) serves as a diffusion barrier in the CVD process



## Sputtering of Mo layer



### DEPOSITION SYSTEM 1

Sputter system for deposition of films with sub-nm accuracy, with possibility of ion polishing during deposition and substrate bias



### DEPOSITION SYSTEM 2

Single wafer sputter coater for deposition of metallic layers



Low sputter pressure

High sputter pressure

High deposition energy

Low deposition energy

Density  
from X-Ray Reflectometry  
Roughness  
from Atomic Force Microscopy

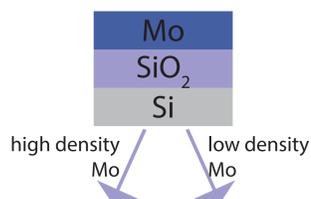
High  
about 10.2 g/cm<sup>3</sup>

Low  
about 8.8 g/cm<sup>3</sup>

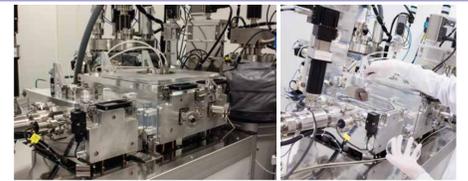
Very low  
R<sub>q</sub> = 0.3 nm

Low  
R<sub>q</sub> = 1.0 nm

## CVD progress



Cold wall reactor chamber  
at 1000C using a feedstock of CH<sub>4</sub>, H<sub>2</sub> and Ar

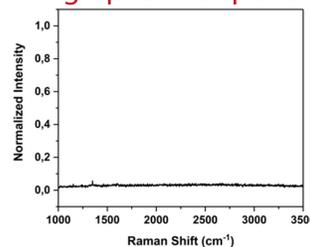


## AFTER CVD progress

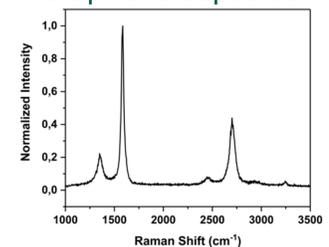


Graphene growth  
from Raman spectroscopy

### No graphene deposition



### Graphene deposition

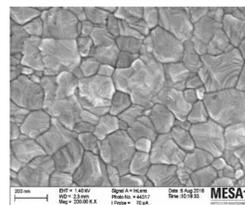


Roughness  
from Atomic Force Microscopy

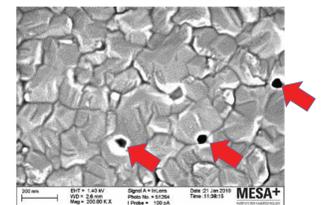
High  
R<sub>q</sub> = 4 nm

Very high  
R<sub>q</sub> = 6 nm

Defects  
Observed by Scanning Electron Microscopy



No pinholes visible



Pinholes visible

CONCLUSION

Results obtained from samples deposited under conditions varying the oxygen content and density show that samples with low density generally lead to graphene growth, in contrast to samples with high density. Additionally, the presence of excess oxygen may play a role in inhibiting graphene growth at higher oxygen levels. The importance of density is tentatively explained by the formation of defects in the low density layers, serving as nucleation points for graphene growth. This suggestion is supported by SEM images, which show that when starting from low density Mo layers, the resulting structure is much more open with increased surface area to volume ratio, resulting in much higher catalytic activity.

These results show that the structure of the initial Mo layer has a profound effect on the graphene growth process, and as such should always be considered in any study of graphene growth on such, and likely similar, catalysts.

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- [1] Zou, Zhiyu, et al. Nano letters 14.7 (2014): 3832-3839
- [2] Grachova, Yelena, et al. Procedia Engineering 87 (2014): 1501-1504