Raman study of graphene/ MoS_2 heterostructure grown by CVD on Ge/Si substrate.

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Molybdenum disulfide (MoS_2) was grown on graphene layer previously grown by CVD on 3 micrometers (111) Ge layer on Si substrate. Successful growth of MoS_2 was implemented in the two steps. The first step was realized with deposition of molybdenum (Mo) in E-beam PVD (Physical Vapour Deposition) system. Next, the sputtered sample with thin Mo layer was placed in the high temperature zone of Chemical Vapour Deposition (CVD) system for sulfurization to form MoS_2. H_2S was used as the source of sulfur and H_2 as carrier gas. The furnace was heated up to 750°C temperature and held for 30 minutes. Raman spectra revealed strong spatial coincidence between graphene and MoS_2 modes intensities (Fig.1). Moreover, the maximal intensity of graphene Raman modes were strongly enhanced (about 20x) when compared with these usually observed for CVD grown graphene on Ge/Si substrates. This enhancement is correlated with the presence of MoS_2. It was confirmed by Raman measurements conducted with increasing laser power (temperature). With increasing laser power both the MoS_2 and graphene Raman modes intensities declined. Finally for the certain laser power, MoS_2 modes vanished and graphene modes decreased of about 20x . From the temperature red-shift of MoS_2 Raman modes we estimated the temperature at which MoS_2 disappeared (thermal decomposition), as about 280 ºC. Above findings, suggests that the most likely MoS_2 was grown either in the space between graphene monolayer and Ge substrates, or between graphene layers in the regions where graphene bilayers exists. In the both cases MoS_2 detach graphene from the substrate which is most likely the reason of the strong enhancement of the graphene Raman modes.

a) b) c)

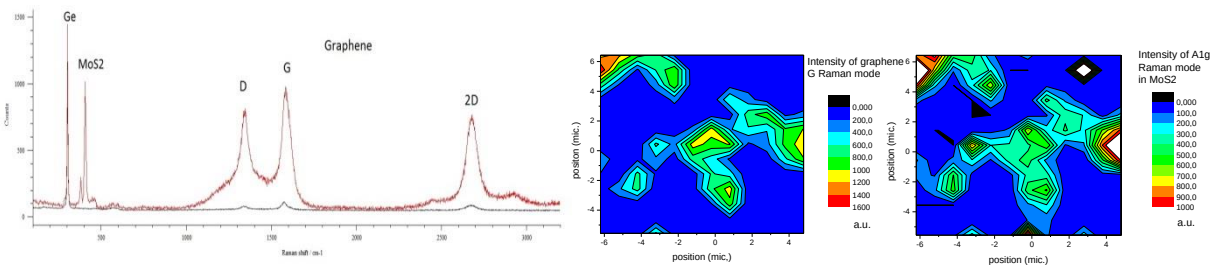

Figure 1: a) Raman spectrum of graphene and MoS_2 . b) and c) spatial maps of Raman modes intensities for graphene and MoS_2, respectively.