Nucleation and growth studies of large area deposited WS_2 on flexible substrates

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Since the first successful exfoliation of graphene, 2D materials have attracted great interest from both the research community and industry. In particular, flexible electronics based on transition metal dichalcogenides (TMDCs) are playing a key role to meet market demands of future technologies in the application areas of the Internet of Things (IoT), wearable electronics, healthcare and electronic skin [1]. TMDCs such as WS_2 are widely studied for advanced electronics, due to their appreciable bandgap and high electron mobility [2]. To be implemented in future flexible electronics on an industrial level, large-scale growth on flexible substrates must be understood and tailored.
In this work, nucleation and CVD growth studies of tungsten disulfide (WS_2) are performed on the crystalline van der Waals material muscovite mica as model substrate and on alkali-metal free flexible glass (*AF32® eco*). The resulting films were characterised in detail via atomic force microscopy (AFM), Raman spectroscopy, X-ray diffraction (XRD), scanning electron microscopy (SEM) and high-resolution transmission electron microscopy (TEM). On both substrates, a crystalline growth of WS_2 at moderate growth temperatures of 600 °C [3] was verified by Raman spectroscopy (Figure 1) and XRD. However, the growth mode and nucleation density differ massively. On mica, an initially planar growth of WS_2 triangular islands is detected, whereas (untreated) glass reveals an out-off plane growth (Figure 2). Detailed XRD and Raman analyses show a tensile strain in the WS_2 films on both substrates, indicating a strong interaction from CVD grown TMDC films with the underlying substrate. In order to avoid such substrate-semiconductor interaction, a substrate pre-treatment is required. In fact, Ar sputtering prior to the WS_2 deposition on glass leads to a planar growth even on the flexible glass substrates.

References

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[2] Zhang, W. et al., Nano Res. 7 (2014), 1731–1737.
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Figures

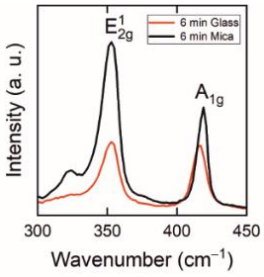

Figure 1: Raman spectrum of WS_2 on mica (black) and glass (red) for CVD grown WS_2 films at 600 °C for 6 min deposition time.

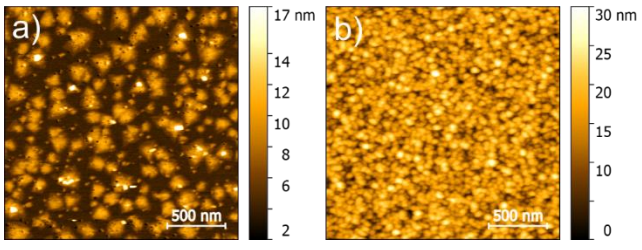

Figure 2: Top-view AFM image of WS_2 films deposited at 600 °C for 6 min on muscovite mica (a) and glass (b).