Growth Study for Chemical Vapor Deposition of Single Layer Graphene on C-Plane Sapphire

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Chemical vapor deposition (CVD) techniques provide the potential for the growth of large-scale uniform and high quality 2D materials, which are attracting rising interest for applications in flexible electronics, photonics and emerging devices for neuromorphic computing. [1][2] The direct growth of single layer graphene (SLG) onto insulating substrates compatible to silicon-based technology is considered essential. However, the growth of high quality SLG from CH_4/H_2 mixture on sapphire is typically performed at high deposition temperatures of about 1400 °C utilizing graphite as susceptor material. To avoid unwanted impurities, SiC coated susceptors are used for growth of transition metal dichalcogenides (TMDCs) at temperatures below 1250 °C. Thus, enabling the (metal organic) CVD of graphene/TMDC heterostructures in one consecutive processing sequence affords a reduction in SLG growth temperature. In this work, SLG was deposited on α-Al_2O_3 (0001) substrates at 0.2° off-cut in an AIXTRON CCS 6x2" cold-wall reactor. H_2 gas and CH_4/H_2 gas mixture in argon were used for sapphire desorption and SLG growth, respectively. The temperature of desorption and growth was decreased from 1400 °C to about 1250 °C. The growth process is followed in-situ by means of a LayTec EpiTT monitoring system. A systematic study of the temperature effect was performed by detailed analysis of the sapphire surface and the SLG quality. For this purpose various microscopic, spectroscopic, and electrical techniques were combined like SEM, AFM, XPS, Raman, Raman mapping, van der Pauw and Hall measurements. The results of this study will be discussed in this presentation. The reduction of the SLG growth temperature paves the way for SLG/TMDC heterostructure fabrication.

References

[1] Mishra, N., et al., SMALL, Issue 50 (2019), 1904906 /1 - 8.
[2] Zhang, D.J., et al, IEEE TRANSACTIONS ON ELECTRON DEVICES, Issue 4 (2021), 2033-2040.

Figures

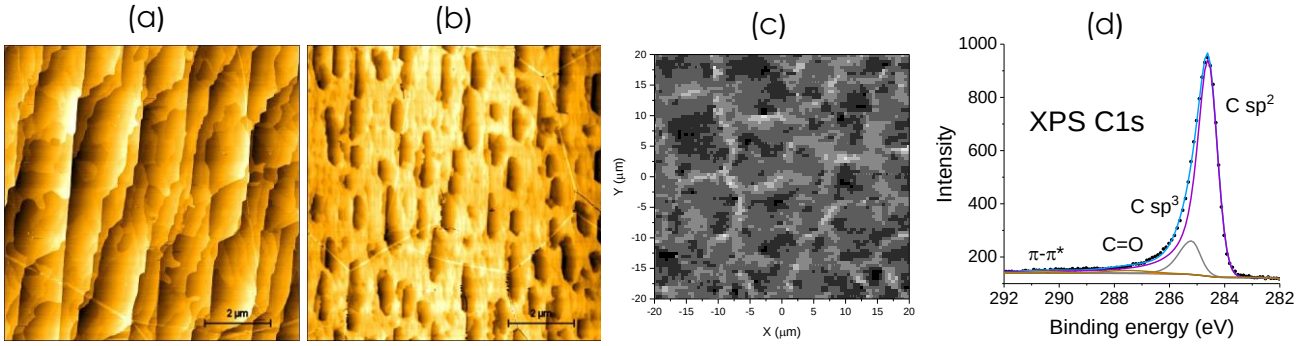

Figure Terrace structure of α-Al_2O_3 (0001) substrates at 0.2° off-cut after SLG growth at 1400 °C (a) and 1250 °C (b). (c) Graphene wrinkles are identified by Raman mapping from shift of the graphene G peak position shown in light gray. (d) The SLG chemical state is analyzed by XPS. The C 1s core level spectrum of SLG grown at 1400 °C mainly reveals C sp^2 component.