Photo-oxidized high-K Dielectric for van der Waals Nano-electronics and Opto-electronics

Namphung Peimyoo

Matthew D. Barnes[1], Jake D. Mehew[1], Adolfo De Sanctis[1], Iddo Amit[1], Janire Escolar[1], Konstantinos Anastasiou[1], Aidan P Rooney[2], Sarah J. Haigh[2], Saverio Russo[1], Monica F. Craciun[1] and Freddie Withers[1]

[1]*Centre for Graphene Science, College of Engineering, Mathematics and Physical Sciences, University of Exeter, Exeter EX4 4QF, United Kingdom.*
[2]*School of Materials, University of Manchester, Oxford Road, Manchester M13 9PL, United Kingdom.*

n.peimyoo@exeter.ac.uk

Abstract

Integration of van der Waals heterostructure with high-*K* oxides is needed to improve the device performance. However, it is limited by the traditional techniques of high-k deposition, which trend to damage the 2D crystals. Here we demonstrate an approach to incorporate a high-K oxide dielectric within van der Waals heterostructure devices without damaging the 2D crystals. This can be achieved by transforming few layer HfS_2 crystals embedded within heterostructures into HfO_X by in-situ laser oxidation. The resultant oxide has a dielectric constant of *K*~15 and the thickness is determined only by the layer number of the parent HfS_2 crystal. We demonstrate the use of this oxide into a broad range of fundamental nano-electronic and optoelectronic devices such as flexible field effect transistors based on transition metal dichalcogenide (TMDC) channels, dual gated graphene transistors, resistive switching random access memories as well as light emitting and detecting tunnelling transistors using thin HfO_X barrier. The approach of embedding a high k-oxide could be important for future flexible van der Waals electronics

Figures

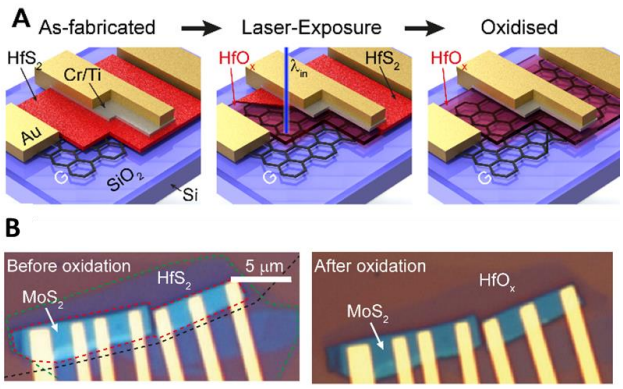

Figure 1: Heterostructure processing route. (A) The transformation of HfS_2 layers embedded within heterostructure into HfO_X using laser oxidation. (B)Optical image of Graphene/HfS_2/MoS_2 heterostructure device before and after photo-oxidation

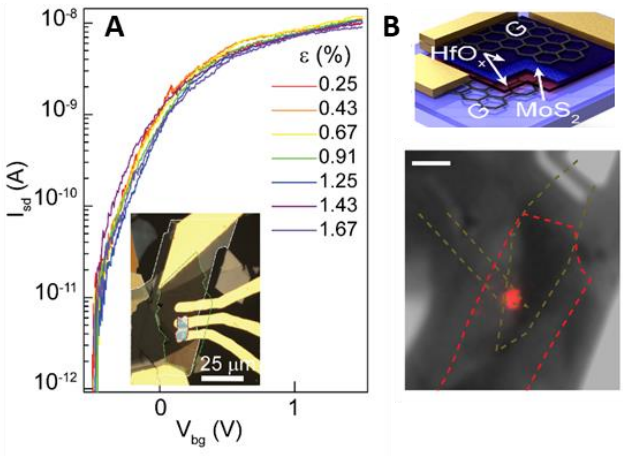

Figure 2: Examples of the use of ultra-thin photo-oxidized HfOx dielectric in different types of devices (A) TMDC flexible field-effect transistor. (B)Vertical light emitting device.