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LEEM/PEEM investigation of ambient oxidized Graphene/Ge(110)

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Germanium (Ge) is an excellent candidate for metal–insulator–semiconductor field-effect transistor (MISFET) devices due to its high intrinsic charge carrier mobility. However, in contrast to the native oxide on Si, the inferior stability and interface quality of the native oxide that forms on Ge under ambient atmospheric conditions hinders practical applications. The recent finding that a graphene monolayer can apparently passivate Ge(100) and can diminish the oxidation rates of Ge(110) and Ge(111) under ambient conditions [1] identifies a possible scheme for overcoming a key challenge to the development of Ge-based electronic devices. Further knowledge of how oxygen permeates graphene to react with Ge is crucial to achieving this goal. In this work, the oxidation of Ge(110) under a graphene monolayer that is caused by ambient exposure was investigated using LEEM and PEEM. Three oxide domains are identified: (B) a mixed monolayer or dispersed submonolayer comprised of GeO_x/GeO_{1+y}, (D1) thin and (D2) thicker GeO_{1+y} over a buried GeO_x interfacial layer in contact with the Ge bulk. The permeability of graphene to oxygen is attributed to pinhole defects at boundaries between the prevalent R0 and R30 graphene grains, within grains and at wrinkles. A statistical treatment for isochromatic correction of energy-resolved PEEM images will also be presented.

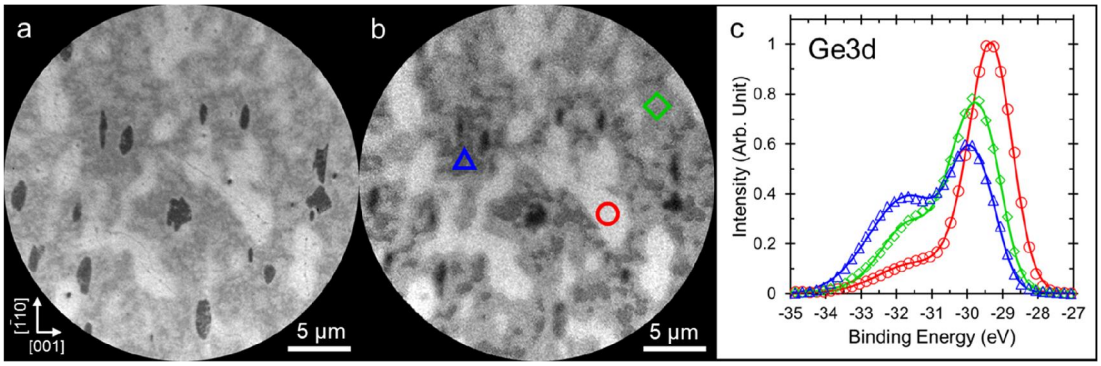

Figure 1. Real space distributions of germanium oxide species in graphene/Ge(110) following ambient exposure. (a) Bright field LEEM image at energy E = 2.5 eV. (b) Isochromatic corrected PEEM Ge3d image at binding energy BE = 29.5 eV with incident photon energy *hv* = 111 eV. B (○), D1 (◇) and D2 (△) domains and spectra are indicated in (b) and (c). (c) Corresponding domain-resolved Ge 3d XPS spectra from the labelled areas in (b).

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References
[1] R. R. Delgado, R. M. Jacobberger, S. S. Roy, V. S. Mangu, M. S. Arnold, F. Cavallo, and M. G. Lagally, ACS Applied Materials & Interfaces **9**, 17629-17636 (2017).