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Atomic Scale Studies of Graphene on Germanium BRIAN KIRALY, Department of Materials Science and Engineering, Northwestern University, ROBERT JACOBBERGER, Materials Science and Engineering, University of Wisconsin - Madison, ANDREW MANNIX, MARK HERSAM, Department of Materials Science and Engineering, Northwestern University, MIKE ARNOLD, Materials Science and Engineering, University of Wisconsin - Madison, NATHAN GUISINGER, Center for Nanoscale Materials, Argonne National Laboratory —

The successful growth of single crystal wafer-scale graphene directly on semiconducting Ge(110) substrates drastically shifted the graphene growth paradigm set in 2009. To further understand the interface between graphene and germanium, we performed ultra-high vacuum scanning tunneling microscopy (STM) and scanning tunneling spectroscopy (STS) experiments of graphene grown on Ge(001), Ge(110) and Ge(111) wafers. The STM studies confirm that graphene grown on the Ge(111) contains rotational disorder resulting in strongly scattering grain boundaries; conversely graphene on the Ge(110) surface demonstrates strong epitaxy. STS shows that the graphene on Ge(111) retains a nearly free-standing character. Upon *in-situ* annealing, reconstructed surface domains appear underneath the graphene covering up to 90% of the Ge(110) and Ge(111) surfaces. Raman spectroscopy reveals band shifts in graphene G/2D band of up to 12 cm^{-1}/50 cm^{-1}, attributed to substantial increase in doping from the underlying substrate. This work shows the electronic interaction between graphene and germanium is both tunable and closely related to the atomic reconfiguration of the underlying germanium surfaces.

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