Graphene crystals grow better under copper cover

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"If graphene can be grown on an insulating substrate with a clean interface, certain devices might function better," says Ph.D. student Bo Tian, who co-led the study under Xixiang Zhang's supervision. "This also opens the door to new types of graphene-based nanodevices," he explains.

Zhang, Tian and coworkers from Asia and Europe tweaked the chemical vapor deposition method, which relies on the copper-catalyzed decomposition of methane into carbon precursors, to generate smooth single-crystal graphene monolayers on wafer-scale single-crystal substrates called c-plane sapphire.

The researchers converted polycrystalline copper foil into its single-crystal counterpart Cu(111) on the sapphire surface and introduced active carbon atoms from the metal substrate-catalyzed decomposition of methane on the resulting film. The carbon atoms diffused through the metallic film toward the copper–sapphire interface, which acted as a template, and formed well-oriented graphene islands that, after several growth cycles, merged to yield a sheet.

In addition to weak surface interactions, the copper film and sapphire displayed similar crystal lattice symmetry to that of graphene, Tian says, which explains the high crystallinity of the graphene monolayer.

The researchers etched away any graphene that had accumulated on top of the copper film using a hydrogen–argon plasma to facilitate carbon diffusion. They immersed the samples in liquid nitrogen before heating them rapidly to 500 degrees Celsius, making the copper film easy to peel off while keeping the graphene monolayer intact.

Field-effect transistors manufactured on the sapphire-grown single-crystal graphene monolayer exhibited excellent performance with higher carrier...
mobilities. The superior electronic performance of the graphene grown on sapphire results from its higher crystallinity and fewer folds on the surface, Tian explains.

"Our team is now trying to grow other two-dimensional materials on the insulator-supported graphene to build functionalized large-scale heterostructures," Tian says. These heterostructures held together by van der Waals interactions are expected to be useful in future nanodevices.


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