Properties of graphene supported on gold-coated black silicon

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Graphene-covered metallic nanostructures provide a unique platform for plasmonic-enhanced graphene devices. Recently, single-layer graphene was transferred and studied onto arrays of metallic nanoparticles, fabricated by lithographic methods.

Here, we integrate graphene with plasmonic Si substrates. We prepare arrays of nanopillars on the surface of Si (black Si) by laser irradiation in water. Laser nanostructuring of Si provides a simple, maskless, single-step, large-area, cost-effective method for the fabrication of plasmonic substrates. Coating the structured Si surface by a thin metallic layer results in the spontaneous formation of metallic nanoparticles, which cover the structured surface, instead of a smooth metallic film. The whole process is scalable and not inherently size-limited.

Single layers of graphene are prepared by chemical vapor deposition on transition metal catalytic substrates (Cu foil) and transferred on the plasmonic Si substrates by a PMMA scaffolding method. The properties of black Si-supported graphene are studied by scanning electron microscopy and optical reflectance spectroscopy. We probe the graphene layer for its plasmonic-enhanced Raman spectral signal via Raman spectroscopy.

Due to the coupling between localized surface plasmons and graphene, the Raman signal of graphene on black Si, coated with metallic nanoparticles, is enhanced by orders of magnitude, compared with the reference substrates employed, *i.e.,* graphene on flat Si with or without metallic coating. This result paves the way for future real-world applications of large-area hybrid nanomaterials.