Towards graphene and diamond integration for electronics application

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Diamond has high carrier mobility (4500 cm^2/Vs) and thermal conductivity (2000 W/mK) at RT [1]. Graphene is 2D material, known for its outstanding transport properties: high electron mobility (~10000cm^2/Vs), high thermal conductivity (~5000W/mK) at RT [2-4]. It was shown that the combination of graphene and diamond refines device properties for electronic applications. For instance, it enhances the intrinsic current-carrying capacity of graphene ~18 times in comparison with conventional graphene on SiO2/Si [5]. Transport properties of graphene-based device significantly depend on the choice of substrate as it defines the dominating scattering mechanism [6]. The substrate roughness defines the effect of electron scattering, which limits carrier mobility. Electron-phonon scattering limits graphene saturation velocity, which corresponds to surface optical phonon energy in substrate material. Graphene, encapsulated in hBN, has high saturation velocity, $5 \times 10^7 cm/s$ as hBN has high phonon energy, ~195 meV [7]. That could be also related to diamond with 163 meV. Recently, enhanced graphene-on-diamond electronic device performance was observed with effective mobility of 2000 cm^2/Vs and estimated comparable saturation velocity of $3.2 \times 10^7 cm/s$ [8].

In this work, as preliminary step, commercial CVD graphene (Graphenea ©) was transferred on a CVD single crystal diamond substrate (4x4 mm^2, optical grade, Element Six ©) with Ra ~1.3 nm. The device with Hall bar geometry (120 x 500 um) was fabricated by a lift-off process after 100 nm/10 nm Au/Ti contact layer deposition. Before/after preparation diamond sample was investigated with AFM, Raman spectroscopy and XPS. Hall measurements were conducted at a temperature range of 150-350 K in a vacuum with 100mV applied along sample. Hall mobility of graphene on diamond was ~873 cm^2/Vs with sheet resistivity of ~652 Ohm/sq. Hall measurements showed stability of graphene on diamond, low temperature-dependence of electrical characteristics within the used range.

The next step will be improved fabrication of graphene FET on diamond followed by electrical transport measurements to elucidate the ways to improve graphene and diamond integration for electronics due to graphene process sensitivity.

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