Developing High-Sensitivity Graphene Terahertz Detectors Through A High-Yield Nanofabrication Process

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Recently it has been demonstrated that graphene can be used to develop large-scale, high-sensitivity coherent detection receivers for astronomy applications in the terahertz bands (300 GHz-5 THz) [1]. Such detectors can be used in large focal plane arrays for high resolution astronomical imaging [2], while offering increased operation bandwidth compared to other superconductors (e.g. niobium nitride− NbN) with lower local-oscillator power requirements, due to the exhibited quantum effects in graphene [1]. However, developing such large-scale graphene sensors is hindered, since graphene fabrication suffers from low yields over large areas [3]. Specifically, graphene adhesion to the carrier substrate (e.g. $Si0_2$ or Si) is typically weak thus leading to easy delamination of graphene during the nanofabrication process (e.g. development, liftoff, etc.) due to the used chemicals [3].

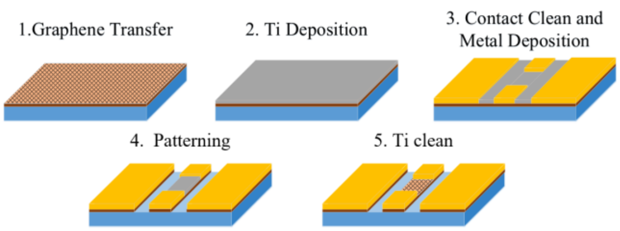

Fig. 1. The proposed nano-fabrication procedure used to develop large-area graphene devices: 1. Transfer graphene on the high-resistivity Si substrate, 2. Deposit a 30 nm Ti sacrificial layer using electron-beam evaporation, 3. Form the metal layer of gold/chrome using photolithography, electron-beam evaporation, and lift-off (before the metal deposition we clean the Ti from the open areas to ensure good metal-graphene contact) 4. Pattern graphene devices using dry etching, 5. Clean the Ti sacrificial layer using wet chemistry.

The scope of our work is to increase the yield of graphene nanofabrication over large areas enabling the development of multi-element graphene sensor arrays for astronomical and other applications. To achieve that we use a sacrificial layer as shown in Fig. 1, that protects the graphene throughout the nanofabrication steps and does not allow the delamination during the wet processes. Exploiting the proposed method, we acquire 92 % yield over a 2 cm × 2 cm aperture, improving the almost zero yield exhibited without the use of the sacrificial layer. The sacrificial layer consists of a 30 nm thick titanium−Ti film and is deposited using electron beam evaporation. The advantages of the proposed method are twofold: 1) we prevent graphene delimitation during the wet processes and 2) Ti helps to retrieve the intrinsic graphene properties by removing any contaminants that adhere to the graphene lattice.

Our fabrication process is verified through Raman spectroscopy and graphene sheet resistance is measured in the 220-330 GHz bands. The test fixture is comprised of a graphene loaded coplanar waveguide (CPW) transmission lines and with the use of RF contact probes we measure the scattering parameters of the devices. Afterwards, the graphene sheet impedance is extracted, and the results are verified with already published showing good agreement. Moreover, the graphene sheet impedance is measured for various biasing voltages and the acquired mobility changes are in accordance with the existing literature, revealing that the proposed nanofabrication process has not harmed the 2D graphene layer.

During the conference, the proposed graphene high-yield fabrication method will be presented alongside the contact probe measurements process.

References

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