Contacting and structuring graphene by helium ion beam processing

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In recent years, the use of highly focused helium ion beams have emerged as a technique for both high-resolution imaging and for nanofabrication. This new technique enables researchers to explore new and exciting possibilities in the field of nano-electronics. Recent advancements include nano-structuring in graphene[1], lithography[2] and deposition of Pt and other materials using helium-ion-beam-induced deposition (HeIBID)[2]. However, the effects of the ion-material interactions are not fully understood, especially for graphene.

Graphene has excellent electrical and mechanical properties, making this material an ideal candidate for future electronics. Electron beam lithography has been used to define contacts and structures in graphene to make nano-devices. However, resist contamination and high resistance to metal contacts degrade the properties of graphene. Furthermore, in order to induce a band gap, intrinsic graphene needs to be structured into fine ribbons. Therefore, alternative nano-patterning methods need to be explored for contacting as well as structuring graphene..

In our work, we used CVD-grown graphene transferred to an Al_2O_3/Si substrate. The contacts to graphene were made by HeIBID combined with atomic layer deposition (ALD). First a thin seed pattern of platinum is grown by HeIBID, followed by selective growth of 99%-pure platinum by ALD on this seed pattern. The source and drain electrodes are defined by this pattern (Figure 1). Doped silicon is used as a back gate. The contacted graphene is then structured by helium ion beam milling at the desired area. In this exploration, lattice damage due to the ion-beam interactions and contact resistance are being studied.

In summary, we have made seed patterns by low-dose HeIBID to trigger the ALD growth of contacts on graphene. In addition, milling of graphene with higher doses is applied for removing large areas. This technique could be useful to design and fabricate next generation nano-electronic devices.

[1]M. C. Lemme *et al.*, ACS Nano **3** (2009)
[2]P. Alkemade et al., Scanning 34, 90-100 455302 (2012)

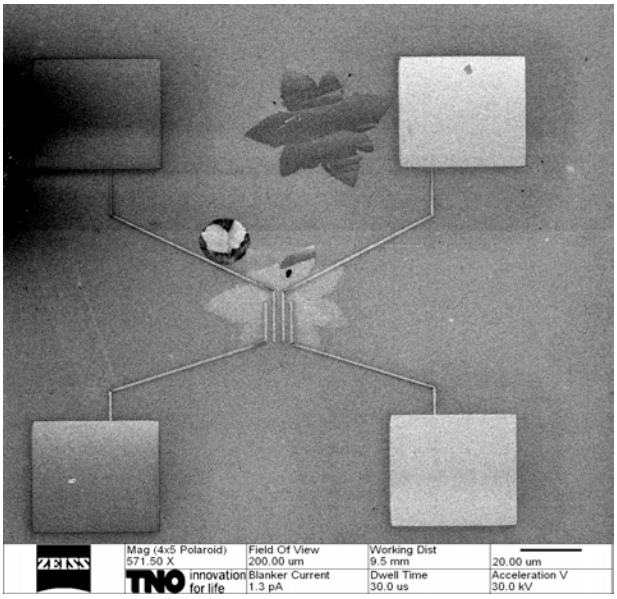

Figure 1: The CVD-graphene flake in the center is connected by four contacts and leads made by HeIBID and ALD.