REALIZING A CRYSTALLOGRAPHIC ORIENTATION DEPENDENT CHEMICAL ETCHING OF GRAPHENE

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The excellent electrical properties of graphene, like very high electron mobility, long coherence length of charge carriers, etc. has brought this exiting 2D crystal into the spotlight of nanomaterials research [1]. Graphene may well turn out to be a key material in shaping post silicon nanoelectronics, with demonstration devices of graphene based field effect transistors having already been realized.

For the large scale implementation of graphene based electronics two major obstacles have to be overcome: preparing large scale graphene layers and patterning these into the desired component architectures. Graphene nanostructures especially nanoribbons are very sensitive to the crystallographic orientation of the nanostructure edges, for example it is predicted that graphene nanoribbons having zig-zag edges are always metallic, while ribbons with armchair edges may be semiconducting. A controlled crystallographic orientation dependent etching of these structures would be a great tool in achieving the kinds of applications dreamt up for graphene. One way to achieve this goal is to use STM lithography [2]. On the other hand we have developed an etching technique, which is subtle enough to differentiate between the slightly different stability of zig-zag and armchair edges in graphene, thus obtaining selective etching. We used graphene samples prepared by micromechanical cleavage deposited onto Si wafers, having a 300 nm thick SiO_2 layer. We present a detailed scanning probe microscopy (STM, AFM) investigation into the nature of the etched graphene layers. It is important to note that contrary to the oxidation of graphene [3], carbon removal only occurs at the sample edges or at previously introduced oxidation holes [3] (see the right Figure) and grain boundaries (see the left Figure) leaving the rest of the graphene layer unharmed, as evidenced by Raman spectroscopy.

Using our etching method we can produce crystallographically oriented structures in graphene samples, opening up new opportunities for device fabrication.

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References:

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Figures:

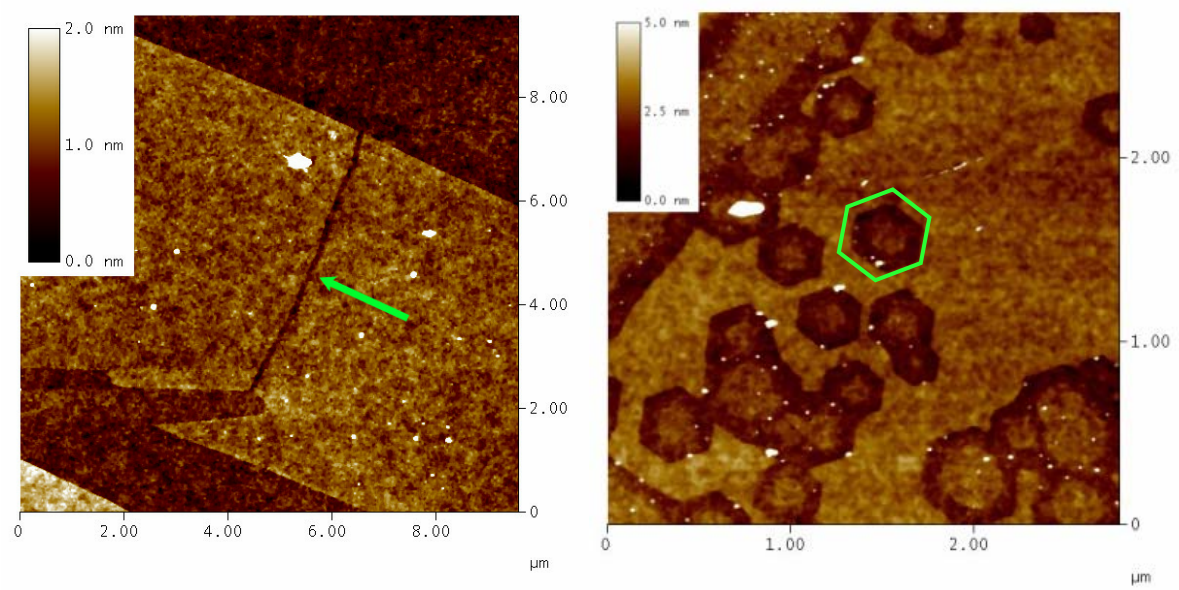

Figure. Etched graphene layers supported on SiO_2 substrates. **Left image:** etching of a grain boundary in graphene. In the position of the grain boundary the graphene has been etched away revealing a trench, as shown by the green arrow. **Right image:** Enlarging of previously introduced oxidation pits in the graphene surface. The pits are hexagonal in nature which proves that anisotropic etching has occurred.