Cutting Graphene with Atomic Force Microscopy

Sven Renkert
James Kerfoot
Park Systems Europe GmbH, Schildkrötstraße 15, 68199 Mannheim, Germany
sven.renkert@parksystems.com

Atomic Force Microscopy (AFM) is well established as an analytic tool to image various properties of 2D nanomaterials with nanometer resolution, from simple topography to complex properties like moiré patterns emerging on twisted bilayers of graphene or hBN/graphene heterostructures. However, AFM also allows for controlled manipulation and fabrication of nanostructures [1] and novel applications like mechanically reconfigurable devices [2]. Advances in local anodic oxidation [3] make these manipulations reliable, clean, fast and easy to use under ambient conditions.
Applying AC instead of DC voltage for local anodic oxidation via capacitive coupling allows using the technique on any sample without an electrode or electric contacts. This approach simplifies sample preparation and enables a vast selection of sample materials, while improving reliability and quality of lithographic cuts without requirements for additional AFM equipment.
In this talk we are discussing the theory of electrode-free local anodic oxidation. The influence of parameters such as relative humidity, applied voltage and frequency are evaluated with practical examples. Automated lithography gives access to more complex patterns and improves both speed and usability of the patterning process.

References

[1] Yu K Ryu and Ricardo Garcia, Nanotechnology, 28 142003 (2017)
[2] Hongyuan Li, Zhe Ying, Bosai Lyu, Aolin Deng, Lele Wang, Takashi Taniguchi, Kenji Watanabe, Nano Letters, 18 12 (2018), 8011-8015
[3] Andrew Z. Barabas, Ian Sequeira, Yuhui Yang, Aaron H. Barajas-Aguilar, Takashi Taniguchi, Kenji Watanabe, Javier D. Sanchez-Yamagishi, Science Advances, 9 14 (2023)

Figures

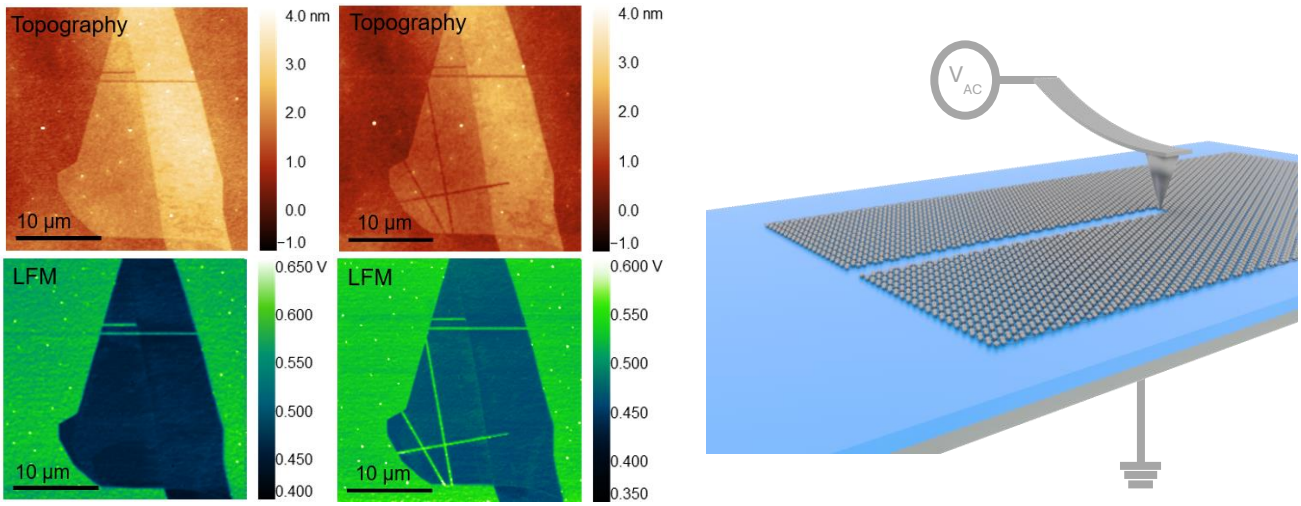

Figure 1: Topography images of a single- and double-layer graphene flake on Silicon after cutting twice (left) and three additional times (right). Lateral Force Microscopy (LFM) images below reveal clean residue free cuts with good contrast in friction. Sketch of working principle of electrode-free local-anodic oxidization [2] on the right side.