At Tip of Scanning Probe

CAS/MPG Partner Group on Thermoelectric Systems

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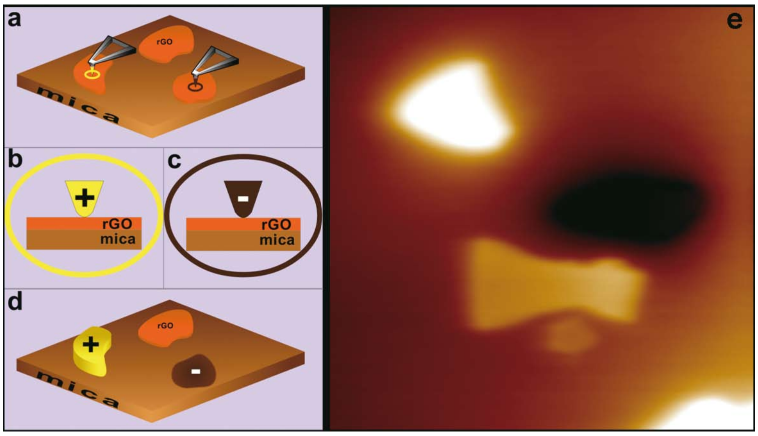
Prof. ZHANG Yi (left) at the the Shanghai Institute of Applied Physics (SINAP), CAS, and Prof. dr. Hans-Jürgen Butt (right) at the Max Planck institute for Polymer Research (MPIP).

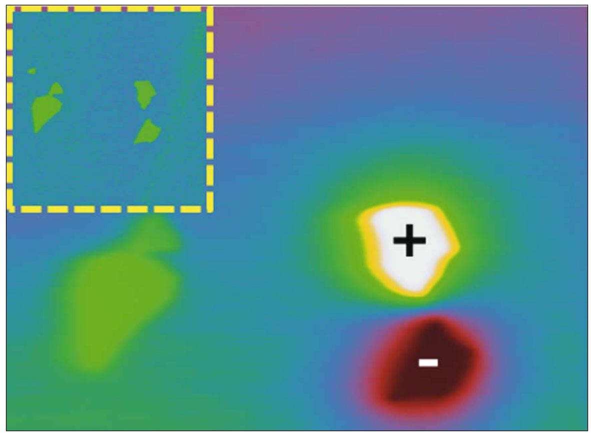
Photos/Images: By courtesy of Prof. ZHANG Yi.

The MPS/CAS Partner Group on Thermoelectric Systems was launched in 2010 as a collaborative effort between the Max Planck Institute for Polymer Research (MPIP) and the Shanghai Institute of Applied Physics (SINAP), CAS. Under the leadership of Prof. Dr. ZHANG Yi from SINAP, the group worked in close collaboration with colleagues from the Polymer Physics Division of MPIP, which is directed by Prof. Dr. Hans-Jürgen Butt. The group's original aim was to carry out joint studies on thermoelectric systems, with focus on a better understanding of the thermoelectric cooling and power generation on the nanometer scale by employing scanning probe microscope-related techniques. The two specific research areas envisioned at the beginning were (1) electrical characterization of thermoelectric materials and (2) thermoelectric effect of a local heating source. During the cooperation, the group found there was actually much more room for collaboration on scanning probe microscope-based characterization techniques, so the emphasis was shifted from thermoelectricity to scanning probe microscope-related studies.

Reported by Group Leader ZHANG Yi



Charging process seen under an electric scanning probe microscope: (a-d) Schematic illustration of charging individual nano-objects with biased scanning probes. (e) Electrical characterization of charged graphene nano-sheets.



Charging and discharging of nanometer-sized and tunable-shaped objects are very important to fundamental research as well as to potential applications. For instance, isolated external charges can be used as an electrostatic gating for material transport in the nano-channels. On the other hand charging and discharging of objects provide a powerful tool to studying the electrostatic properties on the nanometer scale. To this end, we have employed atomic force microscope (AFM) to inject charges into nanometer-sized carbon materials such as graphene sheets. The image shows electrical characterization of charged graphene nano-sheets, while the inset indicates their morphology on a flat substrate.

"I greatly appreciate the Max Planck Society for supporting this partner group, which enabled me a good start in my academic career and helped me set up a very good relationship with partners from the MPIP."

– Prof. ZHANG Yi

The group has scored remarkable progress in the following three aspects. First, a unique operation mode of scanning polarization force microscopy (SPFM) was developed for the electrical characterization of individually-charged nano-objects. Second, a method for the repeated charging and discharging of individual graphene oxide (GO) sheets with varied degrees of reduction was developed. Charge storage on isolated areas with tunable shape and size of a single-layered GO has also been achieved. Third, based on the above achievements, it was revealed that charge transfer can actually occur between reduced graphene oxide (rGO) sheets separated in hundreds of nanometers on insulating substrates. The findings suggested that the charge interflow should not be neglected in a graphene circuit. ◂