Ultra-high performance Conductive Atomic Force Microscope tips coated with graphene

THE INVENTION

We successfully fabricated conductive tips for the CAFM (Conductive Atomic Force Microscope) that show ultra-high performance, by coating commercially available metal-varnished tips with a sheet of GSL (Graphene Single Layer) following a standard transfer process.

Innovative aspects and advantatges

> Graphene-coated tips are shown to be extremely stable and resistant under high currents and frictions.

> Longer device lifetime.

> Graphene prevents tip varnish/sample material interaction.

> Applications: Current and topographical measurements at the nanoscale with AFM techniques that require conductive tips with such characteristics.

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Scientific Team

REDEC: **R**eliability of **E**lectron **DE**vice and **C**ircuits group

Summary

Graphene-coated tips are much more resistant to both high currents and frictions than commercially available metal-varnished CAFM tips, leading to much longer lifetimes and preventing false imaging due to tip–sample interaction. The novel devices can be interesting not only for reducing tip replacement costs, but also for those applications that require high stability and low tip–sample interaction.

Electrical characterization at the nanoscale is an essential procedure for analyzing the performance of many materials used in both industry and academia. In this field, one of the most powerful tools is the conductive atomic force microscope (CAFM), which can characterize the electrical properties of conductive, semiconductive and thin insulating materials at areas as small as 10nm2.

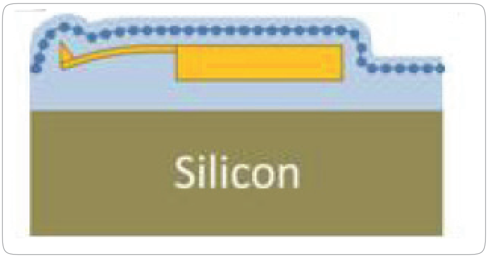

Fig. 1 Schematic of PMMA/AFM tip/PMMA/Silicon block

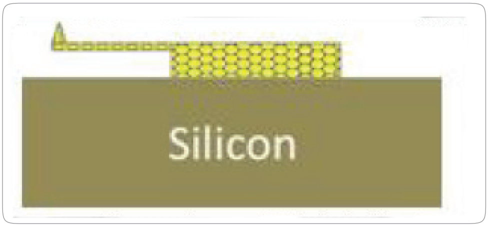

Fig. 2 Schematic of graphene layered tip after acetone removal.

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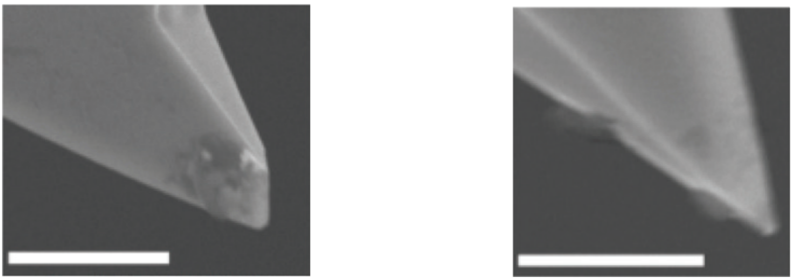
To this end, the sample under test is placed on a holder-like electrode and the ultra-sharp conductive tip of the CAFM acts as a top electrode. When a voltage is applied between the tip and the holder electrode, a current can flow through the sample under test, which is measured and can be used to assess the electrical properties of the material. The main challenge associated with this technique is the poor reliability of the conductive tips. Traditionally, metal-varnished silicon tips are commonly utilized in these kinds of applications. However, due to the low stability of the metallic varnish, these tips can wear out very fast when measuring high currents and/or because of intense tip–sample frictions. The low reliability of the tips results in false imaging and unnecessarily high costs of measurements. A good approach to preserve CAFM tip properties is to varnish them with a very stable material, such as doped diamond. However, this approach not only reduces the lateral resolution of measurement (due to a larger tip radius), but also increases the price of the tips. Moreover, the same happens when using solid metallic AFM tips. Therefore, finding a new method to avoid fast tip wearing is essential for cheap and reliable nanoscale electrical characterization. Here we present a process to cover a **commercial CAFM tip with a GSL, improving their performance with an easy transfer method.**



a) Used Pt-Ir tip — ***b) Used graphene-coated Pt-Ir tip***

Fig. 3 SEM images of (a) Pt–Ir, and (b) graphene-coated tips, after several CAFM measurements. The scale bars in (a) and (b) are 5 μm and 3 μm, respectively.

Invention performance

Fig. 3 shows SEM images of as-received and graphene coated tips, showing that after the graphene transfer the tip keeps the same geometrical characteristics than original varnished ones. EDS analysis (Fig. 3) also shows the presence of the graphene layer after the transfer process.

Graphene-coated tips are much more resistant to both high currents and frictions than commercially available metal-varnished CAFM ones, leading to much longer lifetimes.

The SEM images of both as-received and graphene-coated tips after several experiments. As it can be observed, the initial varnish of the tip without graphene can easily be worn out due to the high currents, while the graphene-coated tip keeps its initial sharp shape (and high conductivity).

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