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EDITORIAL

High-resolution noncontact atomic force microscopy

Guest Editors

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Progress in nanoscience and nanotechnology requires tools that enable the imaging and manipulation of matter at the atomic and molecular scale. During the last two decades or so, scanning probe-based techniques have proven to be particularly versatile in this regard. Among the various probe-based approaches, atomic force microscopy (AFM) stands out in many ways, including the total number of citations and the breadth of possible applications, ranging from materials characterization to nanofabrication and biological studies. However, while nanometer scale operation in different environments became routine, atomic resolution imaging remained elusive for a long time.

The reason for this initial deficiency was that contact with the sample blunts atomically sharp tips, which are mandatory for successful atomic resolution imaging. This problem was overcome in the mid-1990s with the introduction of noncontact atomic force microscopy (NC-AFM), which represents a version of AFM where the cantilever is oscillated close to the sample surface without actually 'touching' it. This allows the preservation of the atomic sharpness of the tip while interaction-induced changes in the cantilever's resonance frequency are used to quantify the tip–sample distance. Since then, progress has been steady and includes the development of commercial instruments as well as the addition of many new capabilities beyond imaging, such as the identification and manipulation of individual atoms. A series of annual international conferences, starting in Osaka in 1998, have contributed significantly to this outstanding performance. The program of the most recent conference from this series, held in Madrid on 15–19 September 2008, reflects the maturity of this field, with an increasing number of groups developing strong activities that involve novel approaches and applications covering areas well beyond the original vacuum-based imaging.

In this special issue of *Nanotechnology* we present a selection of original papers authored by many of the leading groups in the field with the goal of providing a well-balanced overview on the state-of-the-art in this rapidly evolving field. These papers, many of which are based on notable presentations given during the Madrid conference, feature highlights such as (1) the development of sophisticated force spectroscopy procedures that are able to map the complete 3D tip–sample force field on different surfaces; (2) the considerable resolution improvement of Kelvin probe force microscopy (reaching, in some cases, the atomic scale), which is accompanied by a thorough, quantitative understanding of the contrast observed; (3) the perfecting of atomic resolution imaging on insulating substrates, which helps reshape our microscopic understanding of surface properties and chemical activity of these surfaces; (4) the description of instrumental and methodological developments that pave the way to the atomic-scale characterization of magnetic and electronic properties of nanostructures, and last but not least (5) the extension of dynamic imaging modes to high-resolution operation in liquids, ultimately achieving atomic resolution. The latter developments are already having a significant impact in the highly competitive field of biological imaging under physiological conditions.

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