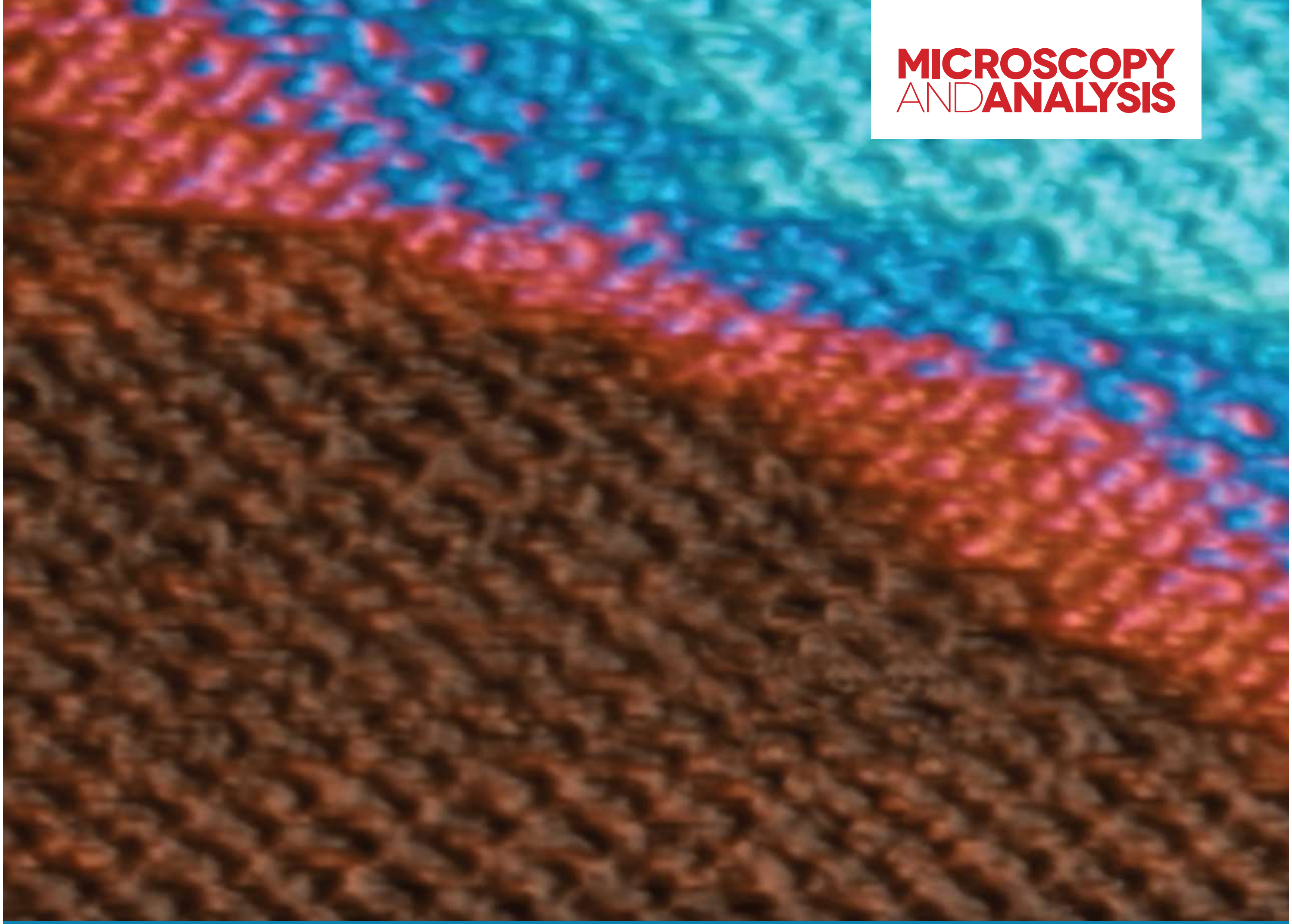
MICROSCOPY
AND ANALYSIS



Atomic Force Microscopy for Materials

Essential
Knowledge
Briefings

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BRUKER

Front cover image: atomic-resolution imaging of calcite in fluid using PeakForce Tapping and a Dimension FastScan atomic force microscope.

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About Essential Knowledge Briefings

Essential Knowledge Briefings, published by John Wiley & Sons, comprise a series of short guides to the latest techniques, applications and equipment used in analytical science. Revised and updated annually, EKBs are an essential resource for scientists working in both academia and industry looking to update their understanding of key developments within each specialty. Free to download in a range of electronic formats, the EKB range is available at www.essentialknowledgebriefings.com

INTRODUCTION

Atomic force microscopy (AFM) is a high-resolution analytical technique that dazzled the scientific world when it was first introduced in the 1980s. For the first time, researchers could capture images of surfaces at the atomic scale, with AFM able to resolve features less than 1nm in size. Since then, AFM has become a widely used technique for characterizing a variety of surface properties on biological, organic and inorganic materials.

AFM uses a cantilever with a sharp tip attached to the free end to detect the varying forces as the tip is scanned over a sample surface. Not only does this allow it to build up a detailed topographic map of the surface showing all the peaks and troughs, but it can also reveal information about a wide range of other surface properties, including adhesion, elasticity, conductivity and temperature.

This wide-ranging ability is primarily due to AFM being able to operate in a variety of different modes. These include several primary imaging modes, which differ in the way the tip interacts with the sample surface, and numerous secondary modes, which often involve specialized tips and cantilevers. It is these secondary modes that can reveal information about surface properties, which can usually be collected at the same time as the topographic information.

Thanks to its versatility, AFM has proved adept at the nanoscale study of many organic and inorganic materials, ranging from metals and polymers to hydrogels and powders. Furthermore, unlike other microscopy techniques, AFM isn't restricted to working under specific conditions: imaging can take place in air, vacuum or a liquid. This has allowed researchers to apply AFM to a wide range of materials applications, from analyzing failure in semiconductors and mapping the different components of composite materials to visualizing electrical and chemical processes in battery electrolytes.

This Essential Knowledge Briefing (EKB) introduces AFM and its materials characterization capabilities; it is one of a pair of EKBs on AFM, with its sister publication looking at life science capabilities. Beginning with a detailed explanation of the operation of a typical AFM instrument, including the role of the tip, cantilever and photodetector, the EKB also outlines how the technique evolved out of scanning tunneling microscopy in the 1980s.

It describes the primary imaging modes and gives a brief introduction to the main secondary modes, before moving on to explain some of the challenges involved in studying inorganic materials, including preparing samples for AFM scanning and selecting the right tip. Finally, it looks at how newer AFM instruments are providing faster imaging, a larger selection of modes and quantitative surface characterization of material samples. In addition, spread throughout the EKB are several case studies highlighting how materials researchers are using AFM in their work.

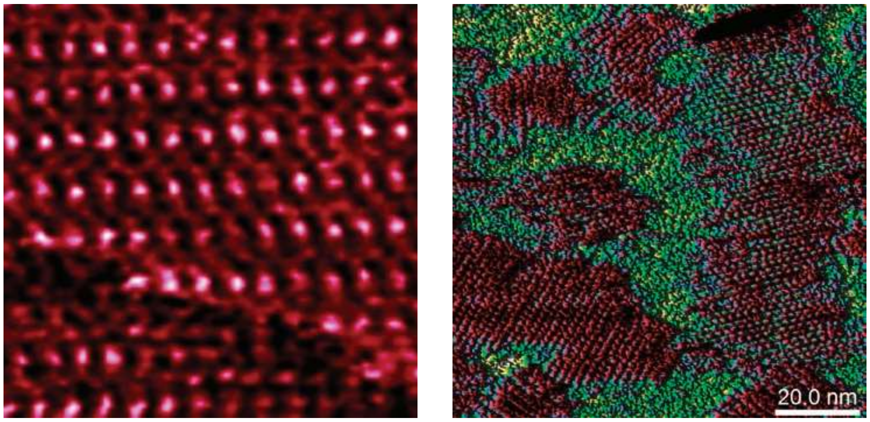

Figure 1. Point defect resolution stiffness on (left) calcite (15nm image) and (right) molecular resolution adhesion on isotactic poly(methyl methacrylate) (iPMMA) (100nm image). iPMMA sample courtesy of Prof Dr Thurn-Albrecht, Martin-Luther-Universität Halle-Wittenberg