COVER IMAGE

Aberration-corrected transmission electron microscopy image of a thin film of the relaxor ferroelectric $Ca_{0.28}Ba_{0.72}Nb_2O_6$ on a $SrTiO_3$ substrate (in false colours). Both the amorphous area on the left (with predominant green colour), created by ion milling during processing, and the complex structure of the material viewed from the [001] crystallographic axis are clearly resolved. Image courtesy of Chun-Lin Jia.

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Electron and X-ray microscopy

Knowledge of the microscopic structure and composition of materials is essential for understanding their properties and designing functional devices. Microscopy techniques based on electrons and X-ray photons have been used to 'look' inside matter for decades. In the past few years, advances in instrumentation and software have led to unprecedented power, both in terms of spatial resolution and sensitivity to composition and physical properties.

With the advent of aberration correction and increasing computational speeds, electron microscopes can now image single atoms buried within structures, and provide information on chemical composition and bonding with atomic resolution. Electron tomography images structures in three-dimensions, and with electron holography it is possible to map electric and magnetic potentials. Advances in optics and the implementation of high-brightness synchrotron radiation sources have led to the development of extremely sensitive X-ray techniques, able, for example, to image composition in organic devices and domain structure in magnetic materials, or strain in nanomaterials.

More exciting developments are just around the corner. With free-electron lasers, such as the one that will soon be operating at the Stanford Linear Accelerator Center, X-ray microscopy will eventually allow us to image dynamics of molecules on the femtosecond timescale, with spatial resolution comparable to interatomic lengths. In addition, milestone achievements in electron microscopy, such as *in situ* atomic resolution and atomic resolution tomography, are likely to be achieved soon through the efforts of dedicated ventures, such as the TEAM (transmission electron aberration-corrected microscope) project in the United States.

The collection of articles in this Insight aims to illustrate what, in our view, are the most outstanding capabilities of modern imaging techniques based on electrons and X-ray photons — usually treated separately — to our wide audience. It is, of course, still a small selection of topics in a broad research field — or rather two fields. We hope, however, that you will enjoy this overview and that it will encourage you to keep up to date with current and future exciting developments.

Fabio Pulizzi, Senior Editor

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