Making the most of simple tools

Valter Sundström

May 2024

Human interest in materials science is as old as civilization itself. What has changed dramatically is the number of different specialized materials we now require, and the complexity of producing and researching them. For extreme performance in heat and energy conduction, as well as other unique properties, we must work at the smallest scale in the relatively new field of nanotechnology, born in the 1980s. Materials where one dimension is on the nanoscale, meaning we have an extremely thin sheet of something rather than a three-dimensional crystal, are called 2D materials or simply nanosheets. Graphite is a material commonly encountered in the form of pencils, and it is made up of nanosheets of graphene. Graphene was successfully isolated in 2004, becoming the first in a new wave of exfoliable 2D materials, and along with superb electrical and thermal conductivity it is currently the mechanically strongest material ever tested.

At the nano-scale, the equipment needed for research becomes highly complex and often very energy intensive. Some technologies allow us to explore material surfaces with fewer resources, such as Scanning Tunneling Microscopy (STM) or Low Energy Electron Diffrac- tion (LEED), but for detailed investigation of material properties, usage of high-energy beams is often required. This either means access to large and expensive lasers, or particle accelerators, of which there are relatively few in the world with long waiting lines and strict selection processes. There simply isn't enough beamtime for everyone who could use it. In light of this situation we would benefit from maximizing the usage of simpler and more accessible tools. By way of example, here we demonstrate how low energy electron diffraction (LEED) can be extended to provide richer insights during sample preparation procedures. A sample can be extremely small, or the surface can be inhomogeneous or hard to clean, making it difficult and time consuming to find good measurement spots. LEED is an especially surface sensitive technique that tells us about the crystal structure at a point on a sample, and it is a simple, common and relatively inexpensive technique available to any lab that needs it. By taking LEED measurements across a whole sample, we can observe subtle variations in crystal ordering or quality, and pinpoint the best measurement spots or find potential preparation issues. This allows for better preparation before gaining access to a beamline or other facility with time limitations, in order to make the most out of the time allotted there.