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IN-SITU AND *OPERANDO* TEM FOR MATERIALS ANALYSIS

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Abstract: Recent developments in transmission electron microscopy (TEM) [1] are well known and prize winning, while others are perhaps less obvious but are challenging 'conventional wisdom' all the same. We now have TEMs with the most important lenses corrected for spherical aberration (after being told for decades that it could not be done). For many researchers other improvements such as better stage stability, availability of FIB for specimen preparation and direct electron-detection cameras, are also having a great impact. In fact many in-situ experiments that are now producing so much excitement were possible 40 or more years ago but the results simply could not be recorded [2]! One challenge for the experimentalist is making the right the link to computer modeling—which is not, of course, a substitute for experimental observation. TEM is widely used to study nanoparticles. One challenge in the study of nanoparticles is that it is now so easy to produce 'pictures' that can be misinterpreted, but the use of 'old-fashioned' image simulation is often assumed to be unnecessary. So I will examine why it is still important to understand what the microscope is really telling us. I will illustrate these recent advances, and the challenges they bring. As an example, I will discuss defect processes occurring during lithiation as an example of using operando and video techniques in the TEM, and consider the future of 4D studies of these and related defect processes [3]. The lithiation process poses several challenges for the microscopists: Li has atomic number 3 so it is particularly light and does not scatter strongly, but it is also small especially when present as the ion Li+, and moves easily through many hosts which is, of course, why it is used in the lithium ion battery (LIB). TEM is the essential tool for characterizing, and thus understanding, nanomaterials. However, there are still many challenges that are inherent in studying nanomaterials, and many of these are glossed over when such studies are carried out. The challenges include the need for 3D information and for statistical analyses of the particles [e.g., 4].

Selective references:

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