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Some Prospects of Transmission Electron Microscopy in Materials Science

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To improve the functionality of nanostructures in many field of materials science research, transmission electron microscopy (TEM) analysis is often the only method of choice. Questions of how local and how accurate the information in fact is have to be answered for each TEM mode separately. To achieve the highest performance possible, advances in TEM instrumentation, method understanding and specimen preparation are required at the same time.

Over the last few years the performance of electron microscopes has undergone a dramatic improvement with significant advances in resolution and mechanical stability. This has been made possible through the development of electron optical components for the correction of the intrinsic aberrations present in conventional electromagnetic round lenses, and due to more stable designs of the microscope columns and specimen stages. It is now possible to acquire atomic resolution structural data from a wide range of materials with single atom sensitivity for a microscope with a corrector for the spherical aberration of the objective lens. We will demonstrate examples for Si_3N_4 [1] and from several areas of materials science when operating the microscope at 300kV. However, often radiation damage is still the limiting factor for the attainable specimen resolution, and therefore the appropriate high tension has to be selected. We will demonstrate the significance of lower high tension for the case of carbon materials when operating at 80 kV, and more general conclusions can be given.

Together with instrumental improvements, a defined gain in understanding of contrast origins is required and, in addition, considerations of new ways of imaging might now be required. As first example we demonstrate that a number of important information such as strain state can be acquired from convergent beam electron diffraction data. For this method the precision of higher order Laue zone line detection is very high however the crucial question is: How local in fact the information is collected in a CBED pattern? Here we show a new understanding of the origin of HOLZ lines [2]. As a second example we consider Z-contrast in a TEM, an incoherent imaging method [3]. We demonstrate first results on the capability in high resolution and show that the contrast is suited for electron tomography [4], which, so far, gives a resolution of about 1 nm, comparable to the resolution of Z-contrast STEM tomography. On the example of embedded precipitates we demonstrate the new insight into the precipitate formation process of such three-dimensional information.

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