Photons in the Environmental Transmission Electron Microscope

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Efficient harvesting of solar energy is the only technology that has the potential of eventually supplying the entire population of the Earth with sufficient energy in a sustainable way as a stand-alone, long-term solution. The potential of harvesting solar energy is emphasized by the fact that covering 0.1% of the surface of the planet with a device that converts solar energy into a useable form at 10% efficiency would give more than the present worldwide consumption of fossil energy. For this purpose, photocatalysts are of fundamental interest as they provide a viable route for converting solar energy into chemical bonds. By means of Transmission Electron Microscopy (TEM) it is possible to gain insight in the fundamentals of their reaction mechanisms, chemical behavior, structure and morphology before, during and after reaction using *in situ* investigations.

Typically, photocatalysts work in gaseous or liquid atmosphere upon light illumination. Here, the aim is to reproduce their working conditions *in situ*. The Environmental TEM (*1*) allows exposing specimens to a controlled gas atmosphere, thus implementation of *in situ* sample illumination is needed. For this purpose, two novel specimen holders capable of shining light onto samples inside the TEM and to probe the sample using visible light spectroscopy techniques were designed and constructed (*2*). The holders were used to characterize photoactive materials in a simulated working environment and employed in the analysis of various photoreactive materials and structures. Novel information on the behavior of such materials during reaction was acquired in a reproducible fashion. In a wider perspective, the aim is to build a versatile experimental platform inside the microscope that allows electron microscopy under nonconventional TEM conditions and new kinds of *in situ* spectroscopy.

As an example of the a photoinduced reaction, the images below show metal impregnated GaN:ZnO before and after visible light illumination for 5 hours at λ = 405 nm in the presence of H_2O but in absence of electron beam. After illumination, Pt particles are clearly visible on the substrate surface.

1. T. W. Hansen, J. B. Wagner, R. E. Dunin-Borkowski, Aberration corrected and monochromated environmental transmission electron microscopy: challenges and prospects for materials science. *Mater. Sci. Technol.* **26**, 1338 (2010).
2. F. Cavalca *et al.*, In situ transmission electron microscopy of light-induced photocatalytic reactions. *Nanotechnology* **23**, (Feb, 2012).