Implementation of a light source in a TEM sample holder for *in situ* studies of photocatalytic materials

F. Cavalca[1], T. W. Hansen[1], J. B. Wagner[1], R. E. Dunin-Borkowski[1], B. E. Kardynal[2], A. B. Laursen[3], A. Kleiman-Shwarsctein[3], F. Dionigi[3], S. Dahl[3]

1. Center for Electron Nanoscopy, Technical University of Denmark , DK-2800 Lyngby, Denmark

2. Department of Photonics Engineering, Technical University of Denmark, Ørsteds Plads 343, DK-2800 Lyngby, Denmark

3. Center for Individual Nanoparticle Functionality, Technical University of Denmark, Fysikvej, Building 312, DK-2800 Lyngby, Denmark

Photocatalysts are of fundamental interest for sustainable energy research [1]. By means of transmission electron microscopy (TEM) it is possible to obtain insight into the structure, composition and reactivity of photocatalysts. Such insight can be used for their further optimization [2].

We have constructed a specimen holder capable of shining light onto samples inside the TEM. The holder contains a laser diode and an optical system that guides light onto a sample with maximum power transmission. The source can be changed and tuned, in principle spanning the whole visible and UV spectrum. The device can be used inside an environmental TEM (ETEM) allowing specimens to be analyzed during exposure to a controlled gas atmosphere and illumination.

The holder is presently being used to study a variety of photoreactive materials and structures, including photocatalysts, photonic devices and solar cells. For example, electron holography can be used to study p-n junctions both in the presence and in the absence of light in order to assess electron beam induced charging and discharging effects during laser light exposure [3].

Here, we present results from both TEM studies of novel photocatalysts and ETEM studies of light-induced phenomena. It has been found that many photocatalysts work better or exclusively when a suitable cocatalyst, such as RuO_2, is deposited on their surface. An innovative method of RuO_2 deposition is key to improving the performance of photocatalysts such as $(Ga_{1-x}Zn_x)(N_{1-x}O_x)$, WO_3, $SrTiO_3$ and TiO_2. We use STEM HAADF, EFTEM and EELS to characterize deposition on TiO_2. The deposition process occurs in two steps, for each of which we are able to inspect RuO_2 distribution, morphology and crystallinity. We can thus understand in detail how the process works and interpret how deposition features influence the effectiveness of the photocatalyst.

Furthermore, phase transitions of Cu_2O nanocubes under visible light exposure in the presence of water vapor have been studied *in situ*. Cu_2O is an active photocatalyst for water splitting under visible light irradiation, but undergoes photodegradation in an aqueous environment [4].

References

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