Ceria supported catalysts are expected to exhibit better stability than other supports in a variety of processes including automotive emission control and water gas shift reactions. Ceria is an important support because of its key role in oxygen storage with oxygen uptake in oxidising conditions, releasing oxygen in reducing conditions. Ceria supported copper catalysts are of interest in water gas shift reactions involving the oxidation of CO and the production of hydrogen [1].

The in-situ direct observation of the surface structural and chemical evolution and the dynamic reaction mode of operation of catalysts under reaction conditions at the atomic scale is crucial in understanding and controlling catalytic reactions and the catalyst performance [2-6]. However there is a general lack of in-situ studies of Cu/ceria catalysts at the atomic level and therefore the dynamic behaviour of the nanocatalysts in the reactions are not well understood. We have therefore examined the copper/ceria catalyst in various reaction environments to obtain the direct evidence of dynamic processes at the catalyst surface.

We prepared electron microscopy samples on both copper and titanium grids and carried out in-situ studies in vacuum and in environments of carbon monoxide (CO) and CO and H2O, using spherical-aberration corrected environmental transmission electron microscope with a humidifier system (Wet-ETEM) [6]. The studies in CO and water have demonstrated changes in the Cu particle morphology as well as in the ceria support as a function of the reaction environment. The experiments have further revealed that under the reaction environments copper oxide in the samples is reduced to copper metal. The existence of highly dispersed copper clusters was observed in CO and water. Examples in Figure 1 and 2 show time resolved sequences of copper/ceria nanocatalysts in vacuum. In the presentation, we will discuss the effect of the different reaction environments as well as the presence of copper metal on the extent of reducibility of ceria substrate and the role of anion vacancies in ceria on the mechanism.

References

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Fig. 1: Time resolved studies of Cu supported on ceria showing no changes in the interface of ceria particles.

Fig. 2: Surface atomic movement in ceria in the catalyst system.