Growth, reduction and re-oxidation of sub-nm thin ceria islands on oxidized Cu(111)

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The exploitation of sustainable energy sources requires the development of new effective low-temperature catalysts for various applications, e.g., for the conversion of surplus renewable energy into effective energy carriers. A promising candidate for the methanol production are Cu nanoparticles on ceria supports. In order to study how the reactivity of the system depends on the crystalline orientation of its constituents, we have prepared the inverse model catalyst system of ceria on Cu(111) and performed an extensive in-situ study employing low-energy electron microscopy (LEEM) and spectroscopic photoemission electron microscopy (PEEM) at the nanospectroscopy beamline at ELETTRA. Depending on the surface oxygen concentration, on Cu(111) ceria islands can be grown in (100) and (111) orientation [1]. Furthermore, oxidized Cu(111) was prepared as substrate by exposing Cu(111) to molecular oxygen at 475°C and $2x10^{-6}$ mbar. The deposition temperature of ceria was kept at 475°C while adjusting the oxygen background pressure in the range of $2x10^{-6}$mbar and $3x10^{-6}$mbar. A detailed micro-diffraction and LEEM-I(V) analysis shows that the lower pressure gives rise to the formation of equal shares of CeO_x(100) and CeO_x(111) while the higher pressure results in a majority of (100)-oriented islands. This surface represents a perfect nano-laboratory for reactivity tests on the different surface orientations under identical conditions. Initial experiments show that annealing at 425°C leads to a significant reduction of the ceria islands, subsequent O_2 exposure to re-oxidation, as confirmed by X-ray absorption spectroscopy (XAS) and resonant photoelectron spectroscopy (RPES), respectively.

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