Tuning surface reactivity via electron quantum confinement

L. Aballe, A. Barinov, A. Locatelli, T.O. Mentes, S. Heun, and M. Kiskinova

Sincrotrone Trieste S.C.p.A., S.S. 14, km 163.5 in Area Science Park, 34012 Basovizza, Trieste, Italy.

The effect of electron quantum confinement on the surface reactivity of ultra-thin metal films was explored by comparing the initial oxidation rate of atomically flat magnesium films of different thickness. The growth of ultra-thin Mg films on W(110) was followed in real time using low energy electron microscopy (LEEM), with atomic height resolution thanks to quantum interference. The thickness-dependent valence band of the film was then characterized by X-Ray Photoemission Electron Microscopy (XPEEM). Surfaces with well defined areas of different atomic thickness were exposed to moderate oxygen pressures, in order to determine the initial oxidation rate by local measurement of the Mg 2p core level emission. Pronounced thickness-dependent variations in the oxidation rate were observed for well ordered films of up to fifteen atomic layers. Quantitative comparison reveals a direct correlation between the surface reactivity and the periodic changes in the density of electronic states induced by quantum-well states crossing the Fermi level. This effect was observed at film thickness above 4 atomic layers, when the chemically active surface layer is already insensitive to the presence of the substrate, and the strain due to lattice mismatch has been relieved. Our results show that reactivity of thin films can be tailored by simply changing the number of atomic layers that build the film.

[1] L. Aballe et al., Phys. Rev. Lett. 93, 196103 (2004)