STM Investigations Of Surface Reactions

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The unique information that can be obtained by using Scanning Tunneling Microscopy to monitor surface reactions will be presented by illustrating selected examples on the Rh(110) surface. It will be shown how the comparison of STM images and Density Functional Theory calculations allowed to determine the details of the mechanisms that control simple catalytic reactions at the atomic level. More specifically, the catalytic oxidation of carbon monoxide on the (1x4) reconstructed Rh(110) surface was found to follow, depending on the substrate temperature, two competing pathways that differ for nucleation sites and surface propagation, and involve different surface moieties [1]. On the same substrate, a new, metastable (10x2) reconstructed phase, characterized by the presence of strain and nanostructuring, was found at high oxygen coverage [2]. On this surface, the water formation reaction was shown to be at room temperature a two-step process. Firstly a reaction front that nucleates from defects propagates on the surface, removing one oxygen atom every two and releasing the adsorbate-induced strain; secondly, the remaining oxygen is reacted off in a process that nucleates homogeneously on the surface [3]. STM movies show that, when the substrate temperature is lowered below room temperature, the reaction front assumes a peculiar, "comb-like" shape on the surface; moreover, at the end of the reaction, some oxygen atoms still remain on the surface, arranged in regular nanopatterns that are locally ordered.
Finally, the first results obtained by our new, home made "fast STM" module will be presented, showing that it is possible to increase the image acquisition rate of a commercial STM by nearly three orders of magnitude, thus allowing to follow the dynamics of surface phenomena on the milliseconds time scale.

References

[1] C. Castellarin Cudia, Saw Wai Hla, G. Comelli, Z. Sljivancanin, B. Hammer, A. Baraldi, K.C. Prince and R. Rosei, Phys. Rev. Lett. 87, 196104 (2001);
[2] E. Vesselli, C. Africh, A. Baraldi, G. Comelli, F. Esch and R. Rosei, J. Chem. Phys. 114, 4221 (2001);
[3] C. Africh, F. Esch, W.X. Li, M. Corso, B. Hammer, R. Rosei and G. Comelli, submitted.