In-situ, Real-time Observation of Thin Film Deposition: Roughening, Zeno, Grain Boundary Crossing Barrier, and Steering

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Thin polycrystalline metal films are becoming increasingly important, as is reflected in the multitude of applications in nanotechnology, nanooptics, microelectronics, vacuum coating, catalysis, medical science, sensor elements, wear protection layers, decorative coatings, and the synthesis of new materials.

As thin film properties are intrinsically linked to the precise film structure, one would like to control the overall film morphology down to the nanometer scale.
This clearly demands fundamental research that links well-known atomic processes, such as diffusion and nucleation, with the mesoscopic film evolution during film growth.

Applying video-rate Scanning Tunneling Microscopy (STM) [1], we succeeded in visualizing film growth with atomic-scale resolution in real-time. We evaporated several tens of monolayers of gold on top of a well-annealed polycrystalline gold film, *while* continuously observing the evolving surface with the microscope. These measurements directly visualize atomic processes that take place *during* film growth.

Analyzing the evolving film structure, we observe a significant increase in the film roughness, which we explain by considering both “well-known”, single crystalline growth modes in combination with additional polycrystalline effects [2]. The grain boundaries play a crucial role in the evolution, as they initiate mound formation, thereby significantly increasing the total film roughness. A possible additional roughness contribution comes from atom steering, which also can delay the film closure in the early stages during film growth.

We expect that our findings are of a very general nature and that the processes described in this talk will occur on almost every polycrystalline film during both its nucleation and growth.

[1] M.J. Rost et al.; Rev. Sci. Instr. **76**, 053710-1 (2005)
[2] M.J. Rost; Phys. Rev. Lett. **99**, 266101 (2007)

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