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WHISKERS GROWTH IN THIN Au FILMS

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Metal nanowhiskers attract a great deal of attention due to their high strength approaching the theoretical shear strength of respective metal and unique optical properties. Whiskers can grow spontaneously on the oxidized metal surface at the weak spots in the native oxide layer.

In the present work, the formation of free-standing, high aspect ratio gold nanowhiskers on Au thin films covered with alumina layer is studied. 10 and 20-nm thick Au films were deposited on glass substrates by e-beam evaporation. Afterwards, the films were covered by a 5-nm thick Al₂O₃ using atomic layer deposition. As-received samples were annealed at the temperatures from 350 °C up to 1000 °C in ambient atmosphere.

20-nm thick Au film had a continuous structure with the grain size comparable to the film thickness, whereas 10-nm thick Au film exhibited an island structure. Thermal heating activates the diffusion of gold along the Au/glass and Au/alumina interfaces, which results in the formation of Au whiskers on the thinner film, and in the constrained dewetting of the thicker film under the alumina layer. Straight gold whiskers of up to 25 μm in length and with a constant diameter in the range of 200-500 nm were obtained after annealing the thinner film at the temperature of 800 °C and above (Figure 1). The driving force for the whiskers growth is the gradient of the compressive stress developing in the film. Thermal behavior of the thicker film is quite different. Solid-state dewetting of Au film under the alumina layer is observed. The formation of Au nanoparticles results in cracks formation and partial delamination of the alumina layer with the gold particles attached to it.

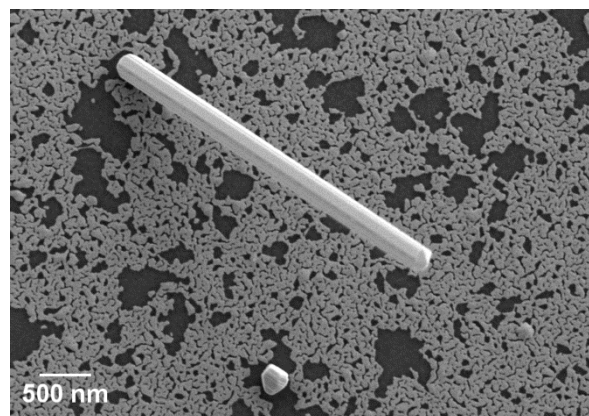


Figure 1. Au whisker formed on the surface of 10-nm thick Au film covered with 5-nm Al₂O₃ layer after annealing at 800 °C.