The Effects of Topography on the Formation of Ordered Arrays of Metallic Nano-particles

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Metal nano-particles formed via solid phase dewetting of continuous thin films can serve as catalysts for semiconductor nano-wire and carbon nano-tube growth. Typically, thin metal films are heated to high temperature to induce dewetting and form nano-particles. However, films allowed to dewet on flat substrates result in particles with broad size and space distributions (Figure 1a). To modify the dewetting process, we have created surfaces with di-periodic topography with periods less than 400 nm using interference lithography. The structures consist of anisotropically etched {111}-bound pits in (100) silicon substrates. Thin gold films were deposited on the topographically modified substrates and induced to undergo solid state dewetting by annealing at high temperatures while remaining below the melting point of the film. For certain geometries of film and topography, we found that dewetting of gold films on di-periodic arrays of {111} bound pits led to periodic square arrays of particles with narrow size distributions (Figure 1a). In addition, the topography was found to significantly reduce the diameter of the particles formed. We have also investigated the effects of substrate topography on particle coarsening and on the crystallographic orientation of the nano-particles. We explain the observed self-organization process with a kinetic mechanism based on the modulation of local curvature of the film by the substrate topography.

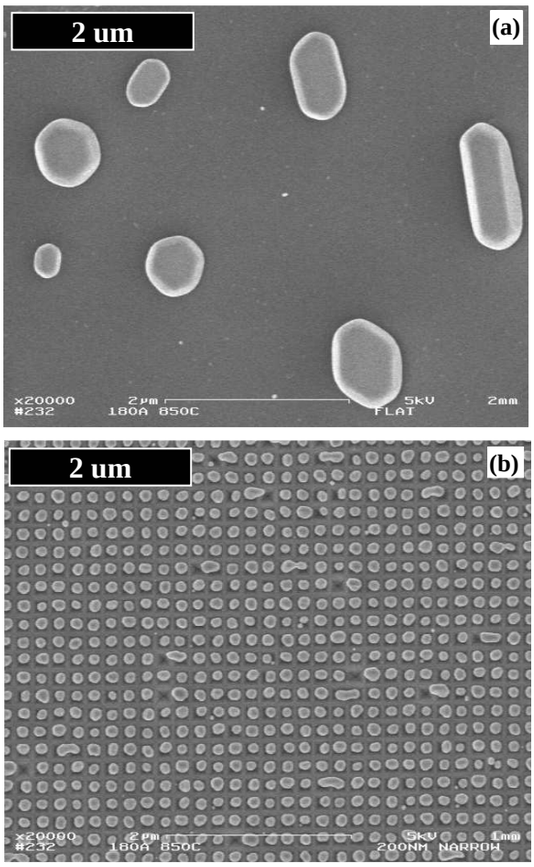

Figure 1. Approximately 21 nm of gold film deposited on: a) a flat (100) oriented silicon surface with a thin oxide, and b) a (100) oriented silicon surface patterned with {111} bound pits with a spatial period of 175 nm. The film was annealed at 850^{o} C for 2 hours to induce solid phase dewetting. (a) and (b) are shown at the same magnification.