Self-propelled motion of Au-Si droplets on Si substrates and Si nanowires growth

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Au droplets on Si substrates tend to dissolve Si. According to the substrate crystallographic orientation, they present interesting different behaviors like formation of holes, nanowires and/or self-propelled motion. The anisotropy of Si dissolution is the origin of these phenomena, which have multiple faces according to the orientation of the substrate.
In this work we study by Low Energy Electron Microscopy (LEEM) the motion of Au-Si droplets and the formation of lateral Si nanowires on substrates of Si (111), (100), (110) and (311). The substrates are prepared by flashing under Ultra High Vacuum, and then Au is deposited by evaporation-condensation from a molecular beam epitaxy effusion cell. On Si(111) Au droplets nucleate, dissolve Si from the terrace steps and thus climb up the steps. This occurs because the (111) Si planes dissolve slower than other orientations and a droplet can dissolve atoms easier from the steps than from the terraces [1]. On Si (110) and (113), the droplets fabricate a Si nanowire and move along the [1-10] axis, in both directions [2]. The nanowire formation can be explained with the following mechanism: (i) Au-Si droplets elongate along the [1-10] axis because of the Si dissolution anisotropy. (ii) Because of local random fluctuations or pinning on one side, a droplet elongates more in one direction than in the other. (iii) An asymmetry of Si dissolution corresponds to the asymmetry of elongation. (iv) A convection flux moves the Si atoms from the dissolution front to the opposite side. (v) The Si accumulated on that side precipitates to form a nanowire. (vi) The droplet moves to follow the edge of the growing nanowire and the mechanism can start again from point (i). We stress that in this case the formation of Si nanowires takes place without external Si flux.
On substrates, where the terraces can be easily dissolved and the droplet-substrate interface is symmetric, like on Si (100), the Au-Si droplets do not move and do not form nanowires but dig a hole in place.
The description of these mechanisms brings new insights on the importance of the anisotropy of dissolution-crystallization for the formation of Si nanowires.

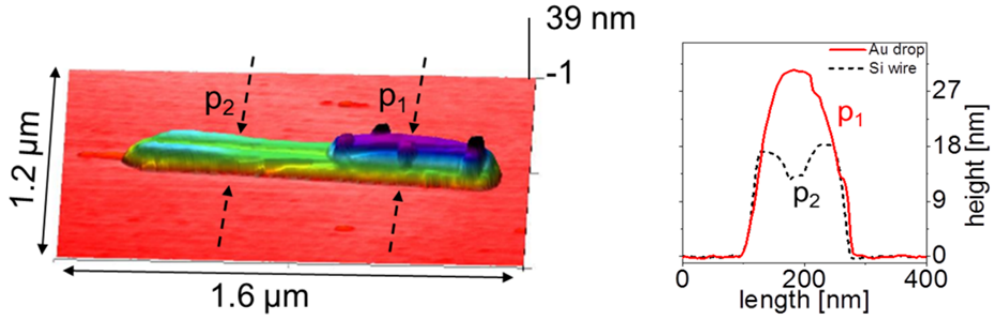

Figure 1: The left panel shows a 3D AFM image of a Au-Si droplet (violet, on the right) that has formed a Si wire (green, on the left). The line profiles taken in the direction of the arrows are reported in the right panel.

1. S. Curiotto, F. Leroy, F. Cheynis, P. Müller. Surface Science 632 (2015) 1-8.
2. S. Curiotto, F. Leroy, F. Cheynis, P. Müller. Nano Letters 15 (2015) 4788-4792.