Gold monolayer islands on a polar AlN(0001) surface

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High-power electronic devices require materials with large electron mobilities and densities and large band gaps. Group-III nitride semiconductors are ideal candidates for these applications. Among these materials, aluminium nitride (AlN) has the largest band gap (6.2 eV). It also has unique properties such as small density, large stiffness, large piezoelectric constant, large fracture resistivity, and chemical inertness.

The growth of metallic nanoclusters on insulating substrates and the study of their physical properties are a wide research domain, pushed by the desire to tailor some specific electronic, magnetic, optical and chemical properties for applications. Most metals grow in the form of three-dimensional (3D) clusters at the early stages of their deposition on such substrates. This situation generally results from the unfavourable surface and interface free energies balance involved in the formation of two-dimensional (2D) islands.

We recently elaborate and characterize AlN(0001) thick films, whose surface is polar. We identified the mechanism of charge compensation for one of its (2×2) reconstructions [1]. Here, we show how the deposition of gold atoms on the (2×2)-N_{ad} AlN surface results to the formation of nano-islands.

Noncontact atomic force microscopy images show that gold grows on the (2×2)-N_{ad} reconstructed polar (0001) surface of AlN insulating films, in the form of large monolayer metallic islands. High-resolution images and in-situ reflection high-energy electron diffraction spectra reveal two moiré patterns from which an atomic model can be built. Density functional theory (DFT) calculations confirm this model and give insight into the mechanisms that lead to the stabilization of the monolayer (Fig.1). Gold adsorption is accompanied, first, by a global vertical charge transfer from the AlN substrate that fulfils the electrostatic stability criterion for a polar surface, and second, by lateral charge transfers that are driven by the local chemical properties of the (2×2)-N_{ad} reconstruction. These results open the way to new strategies using polar surfaces to grow metallic monolayers on insulating substrates.

References

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[2] B. Eydoux, B. Baris, H. Khoussa, O. Guillermet, S. Gauthier, X. Bouju, D. Martrou, submitted (2017).

Figures

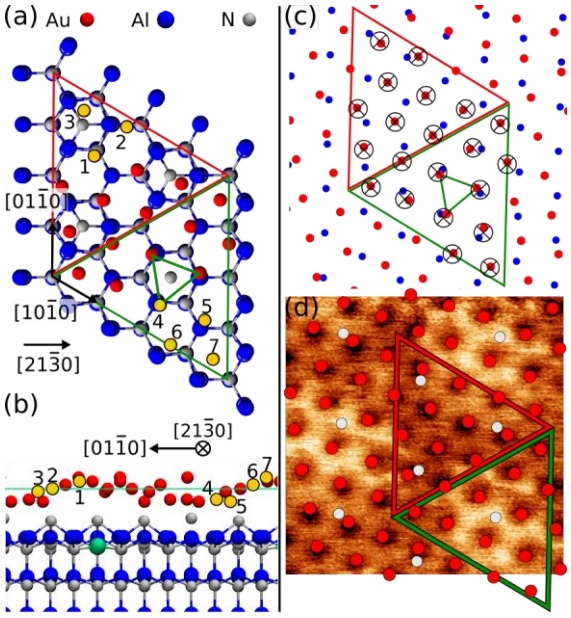

Figure 1. (a) Top view of the DFT optimized structure. (b) Projection along the [2 1 -3 0] axis helps to visualize the different heights of gold atoms with respect to the mean Au plane. (d) NC-AFM image of the Au monolayer on the AlN surface with the superimposed Au atoms calculated positions.