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Gold Nanodot Array with Long-Range Order

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Introduction: Metallic nanostructures on silicon are increasingly of interest for novel electronic applications. Some metals spontaneously grow with needle-like morphology, and may be used as single-crystal nanoscale interconnects. Other metals grow as “dot” structures, and may be useful as active components to provide non-linear current-voltage transport and/or single-electron effects based on Coulomb blockade. For dots of 3nm size, the change in potential due to a single electron is several times kT at room temperature, which facilitates operation of single-electron devices at ambient temperature. We have used the Si(111)-7x7 reconstruction as a robust template to induce ordering of gold dots, which preferentially react on the faulted side of the 2.7nm unit cell. This structure has long-range order imposed by the substrate even though the ordering within each dot is not perfect. This enables the use of X-ray diffraction to measure the average structure of the dots, using standard structural analysis tools.

Methods and Materials: Gold was evaporated from a tantalum heater wire onto a clean Si(111)-7x7 surface. Structure factors for surface diffraction peaks on the 7x7 lattice were measured from integrated rocking curves, for nearly in-plane reflections.

Results: Strong and sharp diffraction features (rods) were found for gold coverage in the range 0-3 monolayers and substrate temperature 25-200C. The 7x7 pattern disappeared irreversibly with annealing above 200C. The figure shows a map of structure factors (reciprocal lattice section with small L) for clean vs. gold-covered surface. The gold induced features are much stronger than those of the clean surface, as expected from the large Z of gold. A distinct pattern of intensities is apparent by inspection, with maximum near the position of Au-Au spacing. We are presently working on structural models for this nanodot array.

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