Submission to the 46th International Symposium of the American Vacuum Society
Oral Session: SS1, Surface Structure/Crystallography

Similarities in Tensile and Compressive Strain Relief in Growth of Cu and Ag on Ru(0001)

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Growth and dynamics of strained films of Cu and Ag on Ru(0001) have been studied at temperatures between 300 and 925 K using x-ray diffraction. A diverse series of structures are observed, which appear to be prevalent in heteroepitaxial growth on hexagonal surfaces. Thin films of both Cu and Ag are initially strained, in the first case from tensile stress of a 5.8% lattice mismatch and in the second from compressive stress of a 6.3% mismatch. Both Cu and Ag form stripe phase reconstructions, in which strain is reduced by uniaxial contraction or expansion along the [100] direction of the film. In Cu films, the stripe phase appears during formation of the second layer, the first being pseudomorphic, while in Ag films the first layer forms the stripe phase. For Cu, the stripe phase undergoes an abrupt incommensurate/commensurate transition to a registry dependant on temperature. Differences in thermal expansion may explain this temperature dependence. A second registry is correlated with third layer growth of Cu, however the third layer is metastable. At higher coverages, both Cu and Ag stripe phases coexist with (111) oriented 3-dimensional islands. For Cu, island formation follows stripe phase development, however for Ag, unstable islands appear first and participate in formation of the stripe phase. Structures grown in equilibrium at high temperature are compared with those grown at room temperature and imaged with scanning tunneling microscopy as well as with results from semi-empirical calculations.

ORNL is managed by Lockheed Martin Energy Research Corp. under US DOE contract DE-AC05-96OR22464. BNL is supported by US DOE DE-AC02-98CH10886.

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