Anton Paar

In-situ GISAXS heating experiments on self-assembled Gold nanoparticles

Thermal morphology changes of self-assembled Gold nanoparticles have been studied using the SAXSpoint system with the temperature controlled GISAXS stage.

Introduction

Colloidal gold (and many other) nanoparticles have widespread use due to their interesting electronic, chemical, and biological properties. These nanoparticles often show interesting self-assembly effects and various two- and three-dimensional nanostructures are known. The electronic properties of such assemblies depend not only on the size of the nanoparticles, but also on their structural arrangement. Monolayers of hexagonally packed Au nanoparticles, for example, are a promising material for strain gauges at the nanoscale level.[1]

The practical applicability of such thin film materials is of course limited by the e. g., thermal stability of such systems. Temperature controlled, in-situ grazing-incidence small-angle scattering (GISAXS) measurements are ideal to study the thermal properties of such films. The Anton Paar SAXSpoint system with its temperature controlled GISAXS stage is the perfect tool for such experiments, as it allows GISAXS measurements at precisely controlled temperature in the range from ambient to 500 °C.

Experimental and Results

Gold nanoparticles with a diameter of about 6 nm were deposited onto Si wafers by a Langmuir-Schaefer method. This way a homogeneous, hexagonal monolayer of nanoparticles on the substrate surface can be obtained.[1] The wafer was placed into the heating attachment of the SAXSpoint GISAXS stage. The angle of incidence was set to 0.2° and kept constant throughout the heating experiment. Before heating the sample, the Au nanoparticles show the typical reflections of a hexagonal close-packed (hcp) arrangement. From the 10 reflection an interparticle spacing of about 8 nm can be calculated. The sample was then slowly heated from room temperature to a final temperature of 220 °C. During the heating process, the intial hcp arrangement of the monolayer was found to be stable to temperatures up to 180 °C. In the temperature range between 180 °C to 190 °C a transformation the small gold nanoparticles to larger structures of around 70 nm could be observed. This transformation was completed at 195 °C and beyond this temperature a stable nanostructure was found.

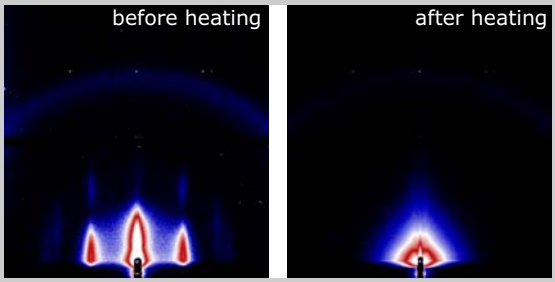

Fig. 1 2D GISAXS patterns of the Au monolayer at room temperature and after heating to 220 °C.

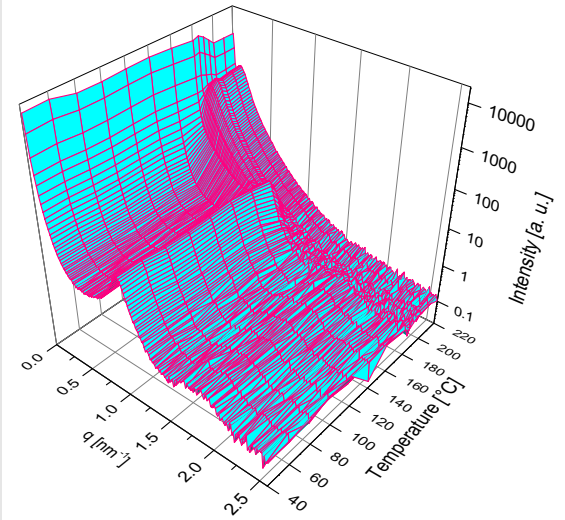

Fig. 2 Morphology changes of the gold nanoparticle thin film depending on temperature.

[1] *K. Vesgo, M. Jergel, P. Siffalovic, M. Kotlar, Y. Halahovets, M. Hodas, M. Pelletta, E. Majkova, SENSOR ACTUAT A-PHYS* ***241*** *(2016) 87-95.*