In situ observation of the phase transition on In/Cu(001)

Shinichiro Hatta[1], Fang Zhun Guo[2], Hiroshi Okuyama[1], Tetsuya Aruga[1]

[1]Department of Chemistry, Graduate School of Science, Kyoto University, Kyoto 606-8502, Japan
[2]SPring-8/JASRI, Sayo-cho, Hyogo 679-5198, Japan

The dynamical behavior accompanying a phase transition has attracted a great deal of interest as an important subject of nonequilibrium statistical mechanics for a long time. The real-time and real-space observation of surface phase transitions is expected to give meaningful information for this issue. The Cu(001) surface with submonolayer coverages of In shows two-dimensional reversible phase transitions. The surface at 0.5 ML undergoes the phase transition between the $(9\sqrt{2}\times2\sqrt{2})R45^\circ$ phase and the $c(2\times2)$ phase at ~350 K [1]. The $(9\sqrt{2}\times2\sqrt{2})R45^\circ$ phase has a rectangular unit cell with its long side aligned along [100] or [010]; therefore, the two mutually-perpendicular domains are formed on the (001) substrate. We obtained the image contrast of the domains in the dark-field image of low-energy electron microscopy, which was used to perform the in situ observation of the phase transition.

The experiment was performed by a spectroscopic photoemission and low-energy electron microscope (SPELEEM) installed at BL27SU of SPring-8. Figure 1 shows a dark-field image of the $(9\sqrt{2}\times2\sqrt{2})R45^\circ$ phase at room temperature. The two-dimensional correlation function of this image showed that the typical size of the domain pattern was ~300 nm. During elevating temperature, this size of the domain distribution seemed not to change until the image contrast disappeared. The contrast was weakened rapidly around 355 K. No contrast was observed above 360 K. On cooling, the contrast came back gradually below 360 K. While the steady domain pattern was observed below 358 K, we found that the gradient of the correlation function near zero distance started to become slow at ~360 K. This short-range correlation may be associated with the dynamical behavior of the phase decomposition near the transition temperature. The domain distribution coming back shows a quite different pattern from that of the pre-annealing surface. However, its scale was almost unchanged. This indicates that the observed domain pattern is dominated by the thermal fluctuation.

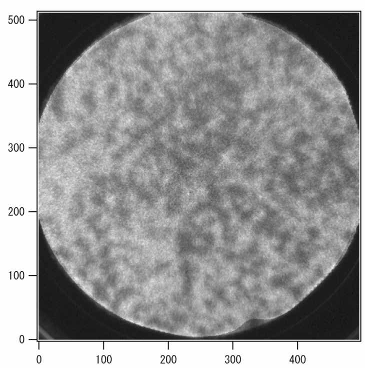

Figure 1. A dark-field image of In/Cu(001)- $(9\sqrt{2}\times2\sqrt{2})R45^\circ$. Field of view is 5 μm.

[1] T. Nakagawa et al., PRL 86, 854 (2001).