Atomic structure and electron distribution of ring-like Co cluster on Si (111) surface by NC-AFM/KPFM at 78 K

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[Background] The adsorption of metal nanoclusters on semiconductor surfaces has been intensively investigated for the past several decades because of low dimensional and quantum properties. They are promising for many novel applications in ultrahigh density recording, nanoelectronics and nanocatalysis, etc [1]. Co adsorption on Si(111)-7×7 surface was highly related to the Co coverage, expose temperature and annealing temperature [2]. However, the atomic structure of individual ring-like Co clusters has not been observed on Si(111)-7×7. In this work, to clarify Co nanocluster with atomic structure, we present an NC-AFM/KPFM study on Co atom adsorbed Si (111)-7×7 surface.

[Method] The experiments were carried out by a home-built low temperature (78 K) NC-AFM/KPFM system in an ultrahigh vacuum (base pressure below 3×10^{-11} Torr). The Co atom was evaporated at RT with a deposition rate of 0.03 ML/min. To get the atomic structure of Co clusters on Si(111) surface, the sample was annealed at 230℃. Combing force spectroscopy and LCPD measurement, we analyzed the atomic structure and electronic distribution, and proposed a model of ring-like Co clusters.

[Results and discussion] A topographic image of ring-like Co cluster with the atomic resolution was shown as the inserted image in Fig. 1(a), which is the atomic structure of Co cluster observed by AFM for the first time. The Co cluster was adsorbed on off-center site in HUC, two center Si adatoms were missing, and it shows a ring-like shape. From the site-dependent force spectroscopy, we found that three sites have different maximum attractive forces, which reveal the different bond energy. Fig. 1(b) show the V_{LCPD} image of ring-like Co cluster, six atoms of Co cluster show more positive charged and the center on ring-like Co cluster shows negative charged. Combing force spectroscopy and LCPD measurement, we analyzed the atom species and electronic distribution in cluster, developed a new model of Co ring-like clusters on Si(111)-7×7 surface (see Fig.1 (c)).

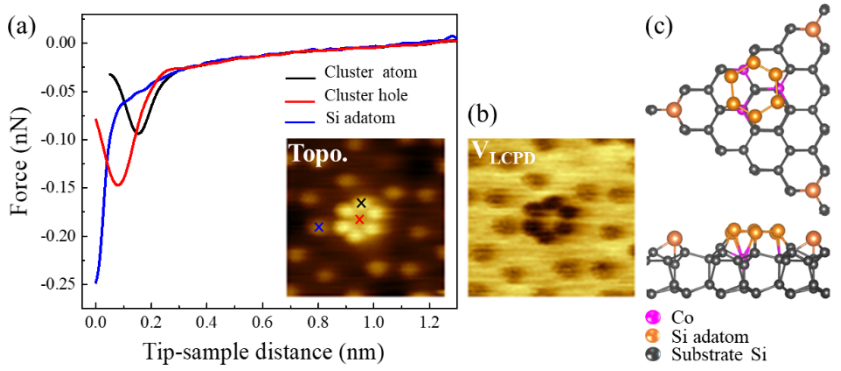

Fig.1 (a) Force spectroscopy as a function of tip-sample distance at cluster atom, cluster hole and Si adatom, The inserted image is topography of ring-like Co cluster on FHUC of Si(111)-7×7. (b) V_{LCPD} image of ring-like Co cluster. (c) Model of ring-like Co cluster. Imaging parameter: 5×5 nm^2, f_0 = 960 kHz, A = 2 nm, Q = 12800, Δf = -6 Hz, V_{CPD} = 200 mV, T = 78 K.

[References]

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