STM study of anisotropic 2D electronic gas states realized in glycine/Cu(100) interface

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Control of electronic states in organic molecular films, for example, by chemical modification of functional groups, is one of the key technologies for realization of future novel molecular devices. For the solid surfaces with two-dimensional nearly free electronic gas states (2DEG), appearance of standing waves caused by the wave nature of electrons is expected. In addition to the analysis of electronic confinements such as lifetimes of surface states and Kondo effect, possibility of controlling the electronic structures, for example, by adsorbates has been energetically studied. However such experiments have been performed for only a few limited systems as Au, Ag, and Cu(111) surfaces.

We performed scanning tunneling microscopy/spectroscopy (STM / STS) measurements on a self-assembled monolayer film of glycine molecules on Cu(100). Figure 1 shows a topographic STM image with a *p*(2x4) superstructure and its d*I*/d*V* mapping obtained at +200 mV sample bias voltage under low temperature (5 K) condition, which represents a spatial distribution of local density of states (LDOS). As shown in the d*I*/d*V* mapping, there is a standing wave pattern with a larger periodicity than that of the molecular structure, indicating the existence of a 2DEG. This is the first demonstration of the electronic standing wave observed for self-assembled molecular structure on Cu(100) surface which has no such 2DEG surface states at this sample bias voltage. From the bias dependence of wavelength of standing waves in the several modulated LDOS images, we obtained nearly free-electron like dispersion relations, as plotted in Fig.2a. Unlike the substrate symmetry, the dispersion relations are anisotropic, and the effective masses obtained from the dispersion relations are $0.061m_e$ for [110] and $0.61m_e$ for [-110] directions. This is likely because of a larger overlap of electronic states in molecules along the [110] direction, originating from the carboxyl or amino groups in the molecules (Fig.2b).

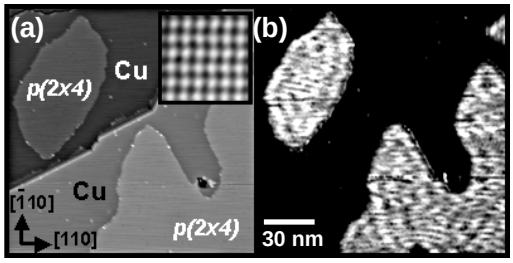

Fig. 1 (a) STM topographic image
(b) d*I*/d*V* mapping at +200 mV.

Our results suggest that we can induce and control the 2D electronic gas states on a solid surface by adsorption of organic molecules and chemical modification of functional groups and side chains in them. This ability brings us a significant improvement for design of electronic structures in the nano-technology field.

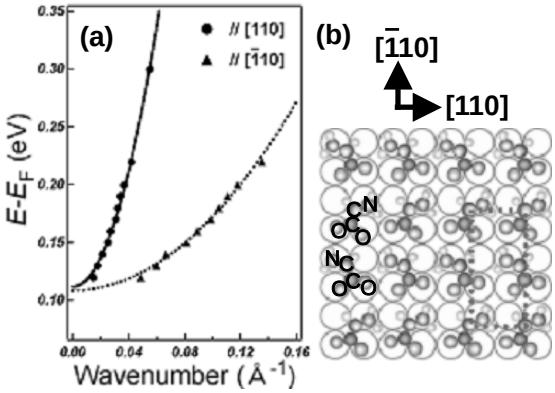

Fig. 2 (a) dispersion curves of 2DEG on the *p*(2x4)
(b) Molecular arrangement of the *p*(2x4)

References

1. http://dora.ims.tsukuba.ac.jp
2. K. Kanazawa et al., J. Am. Chem. Soc. **129** (2007) 740