STM-induced photoemission spectroscopy on rubrene thin films -Does surface plasmon play an essential role for photoemission?-

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Introduction: Scanning tunneling microscope (STM) induced photoemission spectroscopy enables us to study local carrier dynamics of materials. Recently, for example, vibrationally resolved photoemissions from porphyrin molecules were observed [1,2], which has been attracting interest. However, the basic mechanisms for the excitation and relaxation processes are still under discussion.

In the present study, we introduce an intriguing result recently obtained for the STM-induced photoemission spectra from rubrene thin filmes on Au and HOPG substrates.

Experiment: STM and optical system were set in a metallic shading box. Photons emitted from the tunnel junction were focused onto an entrance edge of optical fiber and introduced to monochromator, and detected using a Peltier-cooled CCD. All STM experiments were performed at room temperature with constant-current mode using mechanically cut or electrochemically etched PtIr tips. Bias voltage was applied to the sample.

Rubrene/Au(111) and rubrene/HOPG samples were prepared by vacuum deposition and spin coating.

Results and Discussion: Figure 1 shows an example of STM-induced photoemission spectra from vacuum-deposited rubrene/Au sample measured at various positive bias voltages. With the increase in the bias voltage, new spectral components emerge at higher energy (shorter wavelength) region. These components are close to the values obtained by photoluminescence spectroscopy of rubrene single crystal [3], reflecting the vibronic states of rubrene molecules. As can be seen in Fig. 1, low-energy components of the spectra (rubrene) are observed for the bias voltage lower than the energy gap.

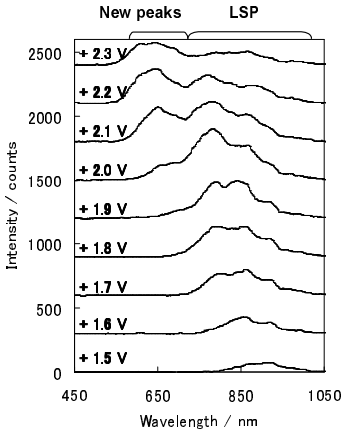

Fig. 1. STM-induced photoemission spectra from rubrene/Au (tunneling current: 5 nA, exposure time of CCD: 2 min/spectra).

Any spectra were not observed from rubrene/HOPG sample, which is consistent with the results in Ref. [4].

These results strongly suggest that the localized surface plasmon of the metal substrate influences the photoemission processes as well as the excitation processes with the effect of phonon-coupling mechanism.

References:

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