STM-induced light emission from an organic-LED structure

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Scanning tunneling microscopy-induced light emission (STM-LE) is the method that enables us to study the optical properties in the nano-sized region of conductive materials. Many works have been carried out for various organic materials on metal substrates such as Au and Ag, where surface plasmon induced by STM influences STM-LE processes. On the other hand, STM-LE measurements have rarely been performed on the structures consisting of composite organic multi-layers, despite the practical importance of such systems. Here, we demonstrate the results of STM-LE measurements performed on a composite organic multi-layered structure consisting of Alq_3, rubrene, and TPD.

The measurements were performed in air and ultrahigh vacuum at 80 K or room temperature. We used a mechanically cut PtIr wire or electropolished PtIr as a STM tip. The light emitted from tunnel junction was focused onto an entrance edge of an optical fiber, and introduced to a monochromater and detected by a high-sensitive CCD. The organic films were prepared by vacuum deposition on the substrates. Film thickness of each layer was monitored using a Quartz crystal oscillator. CCD exposure was started and finished simultaneously with the STM topographic measurement.

Figure 1(a) shows an example of STM-LE spectrum obtained from an Alq_3/rubrene/TPD/Au system. The most prominent emission peak is at around 600 nm. This feature is very similar to that of photoluminescence (PL) from an as-received rubrene powder. However, the longer wavelength component than 600 nm, which is not observed in the PL spectrum, is included in the STM-LE spectrum. The 600 nm- and the long-wavelength spectral components are attributed to those caused by the transition in the rubrene layer and the decay of surface plasmon, respectively. In order to eliminate the effect of the plasmon to analyze the mechanism of the electron-hole recombination process in more detail, we used a conductive oxide substrate, indium tin oxide (ITO). Figure 1(b) shows a STM-LE spectrum from an Alq_3/rubrene/TPD/ ITO system, where the effect of plasmon is well removed. The inset represents the emission mechanism. For a deeper analysis, we also performed 2D photon mapping that we developed. The details will be discussed at the conference.

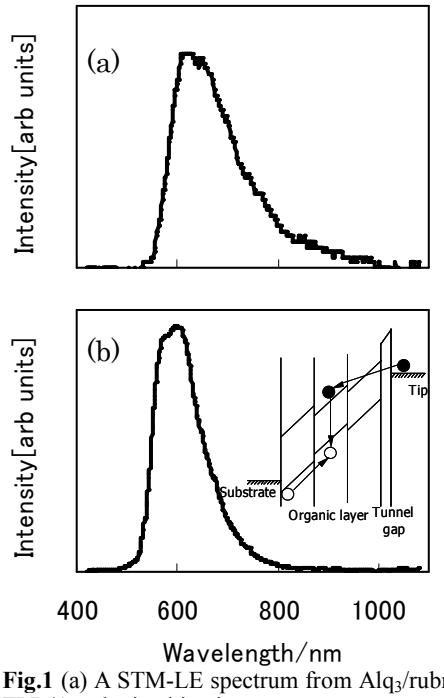

Fig.1 (a) A STM-LE spectrum from Alq_3/rubrene/ TPD/Au obtained in air at room temperature (Bias voltage: 5.0 V, tunneling current: 3 nA, exposure time of CCD: 128 sec/spectrum).
(b) A STM-LE spectrum from Alq_3/rubrene/ TPD/ITO obtained in air at room temperature. (Bias voltage: 6.0 V, tunneling current: 5 nA, exposure time of CCD: 128 sec/spectrum).
(**Inset:** Energy diagram of the layer structure)