Time-resolved Electrostatic Force Microscopy of Patterned Organic Photovoltaic thin films

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Electrostatic Force Microscopy (EFM) is a powerful method capable of detecting and imaging electrostatic charges and polarizations state generated on organic molecules in nanoscale spatial resolution. [1,2] Since we can “see” photo-induced excitons and charges in organic photovoltaic thin film as EFM images, it is possible to study the local charge dynamics related to the surface structure. We have reported that we can observe the drift process of charges to the electrode after photo-induced charge separation in the organic solar cell by frequency shift detection of the cantilever under the amplitude feedback condition. In this presentation, we report the results of time-resolved EFM using synchronization of pulsed-light irradiation to the tip motion to realize charge imaging with micro-second-level time resolution.

We prepared patterned donor / acceptor thin film by the following method. MDMO-PPV (donor) thin film is prepared on the PEDOT:PSS / ITO substrate by spin-cast method. A mesh is applied onto the MDMO-PPV film as a mask, and fullerene (acceptor) is deposited by vapor deposition method. Fig.1 shows principle illustration of time-resolved EFM. We irradiated the sample with nanosecond light pulse train synchronized with the tip oscillation, and we recorded the cantilever frequency shift. We used the cantilever with resonant frequency of 279.232 kHz. During the EFM measurement, electrostatic force between the tip and the sample surface is not constant in time course due to the periodic change of tip-sample distance caused by its oscillation. When the tip-sample distance is short, electrostatic force sensitivity is higher, and this time works as time window. Therefore, it is possible to detect the charge state after a certain time since the pulsed-irradiation by adjusting the timing of the cantilever motion and the pulse irradiation. The pulsed-irradiation timing dependence of frequency shift indicated sinusoidal curve related to the tip motion. In this presentation we report the results of the detailed analysis of the dependence and the time-resolved charge images.

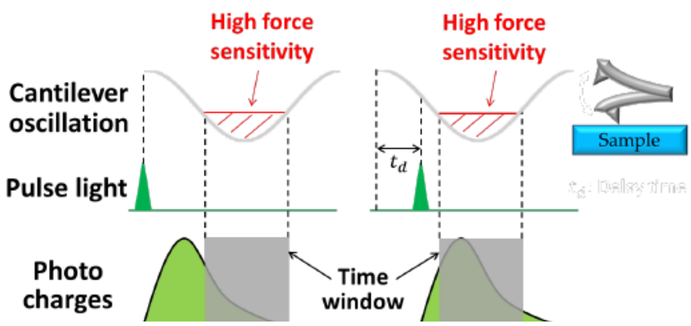

Fig.1. Principle of time-resolved EFM

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