Thermal and non-thermal equilibrium processes of charge extraction in metal/inulator/organic semiconductor/metal (MIOM) junctions

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Accumulated charge measurement (ACM) is an experimental technique for studying the charge injection and extraction processes in the MIOM junction comprising metal electrode 1 (M1), insulator (Ins), organic semiconductor (OS), and metal electrode 2 (M2) (see the inset of Fig. 1(a)). This structure is identical with that of the drain or source electrode in organic FET. In this method, the change in the accumulated charge (Q_{acc}) is estimated by integrating the displacement current when the applied bias voltage (V_{bias}) changes from V_{off} to $V_{off} + V_a$. V_{off} is the constant offset voltage and V_a is the alternating voltage that is changed step-by-step; Q_{acc} is expressed as a function V_a. From the observed dataset of Q_{acc} and V_a, ΔQ and V_{OS} are derived, where ΔQ is the degree of charge injection, and V_{OS} is the voltage drop within the OS layer caused by V_a. The injection barrier at the OS/M2 interface can be evaluated from the plot of ΔQ as a function of V_{OS}.

In this paper, we report that there are two types of charge extraction processes in the MIOM junction based on experiments and theoretical calculations. In the thermal equilibrium (TE) process, charge evacuation simultaneously occurs at the Ins/OS and OS/M2 boundaries. On the other hand, in the non-thermal equilibrium (NTE) process, charge evacuation at the OS/M2 boundary occurs in the first step, followed by charge evacuation at the Ins/OS boundary in the second step. To evaluate the injection barrier at the OS/M2 interface based on ACM, NTE process is more convenient than TE process. Meanwhile, to fabricate an organic FET, TE behavior at the electrodes is better than NTE behavior. When the injection barrier at the OS/M2 boundary is relatively large or mobility of OS is relatively small, MIOM junctions tend to exhibit NTE behavior.

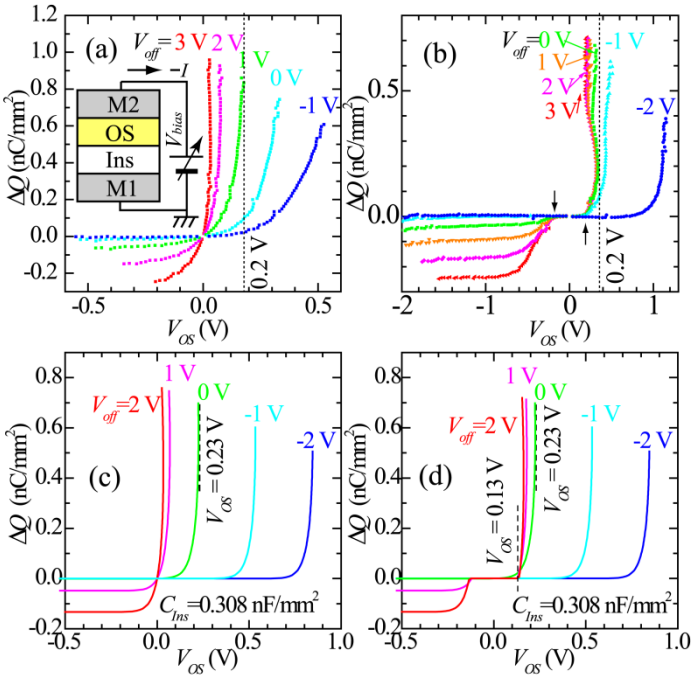

Fig. 1 ΔQ–V_{OS} plots experimentally determined for *n*-Si/SiO_2/pentacene/Au (a) and Al/SiO_2/phthalocyanine/Au (b). The calculations of ΔQ-V_{OS} plots under the assumption of the TE (c) and NTE (d) models. The inset of (a) illustrates schematic of the sample and measurement setup.

References

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