Organic single-crystal transistors and structural studies of the active semiconductors

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Development of high-performance printed semiconductor devices is highly desired with the expectation for the next-generation technologies of “printable electronics”, providing simply fabricated, flexible, large-area, low-cost and environmentally friendly products such as paper-like flexible displays. Here, we report newly developed arrays of patterned crystalline OFETs of air-stable compound 2,9-didecyl-dinaphtho[2,3-b:2’,3’-f]thieno[3,2-b]thiophene (C_{10}-DNTT) formed from hot solution, in which structural studies of the crystalline analysis have provided essential contribution.

In the process of forming organic semiconductor films from solution by naturally evaporating solvent near room temperature, the constituent molecules, which were independently dispersed in the solvent, self-organize into highly ordered crystalline films with the amazing speed of more than 10^{10} molecules per second. Since the speed of the film growth is directly translated to high-throughput production, the technique can be very attractive for the industry.

In the present experiment, highly crystalline films of C_{10}-DNTT are formed from hot solution, where intentionally positioned matrix arrays are fabricated at once. Moreover, these devices are already electrically separated with each other, meaning that no further processes are necessary to divide the devices for their independent operation in the integrated circuitry. Mobility of 5-10 cm^2/Vs is achieved for such OFET arrays, opening a practical way to realize printed and flexible electronics with sufficient switching speed.

The high-energy X-ray diffraction measurement in the KEK beamline has enabled the structural analysis of the thin-film crystals, so that the crystal structure, direction of the crystal growth, and the crystallinity are elucidated. The high-mobility charge transport is grounded on almost perfect molecular periodicity in the crystal films that allows effective intermolecular exchange of the electrons.