Engineering Organic–Organic Interfaces with Spontaneously Formed Orientation Polarization Thin Films

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Abstract

Spontaneous orientation polarization (SOP) in vacuum-deposited polar organic films originates from the preferential orientation of molecular dipoles, generating a giant surface potential (GSP). However, the mechanism governing dipole orientation and the molecular design principles for controlling SOP have remained unclear. In this study, we demonstrate that molecular asymmetry plays a key role in promoting spontaneous molecular orientation and SOP formation. By introducing functional groups such as fluoroalkyl units to tune the polarizability of molecular edges, we controlled intermolecular van der Waals interactions during film growth. The resulting polar molecules exhibited highly efficient orientation in vacuum-deposited films, achieving GSP growth rates nearly 350 mV nm^{-1}, far higher than those of conventional materials (Fig. 1). Furthermore, both the magnitude and polarity of SOP were tuned through molecular design. We also show that SOP layers can modify charge injections at organic/organic interfaces, providing a versatile strategy for electrostatic control in organic electronic devices. These findings establish new molecular design principles for SOP and offer a simple approach to improving OLED performance.

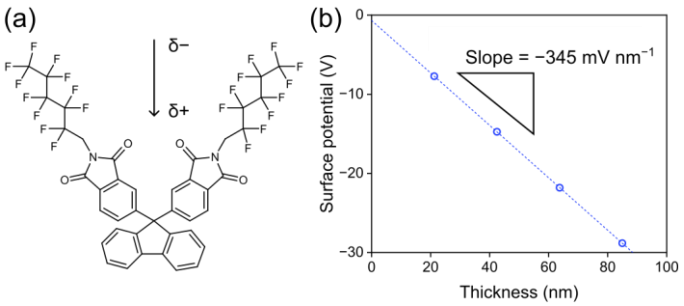


Fig. 1 (a) Chemical structure of an SOP molecule. (b) Thickness dependence of the surface potential of vacuum-deposited films.

Recent Publications

1. M. Tanaka et al., *Nat. Mater.* **21**, 819-825 (2022).
2. M. Tanaka et al., *Nat. Commun.* **15**, 5950 (2024).
3. M. Tanaka, *Nat. Commun.* **15**, 9294 (2024).
4. M. Tanaka et al., *Commun. Mater.* **6**, 92 (2025).
5. M. Tanaka et al., *Small* **22**, e06399 (2026).

Biography



Prof. Masaki Tanaka received his Ph.D. in Engineering from Kyushu University. He is currently an Associate Professor at Kyushu University, Japan. His research interests include organic semiconductor materials and devices, particularly OLEDs, organic photovoltaics, and spontaneous orientation polarization (SOP) in organic thin films. His work spans molecular design, synthesis, device engineering, and fundamental studies of organic semiconductors.