Organic field-effect transistors with bending radius down to 1 mm

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We have investigated the allowed bending radius of high-quality pentacene organic field-effect transistors (OFETs) manufactured on a plastic substrate, and found that the reduction of mobility due to the application of a bending stress with a radius of curvature (R) smaller than about 3 mm, was only 20%. This remained true even at R = 1 mm. We also studied the recovery performance after stressing OFETs.

High-performance OFETs with a mobility of ~ 0.3 cm^2/Vs and an on/off current ratio of above 10^5 have been fabricated by a vacuum evaporation process. First, the gate electrode was formed by thermal evaporation of 5 nm Cr and 50 nm Au through a shadow mask on a 75 μm flexible polyimide-sheet plastic substrate. Then, a polyimide gate dielectric layer was prepared by spin coating and a 30 nm thick pentacene film was deposited through thermal evaporation. Finally the 50 nm Au drain-source electrodes were formed using a shadow mask. The channel length and width of OFETs are normally 50 μm and 16 mm, respectively. The electrical properties of the OFETs were measured using a three-lead probe (Agilent Technologies 4156c Precision Semiconductor-Parameter Analyzer) while the OFETs were stressed using a stress apparatus. The apparatus consists of a cylinder of radius R variable from 50 to 1 mm, corresponding to an expansive strain in the plane. Systematic measurements focused on the three aspects: mobility, threshold voltage, and typical dc current-voltage characteristics. It should be noted that no significant change in performance has been found when bending the device down to a radius of R = 1 mm except for a slight decrease in the mobility. Additionally, there were no significant residual effects found after the removal of the bending stress.

In the analysis of the mechanical flexibility, we demonstrated that our OFETs electrical properties were fairly stable during the application of a bending stress. Our results can lead to a better understanding of the operation of OFETs under stress, and thereby help produce robust electronic devices that have a higher level of mechanically flexibility.