Enabling Strategies in Organic Electronics Using Ordered Block Copolymer Nanostructures

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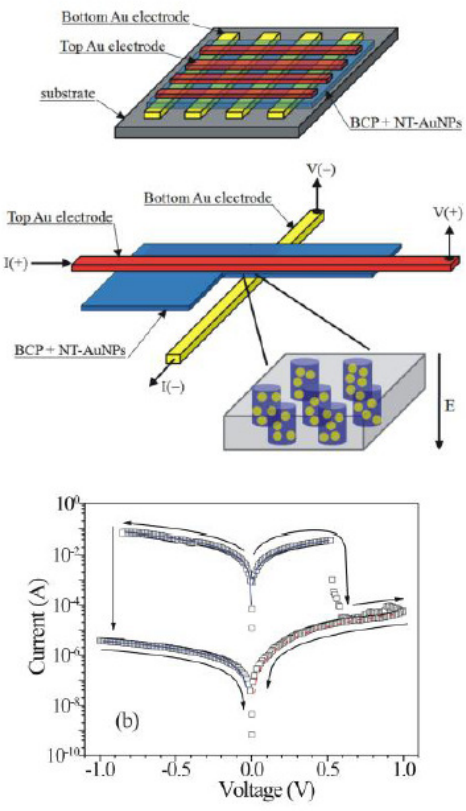
Today's lithographic techniques for carving silicon into circuit patterns are unable to achieve the future target of the semiconductor industry of fabricating ultrahigh density memory devices made of memory cells just few tens of nanometers apart. Methods of extending these approaches to large-scale, high-density circuitry are largely undeveloped. Between emerging self-assembly bottom-up methods for advanced fabrication of electronic devices based on organic matrices, nanocomposites formed by a conducting phase (e.g. metal nanoparticles) dispersed in a polymeric matrix have attracted considerable attention, because these materials might be used as an active layer in almost all kinds of organic electronic devices.



In this paper a different approach for the fabrication of advanced electronic devices is suggested, based on the combination of two concepts: the use of organic materials as active layers that guarantees simplified manufacturing process yielding low-cost, flexible, and light-weight devices, and the use of self-assembly of block copolymers (BCPs) that allows building nanostructures from the bottom up using individual macromolecules.

The ordered cylindrical self-assembled nanostructure formed from PS- b -PMMA is used as host for selectively sequestering gold nanoparticles. The ordered distribution of the functional particles is guided by the ordering of the host matrix and allows arising other numerous possible applications that depend on the nanospecific properties of the sequestered components and the intrinsic flexibility of the polymeric matrix. The BCP structure has many considerable advantages in terms of low material consumptions and reduced operating voltages for producing high bistability effects in well ordered nanostructures. Moreover, the excellent results we achieved in terms of electronic performances as evidenced in the Figure and the high potential opened by this nanotechnology toward the development of innovative materials open the way toward the realization of novel organic devices containing different physical types of functionalized nanoparticles (e.g. oxides, superconductors, etc.), and the investigation of their fundamental properties.

Figure . Schematics of the memory device and IVC measurements.
Device with crossed configuration. The active layer of our BCP nanocomposite film is sandwiched between two crossed gold electrodes. The amplifi ed drawing of the device shows the ordered cylindrical nanostructure of the BCP active layer.
IVCs measurements on a 1 mm2 Au/BCP NT˜ AuNPs/Au device with crossed configuration. The scattered points are the experimental data, the solid and dashed lines are the numerical fitting. The arrows indicate the bias scanning directions.