POTENTIAL OF CONDUCTING NANOCRYSTALS OF ORGANIC SALTS FOR MOLECULAR ELECTRONICS

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A new trend in electronics research is to increasingly employ chemical synthesis techniques in order to fabricate device components exhibiting physical properties addressed to specific applications. In this respect, it is interesting to consider nanowires and nanocrystals of conducting organic salts as an appealing alternative route to fabricate nanoscale devices.

Here we report two new methodologies to electrochemically grow metallic $(TTF)Br_x$ nanocrystals, where TTF = tetrathiafulvalene.[1] The first method combines both bottom-up and top-down approaches, involving the growth of nanocrystals from their precursor molecules on electron-beam patterned gold electrodes. Interestingly, this method gave rise to the production of a large amount of conducting nanocrystals (Fig. 1). The second strategy used allows for the fabrication of nanocrystals on an insulating SiO_2 surface using gold nanoparticles as crystalline nucleation points. Thin layers of SiO_2 are good insulators for electron transport but allow an ion current to pass through them. This technique could be extended to the preparation of a vast number of charge transfer salts and, therefore, organic nanocrystals revealing a large variety of electrical properties or even combining different physical properties could be prepared.

Nanocrystals of conducting TTF salts embedded in a polymeric matrix also offer great potential for applications in electronic devices. We recently reported novel composite materials called bi-layer (BL) films, which consist of a polymeric matrix with a top-layer formed by a nano and microcrystalline network of a TTF based conductor.[2] These materials are very promising since they combine the unique physical properties of molecular conductors and the processability and flexibility of polymeric films. The BL film shown in Fig. 2 is formed by θ-$(BET\text{-}TTF)_2Br\cdot 3H_2O$ [BET-TTF: bis(ethylenethio)tetrathiafulvalene] crystals and exhibited a high conductivity of 120 Scm^{-1}. In addition, it has been demonstrated that the size of the crystals forming the conducting surface layer can be tuned, depending on the temperature during the preparation process, from nano to micro-scale without altering significantly the resultant electrical properties.[3]

The design of electronic components or devices calls for patterning techniques that permits one to place the organic conductors on the substrate at will. We have developed a novel technique, namely *thermochemical printing of organic conductors (TCPOC)*, for patterning the BL films.[4] The patterning is realized employing a local heat source and by taking advantage of the chemistry of the organic conductors, as at high temperature the anion forming the conducting TTF-based crystals can be partially or totally removed. Consequently, by locally heating the film surface the conducting areas, formed by the TTF salts, can be converted into insulating areas, formed mainly by the neutral TTF derivatives. We have also demonstrated the potential of this new technique, which can be further miniaturised, for the design of electronic components and devices (Fig. 3)

References:

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Figures:

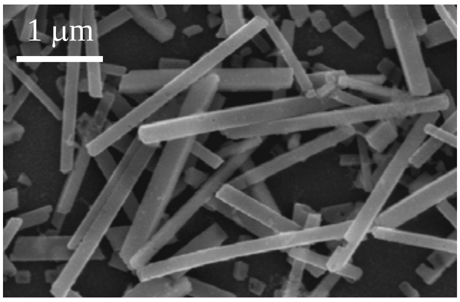

Fig. 1. SEM image of $(TTF)Br_x$ nanocrystals grown electrochemically and on prefabricated gold electrodes.

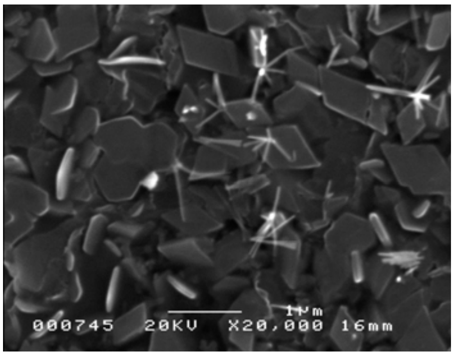

Fig. 2. SEM image of a BL film formed by θ-$(BET\text{-}TTF)_2Br{\cdot}3H_2O$ nanocrystals.

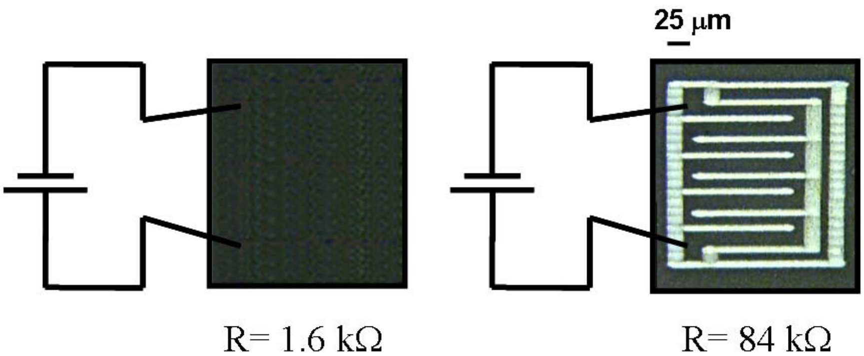

Fig. 3. Electronic circuits in which the BL films of nanocrystals β-$(BET\text{-}TTF)_{2.5}I_3$ without patterning (left) and after patterning (right) are used as micro-resistors. The light zones in the right figure correspond to the laser writing path and are insulating.