SPINTRONICS WITH ORGANIC SEMICONDUCTORS

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Organic semiconductors (OSC) research over the past decades has made continuous and impressive progress [1]. The greatest success has been undoubtedly achieved in the optoelectronics field, where display products based on hybrid light emitting diodes with organic emitter (OLEDs) have become available to consumers, and organic photovoltaic devices are challenging existing commercial applications. These accomplishments generate a strong demand for other mainstream products based on new hybrid organic-inorganic devices. Considerable improvements have already been achieved in organic field effect transistors (OFETs), while organic electric memories for data storage applications are nowadays attracting both fundamental research and applications.

Organic semiconductors have recently caught the attention of spintronics, and significant efforts are being made towards their integration in this field [2, 3]. Spintronics is a branch of electronics that takes full advantage of, not only the charge, but also the spin of the electron. It encompasses different topics, related mainly to the generation of a nonequilibrium spin polarization in various materials and devices, together with its manipulation and detection [4-7].

The most attractive aspect for spintronic applications is the weakness of the spin scattering mechanisms in OSC, implying that the spin polarization of the carriers can be maintained for a very long time in these materials. This property is due to the very low spin orbit coupling in OSC: carbon has a low atomic number (Z), and the strength of the spin orbit interaction is generally proportional to Z^4. Noticeably, spin relaxation times in excess of 10 microseconds were reported by different resonance techniques years before the first organic spintronic experiments [8, 9], values exceeding by orders of magnitude the characteristic times detected in inorganic materials [10].

Organic spintronics can currently be seen as a fascinating puzzle in which many pieces are still lacking. For example, the electronic properties of OSC are radically different from those of such band semiconductors as Si or GaAs. Consequently, their spin properties are also different. The most challenging and exciting aspect of organic spintronics is therefore the need to face a conceptually new physical behaviour and to unveil both its fundamentals and possible application issues. In addition to this stimulating fundamental interest, the results so far obtained in this novel field are very encouraging. It cannot be excluded that OSC will compete with other materials for the leadership in the spintronics field or at least in some selected niche applications.

In this talk I shall focus on the major achievements and questions arising from spin injection and transport in organic semiconductor materials. I will begin by presenting and discussing the concepts and facts which are widely accepted by the community and will conclude by addressing the most controversial issues and open questions [11].

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