

Spin Injection at Organic-Inorganic Interfaces

V. Alek Dediu^{*}, Ilaria Bergenti, Alberto Riminucci, Luis Hueso, Yiqiang Zhan,
Carlo Taliani

ISMN-CNR, Via Gobetti 101, 40129 Bologna, Italy

The study of spin injection in organic materials has recently attracted considerable efforts. We report on hybrid organic-inorganic spin devices like spin valves and organic based light emitting diodes with spin polarized electrodes. Ferromagnetic films of the manganite $\text{La}_{0.7}\text{Sr}_{0.3}\text{MnO}_3$ (LSMO) and Co acted as injectors of spin-polarized charge carriers, while small molecule organic semiconductors tris(8-hydroxyquinoline)aluminum(III) (Alq_3) and sexithiophene (6T) were used as spin transport layers.

The spin valve devices included a tunnel barrier between Co electrode and organic semiconductor. Such a tunnel barrier is expected to amplify the spin injection efficiency from Co. A few percent spin valve effect takes place at least below 210 K, that is the highest temperature so far reported in literature for this effect (spin valve) for organic based devices. We believe this is due to both high quality of manganite injector and increased efficiency of spin injection from the Co layer due to LiF tunnel barrier.

The strength of the effect was found to be strongly asymmetric with respect to the bias voltage: the effect is much stronger at negative voltages, i.e. electrons injected from manganite towards the Co electrode. XPS investigation of the interface between manganite and Alq_3 revealed a strong interface dipole leading to much better matching of the metal Fermi level with Alq_3 LUMO (1.1 eV) rather than HOMO level (1.6 eV). This unequivocally indicates that the current in these devices is dominated by the electron channel, and not by holes as suggested previously by other authors. The knowledge of the energy diagram at the bottom interface allows us to work out a semi-quantitative model explaining both negative spin valve effect and strong voltage asymmetry. The model involves a sharp energy selection for the moving charges by the very narrow LUMO level of the organic material leading to peculiar resonant transfer.

In organic light emitting diodes (OLED), electroluminescence (EL) strongly depends on the relative population of singlet and triplet excitonic states. Quantum constraints determine the statistics of singlet-triplet exciton formation from charge recombination to a 1:3 partition. Spin polarized carriers in organic electroluminescent material should favour the formation of preferred excitonic state providing the way to amplify a chosen electronic transition and modify the device properties. The Alq_3 based OLEDs with LSMO hole injector show a strong red shift with respect to “standard” OLEDs with ITO and Al electrodes. Additional investigations are required in order to better understand the nature of this effect. Nevertheless, observed spectral modification induced by the presence of spin polarized electrodes can open a new fascinating way of tuning the OLED colour.

^{*} adediu@bo.ismn.cnr.it