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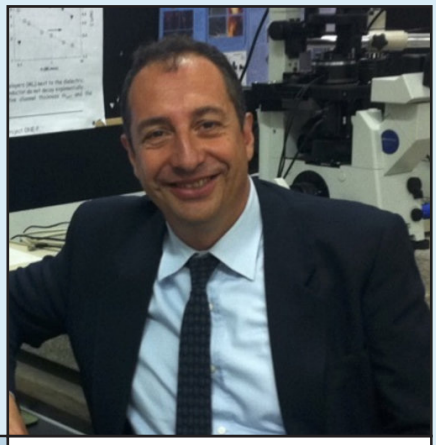
EXTENDED EDITION

Organic bioelectronics: role of ion-π interaction in sensing



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Organic electronics devices are emerging as ultra-sensitive and specific biosensors. Electrolyte gated organic field effect transistors (EGOFET) and organic electrochemical transistors (OECT) are the most used architectures. According to the current understanding two different doping mechanisms intervene in these devices: EGOFET operate in accumulation due to electrostatic doping of ions at the electrical double layer at the interface between the organic semiconductor and the electrolyte; OECT operate in depletion by electrochemical doping upon gate-modulated cation exchange. I will discuss here a unified view of ion-gating mechanism in the two architectures by means of a common mechanism that is based on ion-pi conjugated molecule interaction, a strong non-covalent interaction that is widely studied in protein chemistry and ion batteries, but still largely ignored in organic bioelectronics. The shift of HOMO-LUMO levels in the pi-materials indicate that that the ions can modulate the hopping rate of the charge carriers, and specifically for p-type materials, cations will slow down producing a lower conductivity, while anions will accelerate it, thus increasing the current. This scenario also hints to the fact that the "bulk" of an organic semiconductor thin film is involved in the modulation of the charge transport in EGOFET, similarly to the mechanism invoked in OECT.

These concepts have inspired us to design a new sensor for dopamine (DA), which can be ultra-sensitive and specific at the same time. The selectivity of the sensor was also tested in operational conditions nearer to the in vivo ones in co-presence of physiological concentration of ascorbic acid and uric acid: DA levels in the brain of healthy people are in the nanomolar range of concentration and decrease to picomolar range in patients with Parkinson's disease (PD). Once properly engineered, the proposed sensor could be coupled with actuating devices, leading to the implementation of implantable architectures for the Central Nervous System, that may perform loco-regional delivery of L-Dopa in response to [DA] lowering in animal models, and later in patients, affected by Parkinson's disease.

Prof. Fabio Biscarini is Full Professor of Chemistry at University of Modena and Reggio Emilia (UNIMORE) and Research Associate at the Istituto Italiano di Tecnologia-Center for Translational Neurosciences in Ferrara. He was CNR Researcher (1996-2001), Senior Scientist (2002-2010), and Research Director (2010-2013). and professor of nanotechnology at Alma Mater, Università di Bologna (2004-2013).

His research span across diverse aspects of physical chemistry and nanotechnology of molecular materials and soft matter: from theories of liquid crystals and STM, to experimental activity in fundamentals of thin film growth, self-organization, organic electronics devices, unconventional nanofabrication, advanced characterization techniques in situ- and real time. Current interests are organic bioelectronics in vitro and in vivo, implantable devices, nanomedicine and neurotechnologies.

He authored more than 230 publications to date. He has been coordinator and principal investigator in 30 EU, National, and Regional projects. He was in the Editorial Board of Chemical Society Reviews (Royal Society of Chemistry, UK). He is co-inventor of 19 patents.

He has been awarded the 2012 Premio Sapio Industria, the 2007 EU-Descartes Prize, and has been Fellow of the Royal Society of Chemistry since 2004.

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ISOF 12 – Meeting Room (1st floor)

CNR Research Area

Via Gobetti 101, Bologna

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