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Birck Nanotechnology Center

Professor Antoine Kahn, BNC Seminar

Title: Molecular Doping for Organic Semiconductors Interface Engineering: Principles and Reality

Friday, February 16th, 2018

11:00am – 12:00pm, BRK 1001

Bio: Antoine Kahn, native of France, joined the Princeton faculty in 1979. He is currently the Stephen C. Macaleer ’63 Professor in Engineering and Applied Science, Professor in Electrical Engineering, and the vice-dean of the School of Engineering and Applied Science. He has done extensive work on atomic and electronic structures of surfaces and interfaces of semiconductors. Over the past fifteen years, he focused on the structural, electronic and chemical properties of surfaces and interfaces of intrinsic and doped organic molecular and polymer films. Recent work includes (i) the physics and applications of n- and p-type molecular dopants in organic thin films, (ii) the physics of organic/inorganic and organic/organic heterojunctions, (iii) the use of transition metal oxides in organic photovoltaics, and (iv) the electronic structure of hybrid organic inorganic perovskite systems. Kahn has co-authored over 400 refereed regular and review articles. He was the recipient of a Presidential Young Investigator Award (1984-85), of the Joseph Meyerhoff Visiting Professorship (2002) and of the Weston Visiting Professorship (2009-12, 2015-18), Weizmann Institute of Science, Israel. He was elected Fellow of the American Vacuum Society (AVS) (1999) and American Physical Society (APS) (2002) and Fellow of the School of Engineering of the University of Tokyo, Japan (2015). He was listed among the “World’s Most Influential Scientific Minds”, Thomson Reuters 2014.

Abstract: Molecular doping is an important tool to control the electronic and electrical properties of organic semiconductors, lower contact resistance, enhance bulk conductivity and carrier mobility, and create higher performance devices. This talk reviews processes and options for interface doping in molecular and polymer semiconductors, and the roles that electron spectroscopy and carrier transport measurements have played in defining key issues. Various n- and p-type molecular dopants, their doping strength and the challenges they pose are reviewed first. Specific examples will be reviewed. First is the surface/interface doping of polymer-based devices via soft-contact lamination of highly doped interlayers [1,2]. We look at the electrical characteristics of the laminated polymer/polymer interface (with P3HT, PBDTTT-c or poly-TPD), at the problem of dopant diffusion across boundaries, and at the performance of polymer-based solar cells built with laminated hole-extraction layers [3]. We then turn to the issue of improving contacts to very low electron affinity (EA) electron transport layers (ETL), an issue critical to green and blue OLEDs. We look at the air-stable dimer of (pentamethylcyclopentadienyl)(1,3,5-trimethylbenzene)ruthenium ($[RuCp^*Mes]_2$) [4], and use it to n-dope phenyldi(pyren-2-yl)phosphine oxide ($POPy_2$) (EA = 2.1 eV). We demonstrate that photo-activation of the cleavable dimeric dopant results in kinetically stable and efficient n-doping of the host semiconductor, whose reduction potential is beyond the thermodynamic reach of the dimer’s effective reducing strength [5]. We demonstrate the use of this doped ETL to fabricate high-efficiency organic light-emitting diodes. If time permit, surface n-doping of graphene to decrease its work function, shift its Fermi level and improve electron injection in organic ETLs will be described.

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