Faculty Profile

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Oliver Monti

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Honors

- Swiss National Science Foundation Postdoctoral Fellow, 2001-2003
- Greendale Senior Scholar, Merton College, Oxford, 1998-2001
- 3M Non-Tenured Faculty Awardee, 2005-2007

Education and Appointments

- Dipl. Chem. ETH 1997, ETH
- D. Phil. Oxon 2001, Oxford
- Postdoctoral Fellow 2001-2004, JILA (National Institute of Standards and Technology and University of Colorado, Boulder)

Research Interests

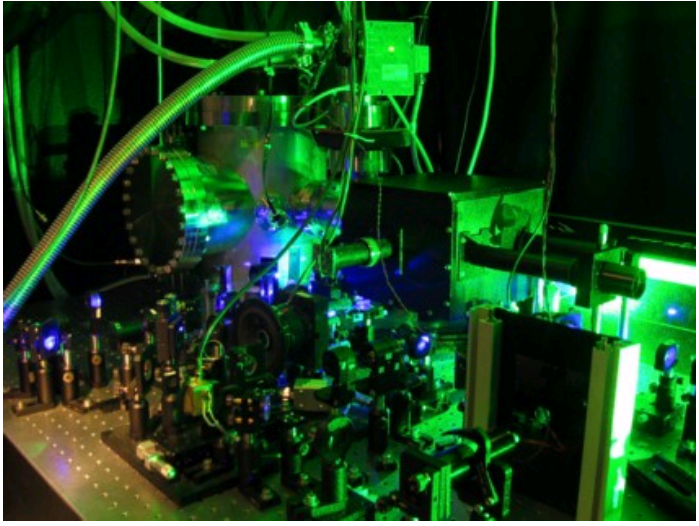
- Physical
- Chemical Physics
- Chemical Reaction Dynamics/Kinetics/Interactions
- Energy Science
- Instrument Development
- Spectroscopy/molecular Structure
- Surfaces and Solid State

Research Summary

Interfacial Structure and Dynamics in Organic Photovoltaic Cells, Organic Thermoelectrics and Organic Spintronics

Organic Electronics, Photoelectron Spectroscopy, Organic Semiconductors, Scanning Probe Microscopy, Ultrafast Spectroscopy, Interfacial Processes, Surface Science

Research in my group is focused on obtaining a detailed understanding of interfacial processes in organic electronic devices such as organic photovoltaic cells, organic thermoelectrics or organic spin valves. Their function is largely controlled by interfacial processes such as exciton dissociation, polaron formation, geminate recombination and heat and carrier transport. Interfaces are intrinsically complex environments, with typically high defect densities and complex structure. Heterogeneity makes it difficult to extract the underlying physics of charge generation and transport in real operating devices. As a consequence, the development of solar cells with significantly higher power conversion efficiencies or more efficient spin valves and thermoelectrics presents a major challenge.



Research in LabMonti seeks to elucidate the chemistry and physics of carriers in organic semiconductors at interfaces *on the short length- and time-scales* present in organic photovoltaic, spin and thermoelectric devices. We develop and use novel forms of optical microscopy in combination with ultrafast photoelectron spectroscopy, scanned probe microscopy and state-of-the-art experiments at synchrotrons to study the electronic structure and dynamics of organic semiconductors under highly controlled conditions.

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Using this experimental approach, we are pursuing research in several complementary directions:

1. Interface formation and charge transport at organic/metal boundaries for organic solar cells, organic light emitting diodes and organic thin film transistors. We use two-photon photoemission spectroscopy and a gamut of photoelectron spectroscopies in conjunction with low-temperature scanning tunneling microscopy to study charge generation and transport at highly controlled interfaces. This approach lets us investigate both occupied (HOMO) and unoccupied (LUMO, higher lying excited states and sometimes transport levels) states at organic semiconductor interfaces, giving insight e.g. to the role of the interface on molecular energy levels and intermolecular interactions. Recent work has focused on the role of short- and long-range electrostatic fields at the interface, showing dramatic effects on interfacial electronic structure.

2. We study the complex interactions at controlled organic/inorganic semiconductor interfaces in order to understand the role of bandgap, defects and dopants on charge injection events in organic solar cells and models of dye-sensitzied solar cells. We use a variety of time-resolved and steady-state photoemission spectroscopies as well as synchrotron-based excited-state and time-resolved spectroscopies in order to unravel charge-transfer and chemical bond formation at these interfaces and its effect on charge-transfer events. Recent work has focused on the role of the band structure of layered semiconductors and transparent oxides on the interfacial electronic structure.

3. When organic semiconductors are in contact with a ferromagnetic electrode such as Co or certain oxides, charge-transfer can be spin-selective. This effect can be used for organic spin-valves, the basis of magnetic memory devices in computers. The process of spin-selection is dominated by the *spinterface*, the interface between electrode and organic semiconductor. We use time-, spin- and momentum-resolved photoelectron spectroscopy to investigate this process and develop an understanding of the fundamental processes at work. Recent work has looked at dynamical reasons for spin-selective charge injection into the organic semiconductor.

4. In order to obtain a detailed picture of the exciton dissociation process, we reduce the complex bulk heterojunction typically used in organic solar cells to a model system, where charge transfer occurs from a *single molecule* to a single crystalline wide bandgap semiconductor under highly defined conditions. Ensemble measurements often obscure some of the most intriguing aspects of such small-scale systems. This requires us to look at individual molecules in order to capture the complete picture and allows us to investigate effects of surface state densities, defect densities, distance etc. on exciton dissociation efficiencies. These experimental results are also accessible to high level ab inito calculations.

Visit also the UA Chemical Physics Program!

Selected Publications

- S. Steil, N. Grossmann, M. Laux, A. Ruffing, M. Wiesenmayer, O.L.A. Monti, M. Cinchetti, M. Aeschlimann, "The nature of spin-filtering at hybrid ferromagnetic metal-organic interfaces", *Nature Physics*, in press (2013)
- A. Terentjevs, M.P. Steele, M.L. Blumenfeld, N. Ilyas, L.L. Kelly, E. Fabiano, O.L.A. Monti and F. Della Sala, "Interfacial Electronic Structure of the Dipolar Vanadyl Naphthalocyanine on Au (111): Push back vs dipolar effects", *J. Phys. Chem. C*, 115 (2011), 21128-21138
- B.-Y. Kim, I.-B. Shim, O.L.A. Monti, and J. Pyun, "Magnetic Self-Assembly of Gold Nanoparticle Chains Using Dipolar Core-Shell Colloids", *Chem. Comm.*, 47 (2011), 890-892
- O.L.A. Monti and M.P. Steele, "Influence of Electrostatic Fields on Molecular Electronic Structure: Insights for Interfacial Charge Transfer", *Phys. Chem. Chem. Phys.*, 12 (2010), 12390, Invited Perspective
- M.P. Steele, M.L. Blumenfeld and O.L.A. Monti, "Image States at the Interface with a Dipolar Organic Semiconductor", *J. Chem. Phys.*, 133 (2010), 124701
- M.P. Steele, M.L. Blumenfeld and O.L.A. Monti, "Experimental Determination of Excited State Polarizability and Dipole Moment in a Thin Organic Semiconductor Film", *J. Phys. Chem. Lett.*, 1 (2010), 2011
- M.L. Blumenfeld, M.P. Steele, O.L.A. Monti, "Interfacial Electronic Structure of Vanadylnaphthalocyanine on HOPG", *Surf. Sci.*, 604 (2010), 1649-1657
- B.-Y. Kim, I.-B. Shim, Z. Ozkan, S.S. Saavadra, O.L.A. Monti, N.R. Armstrong, R. Sahoo, D.N. Srivastava, J. Pyun, "Synthesis and Colloidal Polymerization of Ferromagnetic Au-Co Nanoparticles into Au-Co3O4 Nanowires", *J. Amer. Chem. Soc.*, 132 (2010), 3234
- M.L. Blumenfeld, M.P. Steele, O. L. A. Monti, "Near- and Far-Field Effects on Molecular Energy Level Alignment at an Organic/Electrode Interface", *J. Phys. Chem. Let.*, 1 (2010), 145
- L.K. Schirra, B. S. Tackett, M.L. Blumenfeld, O. L. A. Monti, "Single Molecule Power-Law Behavior on a Crystalline Surface", *J. Chem. Phys.*, 131 (2009), 124702
- M.L. Blumenfeld, B. S. Tackett, L.K. Schirra, J.M. Tyler, O. L. A. Monti, "Confocal single molecule fluorescence spectroscopy in ultrahigh vacuum", *Rev. Sci. Inst.*, 80 (2009), 103101
- L.K. Schirra, M.L. Blumenfeld, B.S. Tackett, J.M. Tyler, O.L.A. Monti, "Toward single molecule interfacial charge transfer dynamics in a dye-sensitized solar cell model", *Proc. SPIE* 7034 (2008), 7034 08

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