Christopher Chidsey

Associate Professor of Chemistry, Emeritus

CONTACT INFORMATION

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Bio

BIO

Professor Chidsey's research interests lie in electrochemistry and electrocatalysis, and in building the chemical base for molecular electronics. He has investigated the role of chemical bonding in promoting long-distance electron tunneling across interfaces and contributed to the development of silicon and germanium surface chemistry, including the self-assembly of complex molecular monolayers on silicon. Today his lab develops molecular systems, analytical tools and theoretical approaches to understand electron transfer between electrodes and among redox species, with applications in sustainable battery technology, fuel chemistry, and biochemical analysis.

Born in 1957, Christopher Chidsey studied chemistry at Dartmouth College (A.B. 1978) and physical chemistry at Stanford University (Ph.D. 1983). After postdoctoral work in electrochemistry with Royce Murray at the University of North Carolina, he joined the technical staff at AT&T Bell Laboratories, where he probed long-distance electron transfer across interfaces and contributed to developments in scanning tunneling microscopy, nonlinear optical materials and optical materials processing. He joined the Stanford Department of Chemistry as Associate Professor in 1992, and in 2009 was also appointed Senior Fellow at the Precourt Institute for Energy. He has received the Dreyfus Teacher-Scholar Award and Bing and Hertz Foundation fellowships, and was elected a fellow of the American Association for the Advancement of Science.

The Chidsey Lab at Stanford uses surface chemistry and electrochemistry to control and investigate a number of important interfacial phenomena.

Water Oxidation

The group has shown that a 2 nm film of TiO_2, created by atomic layer deposition, protects otherwise unstable semiconductor surfaces to achieve efficient and stable photoelectrolysis of water to produce hydrogen and oxygen fuels. Current work involves tailoring alloyed RuO_2/TiO_2 catalyst layers to optimize the turnover frequency for oxygen evolution, with the aim of achieving comparable electrocatalytic activity at a fraction of prior noble metal usage.

Electrocatalysis for Fuel Cells and CO2 Reduction

A major effort involves covalent attachment of electrocatalysts to carbon electrodes and other oxidation-resistant conductive substrates for use in ambient-temperature fuel cells and related energy- and chemical-conversion systems. A new covalent chemistry on graphitic carbon surfaces, based on the ‘click’ reaction of azides and alkynes, has been developed. Another effort involves the formation of electroactive self-assembled thiol monolayers on gold surfaces – an area Professor Chidsey pioneered beginning 15 years ago.

Another project employs transfer hydrogenation catalyts as alcohol oxidation electocatalysts for fuel cells. Lab members study the thermodynamics and kinetics of metal hydride formation from a metal precatalyst and an alcohol fuel, and examine the electro-oxidation of the formed metal hydrides. Running this cycle in the microscopic reverse direction leads to a strategy for CO2 reduction. The aim is to extend this knowledge from working examples to catalyst design for such transformations.

Battery Technology

Many of the electrolyte components used in lithium-ion batteries are not electrochemically stable at the low potentials reached by the anode when the battery charges. However, with the right electrolyte mixture, the decomposition products on the first charge create a solid electrolyte interphase that acts as a lithium-ion conductive, but otherwise passivating layer, slowing electrolyte degradation. Chidsey group members study the formation and useful contributions of this layer.

ACADEMIC APPOINTMENTS

- Emeritus Faculty, Acad Council, Chemistry
- Senior Fellow, Precourt Institute for Energy

ADMINISTRATIVE APPOINTMENTS

- Associate Professor by Courtesy, Department of Chemical Engineering Stanford University, (2008-2011)
- Associate Professor, Department of Photon Science SLAC, Stanford University, (1997-2010)
- Member of Technical Staff, AT&T Bell Laboratories, (1984-1992)

HONORS AND AWARDS

- Fellow, National Science Foundation (1978-1981)
- Fellow, Fanny and John Hertz Foundation (1982-1983)
- Teacher-Scholar, Camille and Henry Dreyfus (1993)
- Bing Fellow, Stanford University (1995)
- Fellow, AAAS (2007)

PROFESSIONAL EDUCATION

- Postdoctoral Fellow, University of North Carolina , Electrochemistsry (1983)
- Ph.D., Stanford University , Physical Chemistry (1983)
- A.B., Dartmouth College , Chemistry (1978)

LINKS

- The Chidsey Lab: http://chidseylab.stanford.edu
- Chemistry Site: http://chemistry.stanford.edu/faculty/christopher-chidsey

- Precourt Institute for Energy: https://energy.stanford.edu

Research & Scholarship

CURRENT RESEARCH AND SCHOLARLY INTERESTS

The Chidsey group research interest is to build the chemical base for molecular electronics. To accomplish this, we synthesize the molecular and nanoscopic systems, build the analytical tools and develop the theoretical understanding with which to study electron transfer between electrodes and among redox species through insulating molecular bridges. Members of the group have synthesized several series of saturated and conjugated oligomers with which we have studied the fundamental aspects of electron tunneling through well-defined molecular bridges. The oligophenylenevinylene bridge of these molecules promotes rapid tunneling over remarkably long distances compared with other unsaturated and saturated bridges we have studied. For instance, starting in the activated complex, the tunneling rate between a gold electrode and an appended ferrocene through 3.5nm of an oligophenylenevinylene (OPV) bridge is 8 x 109 s-1 whereas the tunneling rate through an alkane bridge of the same length is expected to be slower than 1s-1.

To date our electron-tunneling studies have largely focused on what we casually denote as a "one-electrode" measurement with the molecular bridge connecting one electrode to a redox species which acts as a molecular capacitor to an ionically conducting solution. The other electrodes necessary to measure the tunneling conduction are remotely located in an electrochemical cell. We are currently embarked on a broad based effort to make conduction measurements with two electrodes, one on each end of a single molecule. We are also developing strategies to include one or more additional electrodes so that molecular circuits with electrical power gain can be assembled. This effort is leading us to develop nanostructured wiring schemes and self-assembly methods for the construction of whole circuits of wired molecules. We will be examining nanowires formed from doped silicon and other substances. This emerging effort in nanowiring will be greatly aided by the previous work in the Chidsey lab on the surface chemistry of silicon, particularly the self-assembly of complex molecular monolayers on silicon surfaces.

Publications

PUBLICATIONS

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- **Mapping free energy regimes in electrocatalytic reductions to screen transition metal-based catalysts.** *Chemical science*
  Ramakrishnan, S., Moretti, R. A., Chidsey, C. E.
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- **Mapping free energy regimes in electrocatalytic reductions to screen transition metal-based catalysts** *CHEMICAL SCIENCE*
  Ramakrishnan, S., Moretti, R. A., Chidsey, C. E. D.
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- **Atomic Layer Deposited TiO2-IrOx Alloys Enable Corrosion Resistant Water Oxidation on Silicon at High Photovoltage** *CHEMISTRY OF MATERIALS*
  Hendricks, O. L., Tang-Kong, R., Babadi, A. S., McIntyre, P. C., Chidsey, C. E. D.
  2019; 31 (1): 90–100
- **Atomic Layer Deposited TiO2-IrOx Alloy as a Hole Transport Material for Perovskite Solar Cells** *ADVANCED MATERIALS INTERFACES*
  Tan, W., Hendricks, O. L., Meng, A. C., Braun, M. R., McGehee, M. D., Chidsey, C. E. D., McIntyre, P. C.
  2018; 5 (16)
- **Electrocatalytic alcohol oxidation with molecular catalysts**
  Waymouth, R., Waldie, K., McLoughlin, E., Chidsey, C.

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- **Initiation of the Electrochemical Reduction of CO2 by a Singly Reduced Ruthenium(II) Bipyridine Complex.** *Inorganic chemistry*
  Ramakrishnan, S., Chidsey, C. E.
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- **Multielectron Transfer at Cobalt: Influence of the Phenylazopyridine Ligand** *JOURNAL OF THE AMERICAN CHEMICAL SOCIETY*
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- **Electrocatalytic Alcohol Oxidation with Ruthenium Transfer Hydrogenation Catalysts** *JOURNAL OF THE AMERICAN CHEMICAL SOCIETY*
  Waldie, K. M., Flajslik, K. R., McLoughlin, E., Chidsey, C. E., Waymouth, R. M.
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  Ramakrishnan, S., Chidsey, C. E.
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- **Isolating the Photovoltaic Junction: Atomic Layer Deposited TiO2-RuO2 Alloy Schottky Contacts for Silicon Photoanodes** *ACS APPLIED MATERIALS & INTERFACES*
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- **Titanium Oxide Crystallization and Interface Defect Passivation for High Performance Insulator-Protected Schottky Junction MIS Photoanodes** *ACS APPLIED MATERIALS & INTERFACES*
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- **Engineering Interfacial Silicon Dioxide for Improved Metal-Insulator-Semiconductor Silicon Photoanode Water Splitting Performance** *ACS APPLIED MATERIALS & INTERFACES*
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- **Experimental and Theoretical Study of CO2 Insertion into Ruthenium Hydride Complexes.** *Inorganic chemistry*
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- **Conductance and capacitance of bilayer protective oxides for silicon water splitting anodes** *ENERGY & ENVIRONMENTAL SCIENCE*
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