Stanford

# Christopher Chidsey

Associate Professor of Chemistry

**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 $CO_2$ 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

- Associate Professor, 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.

# Teaching

## COURSES

**2019-20**

- Chemophysical analyses of costs to lower atmospheric concentrations of greenhouse gases: CHEM 279 (Spr)
- Electrochemical Measurements Lab: CHEM 174, CHEM 274 (Aut)

**2018-19**

- Electrochemical Measurements Lab: CHEM 174, CHEM 274 (Aut)

**2017-18**

- Electrochemical Measurements Lab: CHEM 174, CHEM 274 (Aut)

**2016-17**

- Electrochemical Measurements Lab: CHEM 174, CHEM 274 (Aut)

## STANFORD ADVISEES

**Doctoral Dissertation Reader (AC)**

Joe Gauthier, Alan Landers, Kurt Lindquist, Rain Mariano, Stefan Seritan, Jared Weaver

**Doctoral Dissertation Advisor (AC)**

Tyler Hernandez

**Doctoral Dissertation Co-Advisor (AC)**

Natalie Geise, Sebastian Schneider

# Publications

## PUBLICATIONS

- **Bromomethylation of high-surface area carbons as a versatile synthon: adjusting the electrode-electrolyte interface in lithium-sulfur batteries** *JOURNAL OF MATERIALS CHEMISTRY A*

  Fretz, S. J., Lyons, C. T., Levin, E., Chidsey, C. D., Palmgvist, A. C., Stack, T. P.

  2019; 7 (34): 20013–25

- **Mapping free energy regimes in electrocatalytic reductions to screen transition metal-based catalysts** *CHEMICAL SCIENCE*

  Ramakrishnan, S., Moretti, R. A., Chidsey, C. D.

  2019; 10 (32): 7649–58

- **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. D.

  2019; 31 (1): 90–100

- **Mapping free energy regimes in electrocatalytic reductions to screen transition metal-based catalysts.** *Chemical science*

  Ramakrishnan, S., Moretti, R. A., Chidsey, C. E.

  2019; 10 (32): 7649–58

- **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. D., McIntyre, P. C.

  2018; 5 (16)

- **Electrocatalytic alcohol oxidation with molecular catalysts**

  Waymouth, R., Waldie, K., McLoughlin, E., Chidsey, C.

  AMER CHEMICAL SOC.2018

- **Multielectron Transfer at Cobalt: Influence of the Phenylazopyridine Ligand** *JOURNAL OF THE AMERICAN CHEMICAL SOCIETY*

  Waldie, K. M., Ramakrishnan, S., Kim, S., Maclaren, J. K., Chidsey, C. E., Waymouth, R. M.

  2017; 139 (12): 4540-4550

- **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.

  2017; 139 (2): 738-748

- **Initiation of the Electrochemical Reduction of CO2 by a Singly Reduced Ruthenium(II) Bipyridine Complex.** *Inorganic chemistry*

  Ramakrishnan, S., Chidsey, C. E.

  2017; 56 (14): 8326–33

- **Initiation of the Electrochemical Reduction of CO2 by a Singly Reduced Ruthenium(II) Bipyridine Complex** *Inorganic Chemistry*

  Ramakrishnan, S., Chidsey, C. E.

  2017: 8326–33

- **Isolating the Photovoltaic Junction: Atomic Layer Deposited TiO2-RuO2 Alloy Schottky Contacts for Silicon Photoanodes** *ACS APPLIED MATERIALS & INTERFACES*

  Hendricks, O. L., Scheuermann, A. G., Schmidt, M., Hurley, P. K., McIntyre, P. C., Chidsey, C. E.

  2016; 8 (36): 23763-23773

- **Titanium Oxide Crystallization and Interface Defect Passivation for High Performance Insulator-Protected Schottky Junction MIS Photoanodes** *ACS APPLIED MATERIALS & INTERFACES*

  Scheuermann, A. G., Lawrence, J. P., Meng, A. C., Tang, K., Hendricks, O. L., Chidsey, C. E., McIntyre, P. C.

  2016; 8 (23): 14596-14603

- **Engineering Interfacial Silicon Dioxide for Improved Metal-Insulator-Semiconductor Silicon Photoanode Water Splitting Performance** *ACS APPLIED MATERIALS & INTERFACES*

  Satterthwaite, P. F., Scheuermann, A. G., Hurley, P. K., Chidsey, C. E., McIntyre, P. C.

  2016; 8 (20): 13140-13149

- **Experimental and Theoretical Study of CO2 Insertion into Ruthenium Hydride Complexes.** *Inorganic chemistry*
  Ramakrishnan, S., Waldie, K. M., Warnke, I., De Crisci, A. G., Batista, V. S., Waymouth, R. M., Chidsey, C. E.
  2016; 55 (4): 1623-1632

- **Conductance and capacitance of bilayer protective oxides for silicon water splitting anodes** *ENERGY & ENVIRONMENTAL SCIENCE*
  Scheuermann, A. G., Kemp, K. W., Tang, K., Lu, D. Q., Satterthwaite, P. F., Ito, T., Chidsey, C. E., McIntyre, P. C.
  2016; 9 (2): 504-516

- **Rapid oxidative hydrogen evolution from a family of square-planar nickel hydride complexes.** *Chemical science*
  Ramakrishnan, S., Chakraborty, S., Brennessel, W. W., Chidsey, C. E., Jones, W. D.
  2016; 7 (1): 117–27

- **Design principles for maximizing photovoltage in metal-oxide-protected water-splitting photoanodes** *NATURE MATERIALS*
  Scheuermann, A. G., Lawrence, J. P., Kemp, K. W., Ito, T., Walsh, A., Chidsey, C. E., Hurley, P. K., McIntyre, P. C.
  2016; 15 (1): 99-?

- **Understanding Photovoltage in Insulator-Protected Water Oxidation Half-Cells** *JOURNAL OF THE ELECTROCHEMICAL SOCIETY*
  Scheuermann, A. G., Chidsey, C. E., McIntyre, P. C.
  2016; 163 (3): H192-H200

- **Rapid oxidative hydrogen evolution from a family of square-planar nickel hydride complexes** *CHEMICAL SCIENCE*
  Ramakrishnan, S., Chakraborty, S., Brennessel, W. W., Chidsey, C. E., Jones, W. D.
  2016; 7 (1): 117-127

- **The Effect of SPA-SiO2 Tunnel Oxide Thickness for Metal-Insulator-Silicon Photoelectrochemical Cells**
  Scheuermann, A. G., Lu, D. Q., Ito, T., Chidsey, C. D., McIntyre, P. C., Roozeboom, F., DeGendt, S., Delabie, A., Elam, J. W., Londergan, A., VanDerStraten, O.
  ELECTROCHEMICAL SOC INC.2014: 265–76

- **Electrooxidation of alcohols catalyzed by amino alcohol ligated ruthenium complexes.** *Journal of the American Chemical Society*
  Brownell, K. R., McCrory, C. C., Chidsey, C. E., Perry, R. H., Zare, R. N., Waymouth, R. M.
  2013; 135 (38): 14299-14305

- **Effects of catalyst material and atomic layer deposited TiO2 oxide thickness on the water oxidation performance of metal-insulator-silicon anodes** *ENERGY & ENVIRONMENTAL SCIENCE*
  Scheuermann, A. G., Prange, J. D., Gunji, M., Chidsey, C. E., McIntyre, P. C.
  2013; 6 (8): 2487-2496

- **Squish and CuAAC: Additive-Free Covalent Mono layers of Discrete Molecules in Seconds** *LANGMUIR*
  Pellow, M. A., Stack, T. D., Chidsey, C. E.
  2013; 29 (18): 5383-5387

- **Gas-Phase Azide Functionalization of Carbon** *JOURNAL OF THE AMERICAN CHEMICAL SOCIETY*
  Stenehjem, E. D., Ziatdinov, V. R., Stack, T. D., Chidsey, C. E.
  2013; 135 (3): 1110-1116

- **ALD-TiO2 Preparation and Characterization for Metal-Insulator-Silicon Photoelectrochemical Applications** *9th International Symposium on Atomic Layer Deposition Applications held during the 224th Meeting of the Electrochemical-Society (ECS)*
  Scheuermann, A. G., Lawrence, J. P., Gunji, M., Chidsey, C. E., McIntyre, P. C.
  ELECTROCHEMICAL SOC INC.2013: 75–86

- **Molecular Junctions of Self-Assembled Monolayers with Conducting Polymer Contacts** *ACS NANO*
  Neuhausen, A. B., Hosseini, A., Sulpizio, J. A., Chidsey, C. E., Goldhaber-Gordon, D.
  2012; 6 (11): 9920-9931

- **Deposition of Dense Siloxane Monolayers from Water and Trimethoxyorganosilane Vapor** *LANGMUIR*
  Lowe, R. D., Pellow, M. A., Stack, T. D., Chidsey, C. E.
  2011; 27 (16): 9928-9935

- **Atomic layer-deposited tunnel oxide stabilizes silicon photoanodes for water oxidation** *NATURE MATERIALS*
  Chen, Y. W., Prange, J. D., Duehnen, S., Park, Y., Gunji, M., Chidsey, C. E., McIntyre, P. C.

2011; 10 (7): 539-544

- **Electrocatalytic O-2 Reduction by Covalently Immobilized Mononuclear Copper(I) Complexes: Evidence for a Binuclear Cu2O2 Intermediate** *JOURNAL OF THE AMERICAN CHEMICAL SOCIETY*
  McCrory, C. C., Devadoss, A., Ottenwaelder, X., Lowe, R. D., Stack, T. D., Chidsey, C. E.
  2011; 133 (11): 3696-3699
- **Redox Catalysis for Dehydrogenation of Liquid Hydrogen Carrier Fuels for Energy Storage and Conversion**
  Driscoll, P. F., Deunf, E., Rubin, L., Luca, O., Crabtree, R., Chidsey, C., Arnold, J., Kerr, J. B., Brisard, G., Wieckowski, A.
  ELECTROCHEMICAL SOC INC.2011: 3–17
- **Group IV semiconductor nanowire arrays: epitaxy in different contexts** *SEMICONDUCTOR SCIENCE AND TECHNOLOGY*
  McIntyre, P. C., Adhikari, H., Goldthorpe, I. A., Hu, S., Leu, P. W., Marshall, A. F., Chidsey, C. E.
  2010; 25 (2)
- **Gold Removal from Germanium Nanowires** *LANGMUIR*
  Ratchford, J. B., Goldthorpe, I. A., Sun, Y., McIntyre, P. C., Pianetta, P. A., Chidsey, C. E.
  2009; 25 (16): 9473-9479
- **Selective Anodic Desorption for Assembly of Different Thiol Monolayers on the Individual Electrodes of an Array** *LANGMUIR*
  Collman, J. P., Hosseini, A., Eberspacher, T. A., Chidsey, C. E.
  2009; 25 (11): 6517-6521
- **Growth of germanium crystals from electrodeposited gold in local crucibles** *APPLIED PHYSICS LETTERS*
  Ratchford, J. B., Goldthorpe, I. A., McIntyre, P. C., Chidsey, C. E.
  2009; 94 (4)
- **Oxide-encapsulated vertical germanium nanowire structures and their DC transport properties** *NANOTECHNOLOGY*
  Leu, P. W., Adhikari, H., Koto, M., Kim, K., de Rouffignac, P., Marshall, A. F., Gordon, R. G., Chidsey, C. E., McIntyre, P. C.
  2008; 19 (48)
- **Kinetic and mechanistic studies of the electrocatalytic reduction of O-2 to H2O with mononuclear Cu complexes of substituted 1,10-phenanthrolines** *JOURNAL OF PHYSICAL CHEMISTRY A*
  McCrory, C. C., Ottenwaelder, X., Stack, T. D., Chidsey, C. E.
  2007; 111 (49): 12641-12650
- **Metastability of Au-Ge liquid nanocatalysts: Ge vapor-liquid-solid nanowire growth far below the bulk eutectic temperature** *ACS NANO*
  Adhikari, H., Marshall, A. F., Goldthorpe, I. A., Chidsey, C. E., McIntyre, P. C.
  2007; 1 (5): 415-422
- **Conditions for subeutectic growth of Ge nanowires by the vapor-liquid-solid mechanism** *JOURNAL OF APPLIED PHYSICS*
  Adhikari, H., McIntyre, P. C., Marshall, A. F., Chidsey, C. E.
  2007; 102 (9)
- **Vertically oriented germanium nanowires grown from gold colloids on silicon substrates and subsequent gold removal** *NANO LETTERS*
  Woodruff, J. H., Ratchford, J. B., Goldthorpe, I. A., McIntyre, P. C., Chidsey, C. E.
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- **Azide-modified graphitic surfaces for covalent attachment of alkyne-terminated molecules by "click" chemistry** *JOURNAL OF THE AMERICAN CHEMICAL SOCIETY*
  Devadoss, A., Chidsey, C. E.
  2007; 129 (17): 5370-?
- **A cytochrome c oxidase model catalyzes oxygen to water reduction under rate-limiting electron flux** *SCIENCE*
  Collman, J. P., Devaraj, N. K., Decreau, R. A., Yang, Y., Yan, Y., Ebina, W., Eberspacher, T. A., Chidsey, C. E.
  2007; 315 (5818): 1565-1568
- **An integrated phase change memory cell with Ge nanowire diode for cross-point memory** *Symposium on VLSI Technology 2007*
  Zhang, Y., Kim, S., McVittie, J. P., Jagannathan, H., Ratchford, J. B., Chidsey, C. E., Nishi, Y., Wong, H. P.
  JAPAN SOCIETY APPLIED PHYSICS.2007: 98–99

- **Rate of interfacial electron transfer through the 1,2,3-triazole linkage** *JOURNAL OF PHYSICAL CHEMISTRY B*
  Devaraj, N. K., Decreau, R. A., Ebina, W., Collman, J. P., Chidsey, C. E.
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- **Nature of germanium nanowire heteroepitaxy on silicon substrates** *JOURNAL OF APPLIED PHYSICS*
  Jagannathan, H., Deal, M., Nishi, Y., Woodruff, J., Chidsey, C., McIntyre, P. C.
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- **Mixed azide-terminated monolayers: A platform for modifying electrode surfaces** *LANGMUIR*
  Collman, J. P., Devaraj, N. K., Eberspacher, T. P., Chidsey, C. E.
  2006; 22 (6): 2457-2464

- **Selective functionalization of independently addressed microelectrodes by electrochemical activation and deactivation of a coupling catalyst** *JOURNAL OF THE AMERICAN CHEMICAL SOCIETY*
  Devaraj, N. K., Dinolfo, P. H., Chidsey, C. E., Collman, J. P.
  2006; 128 (6): 1794-1795

- **Germanium nanowire epitaxy: Shape and orientation control** *NANO LETTERS*
  Adhikari, H., Marshall, A. F., Chidsey, C. E., McIntyre, P. C.
  2006; 6 (2): 318-323

- **Photoemission studies of passivation of germanium nanowires** *APPLIED PHYSICS LETTERS*
  Adhikari, H., McIntyre, P. C., Sun, S. Y., Pianetta, P., Chidsey, C. E.
  2005; 87 (26)

- **Chemoselective covalent coupling of oligonucleotide probes to self-assembled monolayers** *JOURNAL OF THE AMERICAN CHEMICAL SOCIETY*
  Devaraj, N. K., Miller, G. P., Ebina, W., Kakaradov, B., Collman, J. P., Kool, E. T., Chidsey, C. E.
  2005; 127 (24): 8600-8601

- **Role of O-3 and OH. radicals in ozonated aqueous solution for the photoresist removal of semiconductor fabrication** *OZONE-SCIENCE & ENGINEERING*
  Lim, S. W., Chidsey, C. E.
  2005; 27 (2): 139-146

- **Interfacial electron-transfer kinetics of ferrocene through oligophenyleneethynylene bridges attached to gold electrodes as constituents of self-assembled monolayers: Observation of a nonmonotonic distance dependence** *JOURNAL OF THE AMERICAN CHEMICAL SOCIETY*
  Smalley, J. F., Sachs, S. B., Chidsey, C. E., Dudek, S. P., Sikes, H. D., Creager, S. E., Yu, C. J., Feldberg, S. W., Newton, M. D.
  2004; 126 (44): 14620-14630

- **"Clicking" functionality onto electrode surfaces** *LANGMUIR*
  Collman, J. P., Devaraj, N. K., Chidsey, C. E.
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- **Charge transfer on the nanoscale: Current status** *JOURNAL OF PHYSICAL CHEMISTRY B*
  Adams, D. M., Brus, L., Chidsey, C. E., Creager, S., Creutz, C., Kagan, C. R., Kamat, P. V., Lieberman, M., Lindsay, S., Marcus, R. A., Metzger, R. M., Michel-Beyerle, M. E., Miller, et al
  2003; 107 (28): 6668-6697

- **Modular assembly and air-stable electrochemistry of ruthenium porphyrin monolayers** *LANGMUIR*
  Eberspacher, T. A., Collman, J. P., Chidsey, C. E., Donohue, D. L., Van Ryswyk, H.
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- **Heterogeneous electron-transfer kinetics for ruthenium and ferrocene redox moieties through alkanethiol monolayers on gold** *JOURNAL OF THE AMERICAN CHEMICAL SOCIETY*
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- **Photoelectron spectroscopy to probe the mechanism of electron transfer through oligo(phenylene vinylene) bridges** *JOURNAL OF PHYSICAL CHEMISTRY B*
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- **Olefin additions on H-Si(111): Evidence for a surface chain reaction initiated at isolated dangling bonds** *LANGMUIR*
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- **Distance dependence of the electron-transfer rate across covalently bonded monolayers on silicon** *JOURNAL OF PHYSICAL CHEMISTRY B*
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  2001; 105 (44): 10900-10904
- **Synthesis of ferrocenethiols containing oligo(phenylenevinylene) bridges and their characterization on gold electrodes** *JOURNAL OF THE AMERICAN CHEMICAL SOCIETY*
  Dudek, S. P., Sikes, H. D., Chidsey, C. E.
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- **Surface characterization and electrochemical properties of alkyl, fluorinated alkyl, and alkoxy monolayers on silicon** *LANGMUIR*
  Barrelet, C. J., Robinson, D. B., Cheng, J., Hunt, T. P., Quate, C. F., Chidsey, C. E.
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  Lim, S. W., Mo, R. T., Pianetta, P. A., Chidsey, C. E.
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- **Control of ozonated water cleaning process for photoresist removal** *5th International Symposium on Ultra Clean Processing of Silicon Surfaces (UCPSS 2000)*
  Lim, S. W., Chidsey, C. E.
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- **Hole limited recombination in polymer light-emitting diodes** *APPLIED PHYSICS LETTERS*
  Scott, J. C., Malliaras, G. G., Chen, W. D., Breach, J. C., Salem, J. R., Brock, P. J., Sachs, S. B., Chidsey, C. E.
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