



## Robert Huggins

Professor of Materials Science and Engineering, Emeritus

### CONTACT INFORMATION

- **Alternate Contact**

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### Bio

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#### BIO

Professor Huggins joined Stanford as Assistant Professor in 1954, was promoted to Associate Professor in 1958, and to Professor in 1962.

His research activities have included studies of imperfections in crystals, solid-state reaction kinetics, ferromagnetism, mechanical behavior of solids, crystal growth, and a wide variety of topics in physical metallurgy, ceramics, solid state chemistry and electrochemistry. Primary attention has recently been focused on the development of understanding of solid state ionic phenomena involving solid electrolytes and mixed ionic-electronic conducting materials containing atomic or ionic species such as lithium, sodium or oxygen with unusually high mobility, as well as their use in novel battery and fuel cell systems, electrochromic optical devices, sensors, and in enhanced heterogeneous catalysis. He was also involved in the development of the understanding of the key role played by the phase composition and oxygen stoichiometry in determining the properties of high temperature oxide superconductors.

Topics of particular recent interest have been related to energy conversion and storage, including hydrogen transport and hydride formation in metals, alloys and intermetallic compounds, and various aspects of materials and phenomena related to advanced lithium batteries.

He has over 400 professional publications, including three books; "Advanced Batteries", published by Springer in 2009, "Energy Storage", published by Springer in 2010, and Energy Storage, Second Edition in 2016.

#### ACADEMIC APPOINTMENTS

- Emeritus Faculty, Acad Council, Materials Science and Engineering
- Affiliate, Precourt Institute for Energy

#### ADMINISTRATIVE APPOINTMENTS

- Director, Center for Materials Research, Stanford, (1961-1977)
- Director for Materials Sciences, Advanced Research Projects Agency (ARPA), (1968-1970)
- Chief Scientist, Center for Solar Energy and Hydrogen Research, Ulm, Germany, (1991-1995)
- Honorary Professor, University of Ulm, Germany, (1994- present)
- Honorary Professor, University of Kiel, Germany, (2000- present)

## HONORS AND AWARDS

- Hardy Gold Medal, AIME (1957)
- Senior Postdoctoral Fellowship, National Science Foundation (1965-1966)
- Senior United States Scientist Award, Alexander von Humboldt Foundation (1977)
- 23rd Annual Vincent Bendix Award, American Society for Engineering Education (1978)
- Research Award, Electrochemical Society's Battery Division (1982)
- Research Award, International Battery Association (2001)

## PROFESSIONAL EDUCATION

- BA, Amherst College , Physics (1950)
- ScD, MIT , Metallurgy (1954)

## Publications

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### PUBLICATIONS

- **Energy Storage, Second Edition**  
Huggins, R. A.  
Springer.2016
- **Full open-framework batteries for stationary energy storage.** *Nature communications*  
Pasta, M., Wessells, C. D., Liu, N., Nelson, J., McDowell, M. T., Huggins, R. A., Toney, M. F., Cui, Y.  
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- **Full open-framework batteries for stationary energy storage.** *Nature communications*  
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- **Highly reversible open framework nanoscale electrodes for divalent ion batteries.** *Nano letters*  
Wang, R. Y., Wessells, C. D., Huggins, R. A., Cui, Y.  
2013; 13 (11): 5748-5752
- **Oxidation processes on conducting carbon additives for lithium-ion batteries** *JOURNAL OF APPLIED ELECTROCHEMISTRY*  
La Mantia, F., Huggins, R. A., Cui, Y.  
2013; 43 (1): 1-7
- **The Ferrocyanide/Stabilized Carbon System, a New Class of High Rate, Long Cycle Life, Aqueous Electrolyte Batteries** *JOURNAL OF THE ELECTROCHEMICAL SOCIETY*  
Huggins, R. A.  
2013; 160 (5): A3020-A3025
- **Do You Really Want an Unsafe Battery?** *JOURNAL OF THE ELECTROCHEMICAL SOCIETY*  
Huggins, R. A.  
2013; 160 (5): A3001-A3005
- **Cotton-templated hierarchical porous structures for high power lithium rechargeable batteries** *JOURNAL OF MATERIALS CHEMISTRY A*  
Choi, D. I., Lee, H., Lee, D. J., Nam, K., Kim, J., Huggins, R. A., Park, J., Choi, J. W.  
2013; 1 (17): 5320-5325
- **A high-rate and long cycle life aqueous electrolyte battery for grid-scale energy storage** *NATURE COMMUNICATIONS*  
Pasta, M., Wessells, C. D., Huggins, R. A., Cui, Y.  
2012; 3
- **Tunable Reaction Potentials in Open Framework Nanoparticle Battery Electrodes for Grid-Scale Energy Storage** *ACS NANO*  
Wessells, C. D., McDowell, M. T., Peddada, S. V., Pasta, M., Huggins, R. A., Cui, Y.

2012; 6 (2): 1688-1694

- **The Effect of Insertion Species on Nanostructured Open Framework Hexacyanoferrate Battery Electrodes** *JOURNAL OF THE ELECTROCHEMICAL SOCIETY*  
Wessells, C. D., Peddada, S. V., McDowell, M. T., Huggins, R. A., Cui, Y.  
2012; 159 (2): A98-A103
- **Nickel Hexacyanoferrate Nanoparticle Electrodes For Aqueous Sodium and Potassium Ion Batteries** *NANO LETTERS*  
Wessells, C. D., Peddada, S. V., Huggins, R. A., Cui, Y.  
2011; 11 (12): 5421-5425
- **Copper hexacyanoferrate battery electrodes with long cycle life and high power** *NATURE COMMUNICATIONS*  
Wessells, C. D., Huggins, R. A., Cui, Y.  
2011; 2
- **Electrochemical characterization of LiCoO<sub>2</sub> as rechargeable electrode in aqueous LiNO<sub>3</sub> electrolyte** *17th International Conference on Solid State Ionics*  
Ruffo, R., La Mantia, F., Wessells, C., Huggins, R. A., Cui, Y.  
ELSEVIER SCIENCE BV.2011: 289-92
- **Recent results on aqueous electrolyte cells** *JOURNAL OF POWER SOURCES*  
Wessells, C., Huggins, R. A., Cui, Y.  
2011; 196 (5): 2884-2888
- **Synthesis of Nanoscale Lithium-Ion Battery Cathode Materials Using a Porous Polymer Precursor Method** *JOURNAL OF THE ELECTROCHEMICAL SOCIETY*  
Deshazer, H. D., La Mantia, F., Wessells, C., Huggins, R. A., Cui, Y.  
2011; 158 (10): A1079-A1082
- **Synthesis and Electrochemical Performance of a Lithium Titanium Phosphate Anode for Aqueous Lithium-Ion Batteries** *JOURNAL OF THE ELECTROCHEMICAL SOCIETY*  
Wessells, C., La Mantia, F., Deshazer, H., Huggins, R. A., Cui, Y.  
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- **Investigations of the Electrochemical Stability of Aqueous Electrolytes for Lithium Battery Applications** *ELECTROCHEMICAL AND SOLID STATE LETTERS*  
Wessells, C., Ruffo, R., Huggins, R. A., Cui, Y.  
2010; 13 (5): A59-A61
- **Impedance Analysis of Silicon Nanowire Lithium Ion Battery Anodes** *JOURNAL OF PHYSICAL CHEMISTRY C*  
Ruffo, R., Hong, S. S., Chan, C. K., Huggins, R. A., Cui, Y.  
2009; 113 (26): 11390-11398
- **Structural and electrochemical study of the reaction of lithium with silicon nanowires** *14th International Meeting on Lithium Batteries*  
Chan, C. K., Ruffo, R., Hong, S. S., Huggins, R. A., Cui, Y.  
ELSEVIER SCIENCE BV.2009: 34-39
- **Electrochemical behavior of LiCoO<sub>2</sub> as aqueous lithium-ion battery electrodes** *ELECTROCHEMISTRY COMMUNICATIONS*  
Ruffo, R., Wessells, C., Huggins, R. A., Cui, Y.  
2009; 11 (2): 247-249
- **Spinel LiMn<sub>2</sub>O<sub>4</sub> Nanorods as Lithium Ion Battery Cathodes** *NANO LETTERS*  
Kim, D. K., Muralidharan, P., Lee, H., Ruffo, R., Yang, Y., Chan, C. K., Peng, H., Huggins, R. A., Cui, Y.  
2008; 8 (11): 3948-3952
- **High-performance lithium battery anodes using silicon nanowires** *NATURE NANOTECHNOLOGY*  
Chan, C. K., Peng, H., Liu, G., Mcilwrath, K., Zhang, X. F., Huggins, R. A., Cui, Y.  
2008; 3 (1): 31-35
- **Nanowire Batteries for Next Generation Electronics** *IEEE International Electron Devices Meeting*  
Chan, C. K., Connor, S. T., Yang, Y., Hsu, C., Huggins, R. A., Cui, Y.  
IEEE.2008: 175-178

- **Reaction of lithium with FeAsS, a quaternary system** *IONICS*  
McLaurin, R. A., Huggins, R. A.  
2007; 13 (3): 107-110
- **Cause of the memory effect in "nickel" electrodes** *Joint Meeting of the International-Battery-Association/Hawaii Battery Conference (IBA-HBC 2006)*  
Huggins, R. A.  
ELSEVIER SCIENCE BV.2007: 640-45
- **Mechanism of the memory effect in "Nickel" electrodes** *15th International Conference on Solid State Ionics*  
Huggins, R. A.  
ELSEVIER SCIENCE BV.2006: 2643-46
- **Use of simple ac technique to determine the ionic and electronic conductivities in pure and Fe-substituted SrSnO<sub>3</sub> perovskites** *JOURNAL OF POWER SOURCES*  
Thangadurai, V., Huggins, R. A., Weppner, W.  
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- **Determination of the electronic and ionic partial conductivities in several mixed conductors using a simple AC method** *4th International Symposium on Ionic and Mixed Conducting Ceramics*  
Thangadurai, V., Huggins, R. A., Weppner, W.  
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- **Investigations of a Number of Alternative Negative Electrode Materials for Use in Lithium Cells** *IONICS*  
Netz, A., Huggins, R. A., Weppner, W.  
2001; 7 (4-6): 433-439
- **Decrepitation Model For Capacity Loss During Cycling of Alloys in Rechargeable Electrochemical Systems** *IONICS*  
Huggins, R. A., Nix, W. D.  
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- **Investigations of Praseodymium Oxide Electrodes in Lithium Concentration Cells** *IONICS*  
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- **ELECTROCHEMICAL STUDIES OF KINETIC-PROPERTIES OF TITANIUM-HYDROGEN AND VANADIUM-HYDROGEN SYSTEMS AT INTERMEDIATE TEMPERATURES USING MOLTEN-SALT TECHNIQUES** *JOURNAL OF THE ELECTROCHEMICAL SOCIETY*  
Liaw, B. Y., DEUBLEIN, G., Huggins, R. A.  
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- **AN ISOPERIBOLIC CALORIMETER TO STUDY ELECTROCHEMICAL INSERTION OF DEUTERIUM INTO PALLADIUM** *FUSION TECHNOLOGY*  
Gur, T. M., Schreiber, M., Lucier, G., FERRANTE, J. A., Chao, J., Huggins, R. A.  
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- **PARTIAL OXIDATION OF METHANE CATALYZED BY YBA<sub>2</sub>CU<sub>3</sub>OX IN A SOLID-STATE ELECTROCHEMICAL REACTOR** *CATALYSIS LETTERS*  
Gur, T. M., Wise, H., Huggins, R. A.  
1994; 23 (3-4): 387-393
- **HIGH-TEMPERATURE OXYGEN-TRANSPORT AND ELECTROCHEMICAL-BEHAVIOR OF YBA<sub>2</sub>CU<sub>3</sub>OX** *JOURNAL OF THE ELECTROCHEMICAL SOCIETY*  
Gur, T. M., Huggins, R. A.  
1993; 140 (7): 1990-2000
- **INVESTIGATION OF SOLID SODIUM REFERENCE ELECTRODES FOR SOLID-STATE ELECTROCHEMICAL GAS SENSORS** *APPLIED PHYSICS A-MATERIALS SCIENCE & PROCESSING*  
SCHETTLER, H., Liu, J., Weppner, W., Huggins, R. A.

1993; 57 (1): 31-35

- **A NEW CLASS OF OXYGEN SELECTIVE CHEMICALLY DRIVEN NONPOROUS CERAMIC MEMBRANES .1. A-SITE DOPED PEROVSKITES** *JOURNAL OF MEMBRANE SCIENCE*  
Gur, T. M., Belzner, A., Huggins, R. A.  
1992; 75 (1-2): 151-162
- **INVESTIGATION OF THERMODYNAMIC PROPERTIES OF THE TI-H SYSTEM USING MOLTEN-SALT ELECTROLYTES CONTAINING HYDRIDE IONS** *JOURNAL OF ALLOYS AND COMPOUNDS*  
Liaw, B. Y., DEUBLEIN, G., Huggins, R. A.  
1992; 189 (2): 175-186
- **OXYGEN CHEMICAL DIFFUSION IN STRONTIUM DOPED LANTHANUM MANGANITES** *SOLID STATE IONICS*  
Belzner, A., Gur, T. M., Huggins, R. A.  
1992; 57 (3-4): 327-337
- **MULTINARY ALLOY ELECTRODES FOR SOLID-STATE BATTERIES .2. A NEW LI-SI-MG ALLOY NEGATIVE ELECTRODE MATERIAL FOR USE IN HIGH-ENERGY DENSITY RECHARGEABLE LITHIUM CELLS** *JOURNAL OF POWER SOURCES*  
Anani, A., Huggins, R. A.  
1992; 38 (3): 363-372
- **MULTINARY ALLOY ELECTRODES FOR SOLID-STATE BATTERIES .1. A PHASE-DIAGRAM APPROACH FOR THE SELECTION AND STORAGE PROPERTIES DETERMINATION OF CANDIDATE ELECTRODE MATERIALS** *JOURNAL OF POWER SOURCES*  
Anani, A., Huggins, R. A.  
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- **PHASE-BEHAVIOR AND CONDUCTIVITY OF LI<sub>2</sub>SiS<sub>3</sub> COMPOSITION** *SOLID STATE IONICS*  
Ahn, B. T., Huggins, R. A.  
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- **ELECTROCATALYTIC CONVERSION OF CARBON-DIOXIDE TO METHANE AND OXYGEN WITH AN OXYGEN ION-CONDUCTING ELECTROLYTE** *JOURNAL OF CATALYSIS*  
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- **THERMODYNAMIC AND STRUCTURAL CONSIDERATIONS OF INSERTION REACTIONS IN LITHIUM VANADIUM BRONZE STRUCTURES** *SOLID STATE IONICS*  
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Schreiber, M., Lucier, G., FERRANTE, J. A., Huggins, R. A.  
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- **MEASUREMENT OF THE CHEMICAL DIFFUSION-COEFFICIENT OF OXYGEN IN MIXED CONDUCTORS BY A SOLID-STATE ELECTROCHEMICAL METHOD** *7TH INTERNATIONAL CONF ON SOLID STATE IONICS*  
Belzner, A., Gur, T. M., Huggins, R. A.  
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- **RECENT RESULTS ON MIXED CONDUCTORS CONTAINING HYDROGEN OR DEUTERIUM** *7TH INTERNATIONAL CONF ON SOLID STATE IONICS*  
Belzner, A., BISCHLER, U., CROUCHBAKER, S., Gur, T. M., Lucier, G., Schreiber, M., Huggins, R. A.  
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- **2 FAST MIXED-CONDUCTOR SYSTEMS - DEUTERIUM AND HYDROGEN IN PALLADIUM - THERMAL MEASUREMENTS AND EXPERIMENTAL CONSIDERATIONS** *WORKSHOP ON COLD FUSION PHENOMENA*  
Belzner, A., BISCHLER, U., CROUCHBAKER, S., Gur, T. M., Lucier, G., Schreiber, M., Huggins, R. A.

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- **QUATERNARY PHASE-RELATIONS NEAR  $\text{YBa}_2\text{Cu}_3\text{O}_{6+x}$  AT 850-DEGREES-C IN REDUCED OXYGEN PRESSURES** *PHYSICA C-SUPERCONDUCTIVITY AND ITS APPLICATIONS*  
Ahn, B. T., Lee, V. Y., Beyers, R., Gur, T. M., Huggins, R. A.  
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- **PREPARATION, STRUCTURES AND CONDUCTIVITIES OF  $\text{Li}_2\text{Sis}_3$  PHASES** *MATERIALS RESEARCH BULLETIN*  
Ahn, B. T., Huggins, R. A.  
1990; 25 (3): 381-389
- **HIGH-TEMPERATURE PHASE-EQUILIBRIA NEAR  $\text{YBa}_2\text{Cu}_3\text{O}_{6+x}$**  *INTERNATIONAL CONF ON MATERIALS AND MECHANISMS OF SUPERCONDUCTIVITY : HIGH TEMPERATURE SUPERCONDUCTORS 2*  
Ahn, B. T., Lee, V. Y., Beyers, R., Gur, T. M., Huggins, R. A.  
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- **OXYGEN ORDERING IN  $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$**  *INTERNATIONAL CONF ON MATERIALS AND MECHANISMS OF SUPERCONDUCTIVITY : HIGH TEMPERATURE SUPERCONDUCTORS 2*  
Beyers, R., Ahn, B. T., Gorman, G., Lee, V. Y., Parkin, S. S., Ramirez, M. L., Roche, K. P., Vazquez, J. E., Gur, T. M., Huggins, R. A.  
ELSEVIER SCIENCE BV.1989: 548-549
- **THERMODYNAMIC RATIONALIZATION OF MOLTEN-SALT ELECTRODEPOSITION IN OXIDE-BASED SYSTEMS** *JOURNAL OF MATERIALS RESEARCH*  
CROUCHBAKER, S., Huggins, R. A.  
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- **PREPARATION AND CONDUCTIVITY OF THE LAYERED STRUCTURE J-PHASE OF ANHYDROUS CRYSTALLINE  $\text{Li}_2\text{Zr}(\text{PO}_4)_2$**  *JOURNAL OF THE ELECTROCHEMICAL SOCIETY*  
Wang, J. Q., Raistrick, I. D., Huggins, R. A.  
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- **OXYGEN ORDERING, PHASE-SEPARATION AND THE 60-K AND 90-K PLATEAUS IN  $\text{YBa}_2\text{Cu}_3\text{O}_x$**  *NATURE*  
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- **HYDROGEN-TRANSPARENT METAL-SURFACES PRODUCED BY USE OF MOLTEN-SALTS WITH VERY LOW OXYGEN AND WATER ACTIVITIES** *JOURNAL OF THE ELECTROCHEMICAL SOCIETY*  
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- **SYNTHESIS AND LITHIUM CONDUCTIVITIES OF  $\text{Li}_2\text{Sis}_3$  AND  $\text{Li}_4\text{Sis}_4$**  *MATERIALS RESEARCH BULLETIN*  
Ahn, B. T., Huggins, R. A.  
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- **MATERIALS SCIENCE PRINCIPLES RELATED TO ALLOYS OF POTENTIAL USE IN RECHARGEABLE LITHIUM CELLS** *JOURNAL OF POWER SOURCES*  
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- **DEMONSTRATION OF A NOVEL COMPOSITE SOLID LIQUID SOLID ELECTROLYTE CONFIGURATION FOR HYDROGEN-RELATED APPLICATIONS** *ZEITSCHRIFT FUR PHYSIKALISCHE CHEMIE NEUE FOLGE*  
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- **HYDROGEN-CONDUCTING ELECTROLYTE CONFIGURATIONS** *SOLID STATE IONICS*  
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- **PHASE-BEHAVIOR IN THE LI-AL-O-H SYSTEM AT INTERMEDIATE TEMPERATURES** *SOLID STATE IONICS*  
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