

ROBERT W. BIRKMIRE

Institute of Energy Conversion
University of Delaware
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EDUCATION

Ph.D., Physics, University of Delaware, September 1976
M.S., Physics, University of Delaware, August 1970
B.S., Physics, Lowell Technological Institute, June 1968

EXPERIENCE

University of Delaware, Institute of Energy Conversion
Director, 1/96 to present
Professor of Materials Science and Engineering: 9/04 to present
Adjunct Professor of Materials Science: 11/98 to 9/04
Professor of Physics: 2/95 to present
Manager, Electronic Materials Laboratory: 7/83 to 12/95
Acting Director: 1/93 to 12/93
Associate Scientist: 10/80 to 7/83
Research Associate III: 8/78 to 10/80

U.S. Army Ballistic Research Laboratories, Aberdeen, Maryland
National Research Council, Postdoctoral Research Associate: 11/76 to 7/78

University of Delaware, Department of Physics and Astronomy, Newark, Delaware
Postdoctoral Fellow: 9/76 to 11/76
Research Fellow/Teaching Assistant: 2/73 to 8/76
Research Fellow/Teaching Assistant: 9/68 to 8/70

Board of Education of Harford County, Aberdeen, Maryland
High School Teacher: 9/70 to 1/73

Department of the Army, Edgewood Arsenal, Maryland
Physicist: Summer, 1968

Lowell Technological Institute, Lowell, Massachusetts
Student Laboratory Instructor: 1966 to 1968

Philadelphia Electric Company, Philadelphia, Pennsylvania
Technical Assistant: Summer, 1967

R&D MANAGEMENT/ADMINISTRATIVE EXPERIENCE

As Director (and previously Acting Director) of the Institute of Energy Conversion, have responsibility for technical, personnel and fiscal management of the Institute. This requires interacting with University administrators and faculty as well as with external funding organizations.

As Manager of Electronic Materials, had responsibility for technical and personnel management for a staff of 20 professionals, technicians, and post doctoral fellows who were engaged in thin film photovoltaic research projects on amorphous silicon and related alloys, cadmium telluride, and copper indium diselenide and related alloys.

As Principal Investigator on over \$10M in government and industrial contracts have directed, organized and managed highly successful research programs which in part lead to the designation of the Institute of Energy Conversion as a Center of Excellence for Photovoltaic Research and Education by the United States Department of Energy.

RESEARCH ACTIVITIES

Current research efforts are growth and characterization of thin film semiconductors and devices for photovoltaic applications. The research emphasizes the inter-relationship between the growth process, film structural and electro-optical properties and device performance.

STUDENT SUPERVISIONS

Jointly supervise Ph.D. and Masters students in the Mechanical, Chemical, and Electrical Engineering departments, Physics department and Material Science Department. Additionally, supervise undergraduate students in the University's honor program.

TUTORIALS:

"Thin Film Solar Cells - Devices, Materials, and Fabrication," Kim W. Mitchell and Robert W. Birkmire, 21st IEEE PVSC, May (1990).

"Thin Film Solar Cells: Materials, Fabrication & Characterization," Robert W. Birkmire and Alan H. Fahrenbruch, 26th IEEE PVSC, September-October (1997).

"Polycrystalline Compound Thin Film Solar Cells: Laboratory Cells to Modules," Robert W. Birkmire and James Sites, 28th IEEE PVSC, September (2000).

PATENTS:

U. S. Patent no. 4,709,466 dated 12/1/87 "Process for Fabricating Thin Film Photovoltaic Solar Cells"

Inventors: Brian E. McCandless and Robert W. Birkmire

U. S. Patent no. 4,909,863 dated 3/20/90 "Process for Leveling Film Surfaces and Products Thereof"

Inventors: Brian E. McCandless and Robert W. Birkmire

U. S. Patent no. 5,015,503 dated 5/4/91 "Apparatus for Producing Compound Semiconductor Thin Films" Inventors: Robert D. Varrin and Robert W. Birkmire

U. S. Patent no. 5,674,555 dated 10/7/97 "Process for Preparing Group IB-IIIA-VIA Semiconducting Films" Inventors: Robert W. Birkmire, Jerold M. Schultz, Matheswaran Marudachalam and Habib Hichri

U. S. Patent no. 6,310,281 dated 10/30/01 "Thin-film, Flexible Photovoltaic Module" Inventors: Robert G. Wendt, Gregory M. Hanket, Robert W. Birkmire, T.W.F. Russell and Scott Weideman

U. S. Patent no. 6,372,538 dated 4/16/02 "Fabrication of Thin-Film, Flexible PV Module," Inventors: R.G. Wendt, Greg M. Hanket, Robert W. Birkmire, TWF Russell and S. Weideman

U. S. Patent no. 6,676,994 dated 1/13/04 "Method for Producing Thin Films" Inventors: Robert W. Birkmire, Erten Eser, Greg M. Hanket and Brian McCandless

PROFESSIONAL ASSOCIATIONS

Materials Research Society, Member, 6/01-present
International Solar Energy Society, Member, 3/01-present
American Association for the Advancement of Science, Member, 3/01-present
American Solar Energy Society, Member, 8/99-present
Electrochemical Society, Member, 6/99-present
World Renewable Energy Network, Member, 1994-present

PROFESSIONAL SERVICE

Guest Editor, *II-VI Compound Semiconductor Photovoltaic Materials*, Vol. 668, MRS Society Symposium H Proceedings, Spring MRS Meeting, April 16-20, 2001, San Francisco, CA (also Co-Chair Symposium H).

Guest Editor, *Thin Solid Films*, Vol. 387, 1 June 2001, Proceedings of E-MRS Meeting, Strasbourg, France, May 30-June 2, 2000 (Co-Chair, Symposium N, *Thin Film Chalcogenide Photovoltaic Materials*).

Director, Council for Photovoltaic Research (CPR), 1996-present. The Council provides a voice for the photovoltaic research community in establishing federal energy policy.

AWARDS

World Renewable Energy Network Pioneer Award, presented at the World Renewable Energy Congress VII, July 2002, Cologne, Germany.

Department of the Army Special Achievement Commendation: May 1977.

STUDENT ADVISEMENT

GRADUATE STUDENTS

PH.D DISSERTATIONS

R.D. Varrin, Jr., "Selenization: Formation of CuInSe₂ Polycrystalline Thin Films of Photovoltaic Devices," May 1991 (Co-advisor: TWF Russell).

Sandeep Verma, "A Chemical Reactor and Reaction Engineering Analysis of the Formation of CuInSe₂ by Selenization," April 1993 (Co-advisor: TWF Russell).

Matheswaran Marudachalam, "Processing, Structure and Diffusion in CuIn_xGa_{1-x}Se₂ Thin Films for Solar Cells," December 1996 (Co-advisor: Jerold Schultz).

Garth Jensen, "Alloys in Cadmium Telluride Solar Cells," March 1997 (degree from Stanford University; Co-advisor: Richard Bube, Stanford University).

Julius Mwabora, "Copper Indium Diselenide (CuInSe₂) Based Solar Cells: Effect of CuInSe₂ Films Preparation Conditions and Thickness on Performance," February 1999 (degree from University of Dar es Salaam; Co-advisor: R. T. Kivaisi).

Michael Engelmann, "Quantitative Determination of the Incorporation of Sulfur in Copper Indium Diselenide Polycrystalline Thin Films" March 1999.

Gregory M. Hanket, "Manufacture of Large-Area Copper Indium (Gallium) Diselenide Thin Films for Photovoltaic Applications," July 1999 (Co-advisor: TWF Russell).

Atul Pant, "Analysis and Modeling of Hot Wire Chemical Vapor Deposition of Silicon Films," March 2000 (Co-advisor: M. Huff)

Moses W. Haimbodi, "Physical Vapor Deposition and Analysis of Copper Indium Aluminum Diselenide Thin Films for High Band Gap Solar Cells," Winter 2003

S. Tobias Junker, "Modeling and Control of a Continuous Thermo-Evaporation Process for Production of Thin-Film Photovoltaic Modules," Winter 2003

Jochen Titus, "Surface Sulfurization of Copper Indium Diselenide for Application in Solar Cells," Spring 2004.

Ozgen Ebil, "Deposition and Characterization of Silicon Thin-Films by Aluminum-Induced Crystallization," Spring 2005.

MASTER'S THESES

Gregory Norsworthy, "A New Design for Rapid Cooling of Thin Films During Processing," May 1996 (Co-advisor: John Meakin).

Rajesh Venugopal, "The Study of Sulfur Diffusion into CdTe Using X-Ray Diffraction," Summer 1997 (Co-advisor: Jerold Schultz)

Jeffrey Doody, "Thermal Modeling of an Evaporation Source Used for Physical Vapor Deposition of Cu(In-Ga)Se₂ Thin Films for Photovoltaic Applications," Fall 2002.

Clifford Yapp, "Growth and Characterization of $\text{Cu}(\text{In}_x\text{Ga}_{1-x})(\text{S}_y\text{SE}_{1-y})_2$ Films by Elemental Physical Vapor Deposition," Spring 2005.

Scott Stephens, "Modeling Optical Properties of Thin Film $\text{Cu}(\text{In,Ga})\text{Se}_2$ Solar Cells Using Spectroscopic Ellipsometry," Winter 2006.

Sarah Rickman, "Growth and Characterization of MoS_2 , MOSE_2 , and $\text{Mo}(\text{S}_x\text{Se}_{1-x})_2$ Formed Between Mo and $\text{CuIn}(\text{S}_x\text{Se}_{1-x})$ During Growth," Spring 2006.

STUDENTS UNDER CURRENT SUPERVISION

Michael Burrows, Materials Science, Ph.D. Program

Meijun Lu, Physics and Astronomy, Ph.D. Program

Kapil Mukati, Chemical Engineering, Ph.D. Program