Amorphous and Nanocrystalline Silicon Science and Technology — 2005

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Amorphous and Nanocrystalline Silicon Science and Technology — 2005

Symposium held March 28–April 1, 2005, San Francisco, California, U.S.A.

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PREFACE

Symposium A, "Amorphous and Nanocrystalline Silicon Science and Technology — 2005," held March 28–April 1 at the 2005 MRS Spring Meeting in San Francisco, California, marked its twenty-second consecutive year of association with the MRS Spring Meeting. Interest in Symposium A continues unabated into its third decade; in all, 162 abstracts were received. The symposium attracted participants from universities, industries, and government laboratories worldwide. As an indication of the international scope, presenting authors for 65% of the abstracts were affiliated outside the United States, and the final program included representation from 25 nations. The highlights of the symposium were three sessions of invited presentations pertaining to the 2005 World Year of Physics and celebrating, in particular, the centennial of Einstein's modern definition of the photon.

The opening session of the symposium honored pioneers in the use of photons to probe tetrahedrally-bonded amorphous semiconductor thin films. W. Jackson (Hewlett-Packard Laboratories) surveyed the beginnings of photothermal deflection spectroscopy for studies of the defect states in the bandgap, and G. Cody (Rutgers University and Exxon) provided a historical overview of optical absorption for studies of the Urbach edge and disorder. In addition, L. Ley (University of Erlangen) summarized the seminal contributions of photoelectron spectroscopy to the determination of the valence band density of electronic states. All these pioneering advances shaped the research directions subsequently pursued in the field. As an example, the recent rapid advances in the use of photon probes for in-situ and real time characterization of growing Si thin films were described in a special invited session by presenters H. Fujiwara (National Institute of Advanced Industrial Science and Technology), D. Levi (National Renewable Energy Laboratory), and W. Kessels (Eindhoven University of Technology). In recognition of the increasing importance of the interplay of photonics with amorphous/nanocrystalline materials and thin film devices, a new session on photonic devices has been introduced this year. S. John (University of Toronto) described photonic band gap materials with spectacular video animations, and G. Moddel (Phiar Corporation and University of Colorado) described emerging metal-insulator-metal devices for THz detection.

Additional invited presentations focused on new approaches for the fabrication of higher stability amorphous silicon-based materials and solar cells, and on the characterization of materials and cells both structurally and electronically. H. Sonobe (Mitsubishi Heavy Industries and National Institute of Advanced Industrial Science and Technology) described high stability cells with i-layers prepared from triode plasma-enhanced chemical vapor deposition, and K. Lim (Korea Advanced Institute of Science and Technology) described high stability cells obtained using protocrystalline Si:H maintained throughout the i-layer by applying multilayer deposition. These presentations demonstrate that important advances are being made in the maturing amorphous silicon cell technology through a better understanding of fabrication processes and through improved techniques for characterization. As examples, in additional invited presentations, M. Luysberg (Forschungszentrum Jülich) described the characterization of solar cell quality microcrystalline silicon using advanced electron microscopies, and Y. Hishikawa (National Institute of Advanced Industrial Science and Technology) described the characterization of the individual components of multijunction solar cells from optoelectronic analyses of the completed cells.

The symposium attracted stimulating contributed papers as well in topics relevant for solar cells, including (i) the role of hydrogen in metastability phenomena and in deposition processes, and (ii) the application of atomistic material simulations in elucidating film growth mechanisms and structure as characterized by in-situ probes. As in previous MRS Spring Symposia A, the session devoted to metastability brought unexpected results and lively discussions. In comparison with previous years' Symposia A, however, an increasing number of contributions in 2005 Spring were devoted to (i) nanostructures, such as quantum dots and wires, and to (ii) nano/microcrystalline and poly/single crystalline films, the latter involving new concepts in crystalline grain growth and epitaxy. Device applications were highlighted in several sessions ranging from mature, such as thin film transistors, solar cells, and image sensors, operable on the meter scale, to emerging, such as memories, operable on the nanometer scale. On the latter topic, the symposium organizers congratulate the team of J. Kim and collaborators (Myongji University and Samsung), who won a Best Poster Award for *Effect of Post-Oxidation of Silicon Nanocrystals as a Floating Gate of Nonvolatile Memory*. As in previous Symposia A, the poster sessions were well attended, with spirited discussions lasting well into the evening.

Of the 148 papers in the 2005 Symposium A program, 72% appear in these proceedings.

An excellent overview of the photon absorption onset in amorphous silicon by G. Cody constitutes Part I. Professor Cody pioneered the measurement approach and basic understanding of the near band gap optical absorption that is in widespread use today. In recognition and appreciation, photographs of Prof. Cody taken during discussions of these concepts, in 1985 soon after their development and twenty years later, are provided following this Preface.

Subsequent Parts II-VIII of the proceedings address materials fabrication and processing-property relationships that provide insights into fabrication, often with the motivation being to develop materials optimization principles for specific applications. Parts II, III, and IV cover silicon and related thin film materials including those that are amorphous (II), nano/microcrystalline (III), and polycrystalline or epitaxial (IV). Part V includes articles on post-fabrication processing such as thermal annealing, laser annealing, and metal-induced crystallization, along with the associated processing-property relationships that support optimization principles. Parts VI and VII address the fabrication, measurement, and application of nanostructures. Part VI includes articles on nanoparticles, nanocrystals, and quantum dots, whereas Part VII includes those on wires, more advanced nanoscale structures, and photonic materials.

Heterostructures consisting of amorphous or nano/microcrystalline films on bulk single crystal or multicrystalline solid surfaces form the subject of Part VIII. Recent interest in this area has been stimulated by advances in heterojunction solar cells that exploit the technologies of amorphous silicon deposition and bulk single crystal solar cell processing.

Articles in Parts IX and X emphasize silicon-based thin film materials characterization and an understanding of material properties at a basic level. Part IX focuses on the roles of defects, impurities, and hydrogen, as well as the manifestations and origins of light-induced defect generation. Part X focuses on the optical, optoelectronic, and transport properties, including absorption, photoluminescence, electroluminescence, dark and photo conductivity, current transient spectroscopy, and time-of-flight drift mobility.

Finally Parts XI-XIII span the device applications of materials as well as analyses of the devices themselves including thin film solar cells (XI), transistors (XII), and sensors, detectors, and diodes (XIII). Articles on heterojunction devices appear earlier in Part VIII.

Many individuals and organizations volunteered time and donated financial support that ensured the great success of the 2005 MRS Spring Symposium A. Preceding the symposium, J. Conde (Instituto Superior Tecnico, Lisbon) and S. Wagner (Princeton University) presented a tutorial on the fundamental principles of silicon thin film materials as well as on the state of the art in applications. The symposium program was developed with the expert assistance of the following advisors: G. Ganguly (United Solar Ovonic Corporation), R. Weisfield (dpiX), J. Conde, and E. Schiff (Syracuse University). We are particularly grateful to G. Ganguly and R. Weisfield for their continuous efforts devoted to the overall organization of this symposium. In addition, the editors are indebted to the 55 expert referees and their massive effort in helping to improve the overall quality of the submitted manuscripts within a short timeline. The invaluable contributions of the Materials Research Society staff are also greatly appreciated. The symposium organizers acknowledge generous financial support from Fuji Electric Company, Japan Gore-Tex, the Materials Research Society, the National Institute of Advanced Industrial Science and Technology (Tsukuba, Japan), the National Renewable Energy Laboratory, United Solar Ovonic Corporation, and Voltaix, Inc. Administrative support was provided by the University of Utah and the University of Toledo. Finally, 2005 MRS Spring Symposium A and this volume as well would not have been possible without the tireless efforts of Mary Ann Woolf. Mary Ann's extensive experience in administering the submission and refereeing of these articles has been invaluable. We look forward to another stimulating Symposium A in Spring 2006, and next year's organizers hope to see you there!

Robert W. Collins
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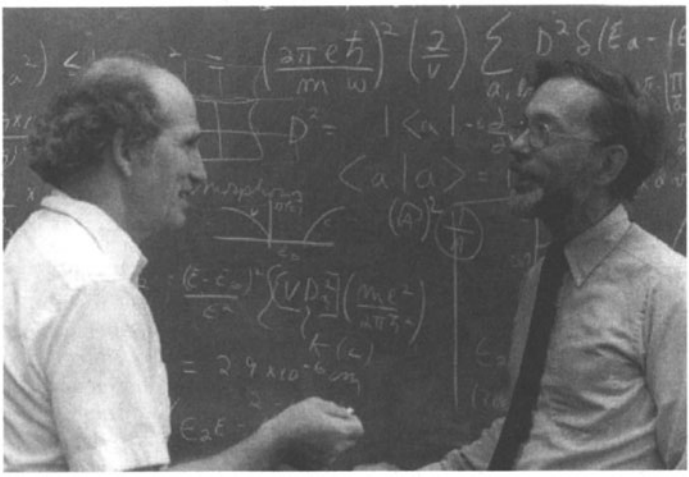
July 2005



Dr. George Cody (right) discusses the optical properties of amorphous silicon with his friend and colleague Dr. Ben Abeles in 1985 at Exxon's Corporate Research Laboratory in Annandale, NJ.

Twenty years later, Professor George Cody (left) discusses his 2005 MRS Spring Symposium A presentation with friend and colleague Dr. Ben Abeles.

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