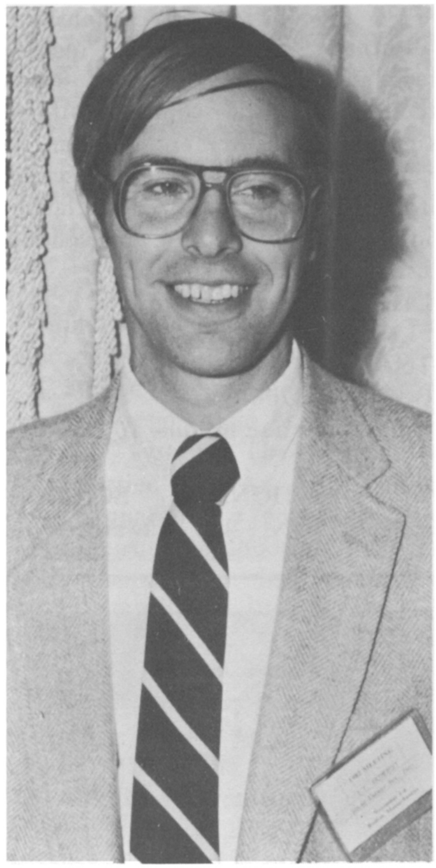
SOLAR ENERGY PHOTOCONVERSION:

The solar energy photoconversion symposium highlighted research and development and production activity in both photovoltaic and photoelectrochemical solar conversion technologies. The symposium assembled eight invited and nineteen contributed papers representing major advances, reviews and projections for these photoconversion methods dealing with the production of electricty and chemicals (fuels). The two-day session was keynoted by Adam Heller of Bell Laboratories, with a review of the chemistry of the radiationless recombination processes of the photogenerated carriers that control the performance and efficiencies of these photovoltaic and photoelectrochemical devices. Heller stressed the importance of surfaces, grain boundaries and lattice defects in photoconversion mechanisms, and reviewed processes for minimizing or passivating their deleterious effects upon cell performance and operating lifetime. Contributed papers by Kazmerski of the Solar Energy Research Institute on interface formation and stability in $CuInSe_2$ heterojunction solar cells, and by Allen of SES Inc., on electromigration of copper ions in Cu_2S-based solar cells, complemented Heller's opening remarks on polycrystalline devices. The latter presentation emphasized the controlling influence of the various cell interfaces on the temperature stability of thin-film, 10%-efficient, $Cd(Zn)S/CuInSe_2$ solar cells. The former provided information on the origin and control of the major degradation mechanism (Cu-migration) in the Cu_2/CdS cell.

A highlight of the first day--and, indeed, the entire symposium--was the presentation by Stanford R. Ovshinsky, president and founder of Energy Conversion Devices of Troy, Mich. Ovshinsky, a pioneer in



L.L. Kazmerski, Chairman

amorphous materials research and application, outlined his company's philosophy and future in the amorphous silicon solar cell arena. Ovshinsky said his company approached the amorphous solar cell development dealing with large area devices and a scaled-up technology from the beginning. Energy Conversion Devices' joint effort with Sharp Electronics in Japan will be in commercial production in early 1983, processing 1 ft^2 area, p-i-n amorphous Si:H:F solar cells. These cells, according to Ovshinsky, have no degradation and have indicated better than 20-year lifetimes under accelerated lifetime testing. Energy Conversion Devices has developed, built and sold three amorphous Si multichamber cell production systems that continuously coat one foot wide flexible stainless steel ribbon with amorphous cells, with a 3 MW/yr production capability. Ovshinsky expects cells in the 11% - 12% range maximum for single junction devices, but over 30% for tandem cells which he says will represent no added cost over single cells. Ovshinsky demonstrated the large-scale production capabilities of his system with a slide of a 1,000 foot long, 1 foot wide tandem amorphous solar cell.

Two contributed papers dealing with the thermal annealing of amorphous Si:H cells (M.K. Han, SUNY) and the characterization of a-Si:Sn:H alloys (D.L.Williamson, Colorado School of Mines and SERI) were also presented.

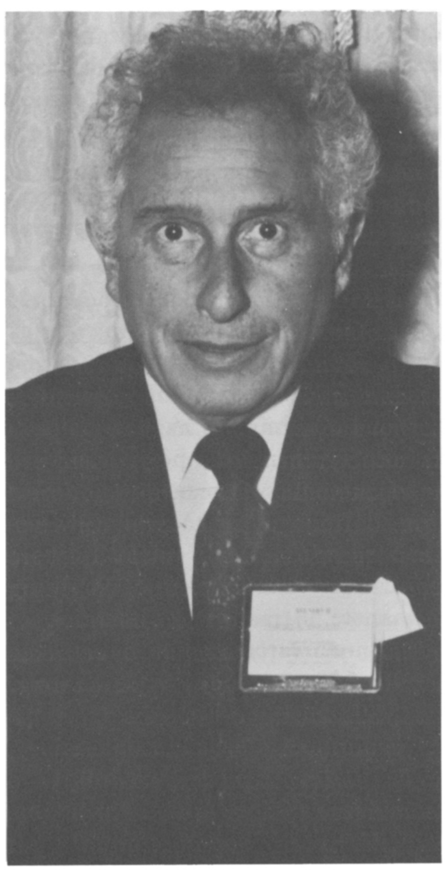
The stability of electrodes in photoelectrochemical cells was discussed in an invited presentation by A. J. Bard of the University of Texas. Incorporation of silicides (Pt, Ir, Ru) and utilization of catalysts provide stable Si photoelectrodes. The status of amorphous hydrogenated Si electrodes was presented by G. S. Calabrese of M.I.T. Although cost considerations favor this material, photovoltages have been limited. Large area thin-film CdSe electrochemical cells with efficiencies in excess of 6% were reported by R. D. Rauh of EIC Laboratories. Areas up to 400cm^2 for these cells have been tested.

Grain boundary limitations in polycrystalline Si cells formed the subject of a group of papers by P. E. Russell, S.E.R.I, E. S. Yang, Columbia University, J. I. Hanoka, Mobil Tyco, S. J. Fonash, Pennsylvania State University, W. F. Regnault, Semix Inc., and J. S. Song, Columbia University. The invited paper by Russell and Yang focused on the role of impurities - specifically oxygen - on the electrical activity of the intergrain regions. Fonash reported that the degree of activation depends significantly upon the thermal and process history of the polysilicon. Hanoka reported an improvement in efficiency (from 8.4% to 9.5%) of hydrogen passivated EFG silicon. Antireflection coated ribbons exhibited efficiencies of up to 14% following hydrogen treatment. Semix reported on the differences in grain boundary behavior with structural and orientational properties. A model for polycrystalline Si photoconductivity was covered by J. S. Song.

A near-commercialization photoelectrochemical system was reviewed by E. L. Johnson of Texas Instruments. This system uses small, (0.02 cm) single crystal Si cells embedded in glass ribbon to produce both electricity and fuel from a HBr electrolyte. Modules are 4' x 8" in size, with 700 watt-hour storage. Systems have 11-12% solar-electricity efficiency, and ~8 solar-chemical efficiency. Accelerated life tests indicated better than 20 year lifetime.

Ted Ciszek of S.E.R.I. reviewed the status of silicon sheet technologies for photovoltaics. He catagorized the sheet technologies into: (1) those with small meniscus height, (2) those with large meniscus height, and (3) those that achieve high growth rates through use of an extended meniscus. Features and difficulties associated with the various technologies, EFG, ESP, RAD, web, etc., were discussed. None of the processes presently delivers Si sheet with: (1) good crystal quality, (2) smooth surfaces, (3) high purity, (4) easy process control, and (5) high throughput and production rate. Stable metal-insulator-semiconductor solar cells of Yb on polycrystalline Si were reported by G. Rajeswaran of SUNY - Buffalo. F. W. Saris of FOM - Institute for Atomic and Molecular Physics, The Netherlands, discussed the beneficial effects of thermal and laser annealing on Si solar cell performance.

An invited review by J. C. C. an of M.I.T. Lincoln Lab provided insights into the use of II-VI and III-V materials for photovoltaic applications. Fan concluded that III-V materials such as GaAs are best utilized in high efficiency solar cells. In fact, past attempts at the use of poly-GaAs and InP have suffered due to severe grain boundary pinning problems. For example, grain boundaries in InP are most probably pinned to make them n-type, and use of ITO as a hetrojunction partner leads to formation of n-n junctions at the grain boundaries. In the II-VI area, R. L. Turcotte of Radiation Monitoring Devices, reported on sprayed CdTe thin film cells. Problems in phase identification of Cu_xS were discussed by L. F. Donaghey of Chevron Research. Significantly, he reported that x-ray diffraction peaks had been frequently misinterpreted in prior work.



S.R. Ovshinsky

In the final session of the symposium, M. Ludowise of Varian Associates reviewed advanced, multijunction concentrator cell research. Current R & D is directed towards production of a 30% efficient, two-junction device for 400 suns in a terrestrial environment, and a three-junction device for use in space under 100x concentration. Prototype GaAlAs/GaAs cells have demonstrated 22% efficiency at 130 AM3 suns, the highest for any multijunction cell reported to date. Several approaches to monolithic device structures were presented, including two, three, and four terminal devices. Spectral splitting concepts were also reviewed. Major problems for the multijunction approach involve efficiency improvement, AR coating, current matching, stability, cell interconnect methodology, and layer thickness and property control. Solid solutions of photovoltaic materials were discussed by J. V. Masi, Western New England College. Transparent electrodes were reported by H. E. Hager of the University of Washington (SnO_2) and S. C. Miller of ARCO Solar (SnO_2 doped with F). The importance of these transparent contacts was demonstrated in each case.

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