



## TABLE OF CONTENTS

### SESSION 1 SILICON SOLAR CELLS

Organizer - J. Goldsmith

Co-chairmen - Dr. S. Karius, W. Cherry

	Page
1.1 SUMMARY OF HIGH EFFICIENCY SILICON SOLAR CELL MEETING HELD AT NASA-LEWIS by D. T. Bernatowicz . . . . .	1
1.2 FUNDAMENTAL LIMITATIONS IMPOSED BY HIGH DOPING ON THE PERFORMANCE OF PN JUNCTION SILICON SOLAR CELLS by F. A. Lindholm, S. S. Li, and C. T. Sah . . . . .	3
1.3 EFFICIENCY OF SILICON SOLAR CELLS AS A FUNCTION OF BASE LAYER RESISTIVITY by P. M. Dunbar and J. R. Hauser . . . . .	13
1.4 EFFECT OF IMPURITY DOPING CONCENTRATION ON SOLAR CELL OUTPUT by P. A. Iles and S. I. Soclof . . . . .	19
1.5 IMPACT OF MATERIAL AND JUNCTION PROPERTIES ON SILICON SOLAR CELL EFFICIENCY by H. Fischer and W. Pschunder . . . . .	25
1.6 EFFECTS OF HIGH DOPING LEVELS ON SILICON SOLAR CELL PERFORMANCE by M. P. Godlewski, H. W. Brandhorst, Jr., and C. R. Baraona . . . . .	32
1.7 ADVANCES IN THE THEORY AND APPLICATION OF BSF CELLS by J. Mandelkorn and J. H. Lamneck . . . . .	36
1.8 OPTICAL PROPERTIES OF THE COMSAT NON-REFLECTING CELL by R. A. Arndt, J. F. Allison, J. G. Haynos, and A. Meulenberg, Jr. . . . .	40
1.9 V-GROOVED SILICON SOLAR CELLS by C. R. Baraona and H. W. Brandhorst, Jr. . . . .	44
1.10 INFLUENCE OF IMPURITIES ON SILICON SOLAR CELL PERFORMANCE by G. F. Wakefield, P. D. Maycock, and T. L. Chu . . . . .	49
1.11 GRAIN BOUNDARY AND IMPURITY EFFECTS IN LOW COST SILICON SOLAR CELLS by S. I. Soclof and P. A. Iles . . . . .	56
1.12 MEASUREMENT OF PHYSICAL PARAMETERS OF SEMICONDUCTOR MATERIAL BY A TECHNIQUE OF ANALYSIS USING COMBINED MICROWAVE AND OPTICAL TECHNIQUE by M. Orgeret, J. Cacheux, J. Boucher, and M. Daurie . . . . .	62
1.13 DIFFUSION LENGTH MEASUREMENT USING THE SCANNING ELECTRON MICROSCOPE by V. G. Weizer. . . . .	67
1.14 DOPING CHARACTERISTICS OF ADVANCED SILICON SOLAR CELLS AS MEASURED VIA C-V TECHNIQUES by J. J. Galloway. . . . .	72
1.15 APPLICATION OF THE MOS C-V TECHNIQUE TO DETERMINE IMPURITY CONCENTRATIONS AND SURFACE PARAMETERS ON THE DIFFUSED FACE OF SILICON SOLAR CELLS by I. Weinberg . . . . .	78

### SESSION 2 SOLAR ARRAY TECHNOLOGY

Organizer - W. Luft

Co-chairmen - A. Dollery, P. Goldsmith

2.1 TESTING OF THE COMMUNICATIONS TECHNOLOGY SATELLITE DEPLOYABLE SOLAR ARRAY SUBSYSTEM by J. S. Smith, S. S. Sachdev, and J. A. Hunter. . . . .	83
2.2 LIGHTWEIGHT RIGID SOLAR ARRAY DEVELOPMENT by W. Luft and R. E. Patterson . . . . .	94

	<u>Page</u>
2.3 LIGHTWEIGHT RIGID SOLAR ARRAY STRUCTURAL CONSIDERATIONS by D. A. Corbett and W. J. Dean . . . . .	103
2.4 DESIGN OF THE IUE SOLAR ARRAY by B. Gorgens and E. G. Suppa . . . . .	110
2.5 THE GEOS SOLAR GENERATOR by G. Pohl and H. Braasch . . . . .	117
2.6 EVALUATION OF FLIGHT ACCEPTANCE THERMAL TESTING FOR THE ATS-6 SOLAR ARRAY by A. Smith, F. Hornbuckle, and F. Betz . . . . .	120
2.7 WELDING OF SOLAR CELLS IN PRODUCTION LINE by R. Buhs, H. J. Durre, and H. W. Boller . . . . .	126
2.8 NDT EVALUATION OF SOLAR CELL WELD JOINTS WITH DETAILS OF SELECTED POST-BOND AND PRE-BOND SYSTEMS by D. R. Lott, J. S. Katzeff, H. A. Boltz, and W. L. Crabtree . . . . .	134
2.9 COMPARATIVE DEEP THERMAL CYCLING OF SOLAR CELL PANELS by F. C. Treble, A. Dunnet, and R. L. Crabb . . . . .	145
2.10 ACCELERATED FATIGUE TESTS OF SOLAR CELL INTERCONNECTORS FOR SIMULATION OF THERMAL CYCLES by H. W. Boller and J. Koch . . . . .	153
2.11 FEP-TEFLON ENCAPSULATED SOLAR CELL MODULES - FURTHER PROGRESS by H. S. Rauschenbach, M. D. Cannady, and A. F. Ratajczak . . . . .	162
2.12 INTEGRALLY BONDED COVERS FOR SILICON SOLAR CELLS by A. R. Kirkpatrick. . . . .	169

### SESSION 3 RADIATION EFFECTS

Organizer - Dr. E. Stofel

Co-chairmen - Dr. B. Anspaugh, R. Crabb

3.1 PARTICULATE IRRADIATIONS OF AN ADVANCED SILICON SOLAR CELL by L. J. Goldhammer . . . . .	172
3.2 ELECTRON AND NEUTRON IRRADIATION OF ADVANCED SILICON SOLAR CELLS by W. P. Rahilly. . . . .	179
3.3 HIGH VACUUM UV TEST OF IMPROVED EFFICIENCY SOLAR CELLS by G. S. Goodelle, G. R. Brooks, and J. R. Mosher . . . . .	184
3.4 SOLAR CELL EXPERIMENTS ON THE NTS-1 SATELLITE by R. L. Statler and D. H. Walker . . . . .	190
3.5 EARLY RESULTS OF THE ATS-6 SOLAR CELL FLIGHT EXPERIMENT by L. J. Goldhammer and J. P. Corrigan. . . . .	194
3.6 THE LES-6 SOLAR CELL EXPERIMENT AFTER SIX YEARS by F. W. Sarles, Jr. . . . .	199
3.7 RADIATION DAMAGE TO THE COMSAT NON-REFLECTIVE CELL by A. Meulenberg, Jr., J. F. Allison, R. A. Arndt, and J. G. Haynos . . . . .	204
3.8 LIMITATIONS OF THE 1-MEV EQUIVALENT ELECTRON FLUENCE METHOD IN THE EVALUATION OF SPACE RADIATION DEGRADATION by M. C. Wilkinson and W. E. Horne. . . . .	209
3.9 EFFECTS OF SIMULTANEOUS ULTRAVIOLET, ELECTRON, AND PROTON IRRADIATION OF SILICON SOLAR CELLS by R. A. Arndt, J. Bernard, and R. Reulet . . . . .	217
3.10 EFFECT OF ELECTRON IRRADIATION IN VACUUM ON FEP - A SILICON SOLAR CELL COVERS by S. J. Marsik and J. D. Broder. . . . .	221
3.11 LITHIUM-DOPED DRIFT-FIELD RADIATION-RESISTANCE P/N-TYPE SILICON SOLAR CELLS by A. Usami and M. Yamaguchi. . . . .	227

	<u>Page</u>
3.12 THE EFFECT OF SUNSHINE TESTING ON TERRESTRIAL SOLAR CELL SYSTEM COMPONENTS by A. F. Forestieri and E. Anagnostou . . . . .	232
3.13 SPACE CALIBRATION OF STANDARD SOLAR CELLS USING HIGH ALTITUDE SOUNDING ROCKETS by N. L. Thomas and D. M. Chisel. . . . .	237
3.14 DETERMINATION OF LARGER-THAN-SILICON BAND GAPS FOR OPTIMAL CONVERSION OF THE DIFFUSE COMPONENT by P. T. Landsburg and J. Mallinson . . . . .	241
3.15 SHALLOW JUNCTION SOLAR CELLS FABRICATED BY BF <sub>3</sub> CORONA DISCHARGE by R. Wichner . . . . .	243

## SESSION 4 SILICON TECHNOLOGY FOR TERRESTRIAL APPLICATIONS

Organizer - Dr. L. Magid

Co-chairmen - Dr. H. R. Blieden, Dr. K. Krebs

4.1 MISSION ANALYSIS OF PHOTOVOLTAIC CONVERSION OF SOLAR ENERGY FOR TERRESTRIAL APPLICATIONS by S. L. Leonard. . . . .	245
4.2 BUSINESS ANALYSIS OF SOLAR PHOTOVOLTAIC ENERGY CONVERSION by P. D. Maycock and G. F. Wakefield. . . . .	252
4.3 MITRE TERRESTRIAL PHOTOVOLTAIC ENERGY SYSTEM by G. M. Haas and S. Bloom. . . . .	256
4.4 FEASIBLE REACTIONS FOR THE SYNTHESIS OF SILICON AS DETERMINED BY A THERMODYNAMIC AND ECONOMIC SCREENING PROCESS by L. P. Hunt . . . . .	259
4.5 DIRECTIONAL FREEZING FOR UPGRADING METALLURGICAL-GRADE SILICON FOR SOLAR CELL APPLICATIONS by J. R. McCormick, L. D. Crossman, and A. Raucholz . . . . .	270
4.6 SINGLE CRYSTAL SILICON INGOT PULLED FROM CHEMICALLY UPGRADED METALLURGICAL-GRADE SILICON by V. D. Dosaj, L. P. Hunt, and L. D. Crossman . . . . .	275
4.7 EFG SILICON RIBBON SOLAR CELLS by K. V. Ravi, H. B. Serreze, H. E. Bates, A. D. Morrison, D. N. Jewett, and J. Ho. . . . .	280
4.8 EVALUATION OF SILICON RIBBON MATERIAL FOR SOLAR CELL FABRICATION by M. Leipold, R. Stirn, J. Zoutendyk, and R. DeAngelis . . . . .	290
4.9 DENDRITIC WEB: A VIABLE MATERIAL FOR SILICON SOLAR CELLS by R. G. Seidensticker, L. Scudder, and H. W. Brandhorst, Jr. . . . .	299
4.10 POLYCRYSTALLINE SILICON SOLAR CELLS FOR TERRESTRIAL APPLICATIONS by T. L. Chu, H. C. Mollenkopf, K. N. Singh, S. S. Chu, and I. C. Wu. . . . .	303
4.11 PROGRESS IN NEW LOW COST PROCESSING METHODS by M. Wolf. . . . .	306
4.12 RECENT ADVANCES IN LOW COST SOLAR CELL PROCESSING by E. Ralph . . . . .	315
4.13 RECENT DEVELOPMENTS IN TERRESTRIAL PHOTOVOLTAICS by J. Lindmayer . . . . .	317
4.14 ON HEAT REJECTION FROM TERRESTRIAL SOLAR CELL ARRAYS WITH SUNLIGHT CONCENTRATION by L. W. Florschuetz. . . . .	318
4.15 INTEGRATION OF PHOTOVOLTAIC AND SOLAR-THERMAL ENERGY CONVERSION SYSTEMS by D. G. Schueler, J. G. Fossum, E. L. Burgess, and F. L. Vook. . . . .	327
4.16 EXPERIMENTS ON SOLAR PHOTOVOLTAIC POWER GENERATION USING CONCENTRATOR AND LIQUID COOLING by B. H. Beam and C. F. Hansen. . . . .	332

4.17 PEELED FILM TECHNOLOGY FOR SOLAR CELLS by A. G. Milnes and D. L. Feucht. . . . .	<u>Page</u> 338
--	--------------------

## SESSION 5 NEW APPROACHES

Organizer - J. Wise

Co-chairmen - C. Bernatowicz, Dr. E. Stofel

5.1 SILICON SOLAR CELLS MADE BY ION IMPLANTATION AND GLOW DISCHARGE by J. P. Ponpon and P. Siffert. . . . .	342
5.2 FABRICATION OF AN IMPROVED VERTICAL MULTIJUNCTION SOLAR CELL by W. W. Lloyd. . . . .	349
5.3 THE HIGH INTENSITY SOLAR CELL - KEY TO LOW COST PHOTOVOLTAIC POWER by B. L. Sater and C. Goradia . . . . .	356
5.4 INDUCED JUNCTION SILICON SOLAR CELLS by G. C. Salter and R. E. Thomas. . . . .	364
5.5 ANALYSIS OF SILICON SCHOTTKY BARRIER SOLAR CELL by R. F. McQuat and D. L. Pulfrey . . . . .	371
5.6 METAL-THIN FILM INSULATOR-SEMICONDUCTOR SOLAR CELLS by S. J. Fonash . . . . .	376
5.7 EXPERIMENTAL AND THEORETICAL STUDIES OF $\text{Cu}_2\text{O}$ SCHOTTKY BARRIER SOLAR CELLS by L. C. Olsen and R. Bohara. . . . .	381
5.8 IMPROVED SCHOTTKY BARRIER SOLAR CELLS by Y. M. Yeh and R. J. Stirn. . . . .	391
5.9 $\text{In}_2\text{O}_3/\text{Si}$ HETEROJUNCTION SOLAR CELLS by S. W. Lai, S. L. Franz, G. Kent, R. L. Anderson, J. K. Clifton, and J. V. Masi . . . . .	398
5.10 GaAs CONCENTRATOR SOLAR CELLS by L. W. James and R. L. Moon . . . . .	402
5.11 LARGE AREA GaAlAs/GaAs SOLAR CELL DEVELOPMENT by J. Ewan, S. Kamath, and R. C. Knechtli . . . . .	409
5.12 HIGH EFFICIENCY GRADED BAND-GAP $\text{Al}_x\text{Ga}_{1-x}\text{As}$ - GaAs p-on-n SOLAR CELL by J. A. Hutchby. . . . .	414
5.13 PERFORMANCE OF GERMANIUM PIN-PHOTOVOLTAIC CELLS AT HIGH INCIDENT RADIATION INTENSITY by E. Kittl, M. D. Lammert, and R. J. Schwartz. . . . .	424
5.14 ENHANCED PHOTOVOLTAIC PERFORMANCE OF THIN SILICON FILMS BY MULTIPLE LIGHT PASSES by D. Redfield. . . . .	431
5.15 DIFFUSION LENGTH IMPROVEMENTS IN GaAs ASSOCIATED WITH Zn DIFFUSION DURING $\text{Ga}_{1-x}\text{Al}_x\text{As}$ GROWTH by H. Hovel and J. Woodall. . . . .	433
5.16 THE AMOS CELL - AN IMPROVED METAL-SEMICONDUCTOR SOLAR CELL by R. J. Stirn and Y. C. M. Yeh . . . . .	437
5.17 NOTE ON THE ELECTROCHEMICAL DECOMPOSITION OF COPPER SULPHIDE by H. Rickert, C. Wedde, W. Palz, J. Vedel, and T. Nguyen Duy . . . . .	439

## SESSION 6 COMPOUND SOLAR CELLS

Organizer - Prof. M. Wolf

Co-chairmen - Prof. J. J. Loferski, Dr. W. Palz

6.1 OPTICAL PROPERTIES AND THEORETICAL MODEL OF THE $\text{Cu}_x\text{S}-\text{CdS}$ HETEROJUNCTION by G. H. Hewig, F. Pfisterer, and W. H. Böll . . . . .	441
---	-----

	<u>Page</u>
6.2 EVOLUTION OF DARK CURRENT AND CAPACITANCE WITH DOPED CdS AND COMPOSITION OF CUPROUS SULPHIDE IN Cu <sub>x</sub> S-CdS PHOTOCELLS by H. Luquet, L. Szepessy, J. Bougnat, M. Savelli, and F. Guastavino. . . . .	445
6.3 MATERIAL ASPECTS OF CdS/Cu <sub>2</sub> S CELLS by H. Hadley, Jr., J. D. Meakin, J. E. Phillips, W. F. Tseng, and H. M. Windawi . . . . .	450
6.4 AN ELECTRON BEAM INDUCED CURRENT METHOD OF DETERMINING MINORITY CARRIER DIFFUSION LENGTHS IN THIN FILM SOLAR CELLS by J. J. Oakes, I. G. Greenfield, and L. D. Partain . . . . .	454
6.5 PERFORMANCE OF Cu <sub>x</sub> S-CdS SOLAR CELLS AFTER ADDITIONAL Cu-TREATMENT by F. Pfisterer, G. H. Hewig, and W. H. Bloss . . . . .	460
6.6 PERFORMANCE AND STABILITY OF Cu <sub>2</sub> S-CdS SOLAR CELLS by H. Windawi . . . . .	464
6.7 EVALUATION OF CdS SOLAR CELLS AS FUTURE CONTENDER FOR LARGE SCALE ELECTRICITY PRODUCTION by J. Besson, T. Nguyen Duy, A. Gauthier, W. Palz, C. Martin, and J. Vedel. . . . .	468
6.8 REFLECTION MODE OF OPERATION OF THE Cu <sub>2</sub> S-CdS SOLAR CELL by A. Rothwarf, L. Burton, H. Hadley, and G. M. Storti. . . . .	476
6.9 PREPARATION AND CHARACTERIZATION OF Cu <sub>x</sub> S AND CuInS <sub>2</sub> FILMS ON VARIOUS SUBSTRATES FOR PHOTOVOLTAIC JUNCTIONS by J. Shewchun, J. J. Loferski, A. Wold, R. Arnott, E. A. DeMeo, R. Beulieu, C. C. Wu, and H. L. Hwang. . . . .	482
6.10 II-VI PHOTOVOLTAIC HETEROJUNCTIONS FOR SOLAR ENERGY CONVERSION by A. L. Fahrenbruch, F. Buch, K. Mitchell, and R. H. Bube. . . . .	490
6.11 A NEW LOOK AT CdTe SOLAR CELLS by R. O. Bell, H. B. Serreze, and F. V. Wald. . . . .	497
6.12 PREPARATION AND PROPERTIES OF InP/CdS AND CuInSe <sub>2</sub> /CdS SOLAR CELLS by J. L. Shay, S. Wagner, K. Bachmann, E. Buehler, and H. M. Kasper . . . . .	503
6.13 LOW COST CdS-Cu <sub>2</sub> S SOLAR CELLS BY THE CHEMICAL SPRAY METHOD by J. F. Jordan . . . . .	508
6.14 ASSESSMENT OF THE INTERNATIONAL WORKSHOP ON CdS SOLAR CELLS by K. Boer. . . . .	514

PHOTOGRAPHS TAKEN AT CONFERENCE ON PAGES 516 to 519