

# AIP CONFERENCE PROCEEDINGS 234

## AMORPHOUS SILICON MATERIALS AND SOLAR CELLS

DENVER, CO 1991

EDITOR:

BRYON L. STAFFORD  
SOLAR ENERGY  
RESEARCH INSTITUTE

AIP

American Institute of Physics

New York

## CONTENTS

Preface .....	ix
---------------	----

### PART I. OPENING PRESENTATIONS

<b>Stabilized Module Performance as a Goal for the Photovoltaic Amorphous Silicon Program in the United States .....</b>	<b>3</b>
W. Luft, B. Stafford, and B. von Roedern	
<b>Research on the Stability of <math>\alpha</math>-Si:H Based Solar Cells by SMART .....</b>	<b>11</b>
C. R. Wronski and N. Maley	

### PART II. MODELING METASTABILITY

<b>Metastability and the Hydrogen Distribution in <math>\alpha</math>-Si:H.....</b>	<b>21</b>
R. A. Street	
<b>Metastability in Hydrogenated Amorphous Silicon:</b>	
<b>The Adler Model Revisited.....</b>	<b>29</b>
Howard M. Branz, Richard S. Crandall, and Marvin Silver	
<b>Theoretical and Experimental Investigation of Hydrogen Bonding</b>	
<b>Configurations in Si .....</b>	<b>37</b>
W. B. Jackson, S. B. Zhang, C. C. Tsai, and C. Doland	
<b>New Interpretations of the Staebler-Wronski Effect in <math>\alpha</math>-Si:H with</b>	
<b>Molecular Dynamics Stimulations .....</b>	<b>45</b>
R. Biswas and I. Kwon	
<b>Saturation of Light-Induced Defects in <math>\alpha</math>-Si:H .....</b>	<b>51</b>
P. V. Santos, W. B. Jackson, and R. A. Street	
<b>Investigation of the Staebler-Wronski Effect in <math>\alpha</math>-Si:H by Spin-</b>	
<b>Dependent Photoconductivity .....</b>	<b>59</b>
Martin S. Brandt and Martin Stutzmann	
<b>The Rehybridized Two-Site (RTS) Model for Defects in <math>\alpha</math>-Si:H .....</b>	<b>66</b>
David Redfield and Richard H. Bube	
<b>The Application of a Comprehensive Defect Model to the Stability of <math>\alpha</math>-Si:H.....</b>	<b>72</b>
N. Hata and S. Wagner	

### PART III. EXPERIMENTAL DATA AND MODEL VERIFICATION

<b>Defect Equilibration in Device Quality <math>\alpha</math>-Si:H and its Relation to</b>	
<b>Light-Induced Defects .....</b>	<b>83</b>
T. J. McMahon	
<b>Investigation of Defect Reactions Involved in Metastability of Hydrogenated</b>	
<b>Amorphous Silicon.....</b>	<b>91</b>
J. David Cohen and Thomas M. Leen	
<b>Light-Induced Changes in Compensated <math>\alpha</math>-Si:H Films .....</b>	<b>98</b>
J. K. Rath, B. Hackenbuchner, W. Fuhs, and H. Mell	

<b>Accelerated Stability Test of <math>\alpha</math>-Si:H by Defect Saturation .....</b>	<b>106</b>
M. Isomura and S. Wagner	
<b>An Experiment to Distinguish Between Bimolecular and Single-Carrier Driven Models of Metastable Defect Generation .....</b>	<b>114</b>
S. J. Fonash, J.-L. Nicque, J. K. Arch, S. S. Nag, and C. R. Wronski	
<b>The Staebler-Wronski Effect—A Fresh Assessment.....</b>	<b>122</b>
Bolko von Roedern	
<b>Scenarios of Defect Generation in <math>\alpha</math>-Si:H Material for Very Long-Term or Very Intense Irradiation.....</b>	<b>130</b>
M. Gorn, B. Scheppat, and P. Lechner	
<b>Degradation Rate and Saturation Defect Density in <math>\alpha</math>-Si:H as a Function of Temperature and Light Intensity.....</b>	<b>138</b>
M. Grimbergen, L. E. Benatar, A. Fahrenbruch, A. Lopez-Otero, D. Redfield, and R. H. Bube	
<b>Light-Induced Changes in Subband Absorption in <math>\alpha</math>-Si:H Using Photoluminescence Absorption Spectroscopy .....</b>	<b>146</b>
S. Q. Gu, P. C. Taylor, and S. Nitta	
<b>Capacitance Studies of Bias-Induced Metastability in <math>p</math>-Type Hydrogenated Amorphous Silicon.....</b>	<b>154</b>
Richard S. Crandall, Kyle Sadlon, Stanley J. Salamon, and Howard M. Branz	
<b>What Electroluminescence and Transient Space Charge Limited Currents Tell Us About Staebler-Wronski Defects .....</b>	<b>162</b>
K. Wang, D. Han, and M. Silver	
<b>Interface States in <math>\alpha</math>-Si:H as Probed by Optically Induced ESR .....</b>	<b>170</b>
J. Hautala, P. C. Taylor, and J. Ristein	
<b>Dependence of the Saturation Behavior of the Metastable Defect Creation on <math>\alpha</math>-Si:H Material Properties Measured by keV Electron Irradiation .....</b>	<b>178</b>
A. Scholz and B. Schröder	
<b>Accuracy of Defect Densities Measured by the Constant Photocurrent Method .....</b>	<b>186</b>
N. W. Wang, X. Xu, and S. Wagner	

#### PART IV. MATERIAL STUDIES

<b>A Reduction in the Staebler-Wronski Effect Observed in Low H Content <math>\alpha</math>-Si:H Films Deposited by the Hot Wire Technique .....</b>	<b>195</b>
A. H. Mahan and Milan Vanecik	
<b>Very Stable <math>\alpha</math>-Si:H Prepared by “Chemical Annealing” .....</b>	<b>203</b>
Hajime Shirai, Jun-ichi Hanna, and Isamu Shimizu	
<b>A Comparative Study of the Light-Induced Defects in Intrinsic Amorphous and Microcrystalline Silicon Deposited by Remote Plasma Enhanced Chemical Vapor Deposition .....</b>	<b>211</b>
M. J. Williams, Cheng Wang, and G. Lucovsky	
<b>Light Stability of Amorphous Germanium .....</b>	<b>218</b>
R. Plättner, E. Günzel, G. Scheinbacher, and B. Schröder	
<b>Characterization and Study of Light Degradation Effects in ECR <math>\alpha</math>-Si:H, Cl Films.....</b>	<b>226</b>
C. P. Palsule, S. Gangopadhyay, C. Young, T. Trost, and M. Kristiansen	

<b>Preparation and Properties of Amorphous Silicon Films Produced Using Electron Cyclotron Resonance Plasma .....</b>	<b>234</b>
Vikram L. Dalal, Ralph D. Knox, B. Moradi, A. Beckel, and S. VanZante	
<b>Studies of Light Soaking Stability in rf Sputter-Deposited <math>\alpha</math>-Si:H .....</b>	<b>241</b>
A. Wynveen, J. Fan, J. Kakalios, and J. Shinar	
<b>Light-Induced Changes in Photocarrier Transport in Magnetron Sputtered <math>\alpha</math>-Si:H.....</b>	<b>248</b>
J. R. Doyle, N. Maley, and J. R. Abelson	

## PART V. SOLAR CELL STUDIES

<b>Accelerated Light Soaking and Prediction of One-Sun Photostability in <math>\alpha</math>-Si:H Solar Cells.....</b>	<b>259</b>
T. Tonon, X. Li, and A. E. Delahoy	
<b>Light-Induced Degradation in <math>\alpha</math>-SiH Alloy Solar Cells at Intense Illumination .....</b>	<b>268</b>
A. Banerjee, S. Guha, A. Pawlikiewicz, D. Wolf, and J. Yang	
<b>Accelerated Light Degradation of <math>\alpha</math>-Si:H Solar Cells and its Intensity and Temperature Dependence .....</b>	<b>275</b>
L. Yang, L. Chen, and A. Catalano	
<b>Selecting the Band Gap for Best Long-Term Performance of <math>\alpha</math>-Si:H Solar Cells.....</b>	<b>282</b>
X. Xu, M. Kotharay, N. Hata, J. Bullock, and S. Wagner	
<b>Enhanced Surface Recombination in <math>\alpha</math>-Si:H Solar Cells Caused by Light Stress.....</b>	<b>290</b>
W. Kusian and H. Pfeiderer	
<b>Design Considerations for Stable Amorphous Silicon Based Solar Cells .....</b>	<b>298</b>
Vikram L. Dalal, B. Moradi, and G. Baldwin	
<b>Thermal Annealing of Photodegraded <math>\alpha</math>-SiGe:H Solar Cells.....</b>	<b>306</b>
M. Bennett and K. Rajan	
<b>Stability of Amorphous Silicon Solar Cells.....</b>	<b>312</b>
P. K. Bhat, D. S. Shen, and R. E. Hollingsworth	

## PART VI. SUMMARY AND CLOSING REMARKS

<b>Panel on Metastability Modeling .....</b>	<b>321</b>
W. Fuhs, moderator	
<b>Stability of <math>\alpha</math>-Si:H Materials and Solar Cells—Closing Remarks.....</b>	<b>323</b>
P. G. LeComber	
<b>Author Index.....</b>	<b>333</b>