

Area 1

Advanced Technologies for Crystalline Silicon Materials and Solar Cells

- ◆ Crystal Growth and Materials Characterization
 - Fundamental investigation of silicon crystallization has been studied for high quality multicrystalline silicon formation. (Tohoku Univ., JAXA, Kyoto Univ.)
 - Slicing technology and recycling process of silicon powder have been investigated. (Kobelco, TUAT)

- ◆ Technologies for Higher Efficiency Si Solar Cells
 - High efficiency around 23% Hetero-Junction Back-Contact cells have been realized. (LG Elec, Kaneka)
 - Many kind of emitter tailoring technologies have been studied. (ECN, NAIST, UNSW, TUAT, etc.)
 - Back Contact cells are also presented. (ISC-Konstanz, UNSW)

(continued)

- Low temperature and low cost Cu-based metallization have been investigated. (AIST, Kaneka)
- Formation methods for fine line electrodes have been demonstrated. (Motech, centrotherm, Shinsung, etc.)
- Metal Wrap Through cells have been studied. (Fraunhofer ISE, Zhejiang Univ.)

◆ Modeling, Analysis, and Characterization of Si Cells

- Detailed analysis and characterization by EL, PL, spectroscopic ellipsometry, etc. have been progressed. (Hamamatsu Photonics, Gifu Univ., NAIST, etc.)



Area 2

High Stabilized Efficiency Modules ($\sim 1.4 \text{ m}^2$)

10.8% Tandem (Oerlikon Solar from EPFL)

10.7% Tandem (Sanyo)

10.4% Triple (LG)

High Stabilized Efficiency Cells ($\sim 1 \text{ cm}^2$)

12.3% Tandem (Oerlikon & Corning (from EPFL))

12.2% Tandem (Sanyo)

New Light Trapping Techniques

Multi Scale Textures (Asahi Glass, EPFL, TIT, Delft univ., etc.)

Refractive index control for anti-reflection/high-reflection/

New index for very high Haze (Texture morphologies, Angular-distribution)

New Material Concepts

Divacancy model for a-Si

SiO_x window layers

New process for thin film crystalline silicon

Nano-Ink electrodes, BaSi₂ active layers, etc.



Area 3

CIS, CdTe and Other (II-VI) Thin Film Solar Cells

Plenary

History of R&D and manufacturing plan of SF (Dr. Kushiya)

Cell Technology

R&D activities in Korea (KIER)

Behavior of Na during three stage process (HZB)

New materials ZnCuInS_2 , $\text{Cu}(\text{Al}, \text{In})\text{S}_2$, CuIn_3Te_5 and

$\text{Ag}(\text{In}, \text{Ga})\text{Se}_2$

Module Technology

Module ($90 \times 120 \text{cm}^2$) with $\text{Eff}_{\text{AA}} = 15.76\%$ (Solar Frontier)

Monolithically-integrated submodules

on zirconia (15.9%) by AIST

on stainless steel (15.0%) by FUJIFILM

Printing technique for grid formation at LT (DNP)

(continued)

Characterization

Role of oxygen in Zn- and In-based buffer (Kagoshima Univ.)

Atomic reconstruction of Cu-In, O-S at the grain boundary (HZB)

Optical absorption coefficients small? (Gifu Univ.)

Cu-Se phase observed for high Ga-CIGS (Tsukuba Univ.)

Special Session: Potential of CIGS and new Materials for GW production

Current status and prospects of CZTS solar cells (IBM)

$\eta=18.7\%$ flexible solar cell on PI at LT (EMPA)

History and critical issues of CZTS solar cells (NNCT)

CZTSSe

$\eta=8.09\%$ submodule with aperture area 14.9cm^2 (Solar Frontier)

Various deposition techniques reported.



Area 4

New world record of 36.9% (AM1.5G, 1sun) and over 43% (~500suns) were achieved with Inverted triple-junction by Sharp Corp.

Constructive discussion on

- advanced concepts such as “Inter-Mediate-Band” and “Hot-carrier”
- measurement of effectiveness on quantum wells or dots sub-bands

Productive discussion on optimal solar cell or module structures with consideration of usage environments for CPV or space applications



Area 5

DSC, OPV , and Nanostructured PVs

Invited: 9. DSC: 74 (oral 19), OPV:56 (oral 8), Nanostructured PV: 50 (oral 11)

Total: 189

Summary

High efficiency, low cost, stability, large modules, plastics, I₂ free electrolytes, Quantum dots, Pt free counter electrode, solidifications, antireflective, fabrication of nanostructures and their characterizations. TCO layers.

Efficiency: DSC cell 11-12%, Module: 8.1% monolithic, Iodine free, 7.9%.

Special session on OPV: 5.5% (Phase segregation control, Toray), 8.1 % (IR polymer by Sumitomo Chem.), **10% certified (Development of IR materials Mitsubishi Chem.)**, 5.1 % (Development of ETL material JX), -1000nm, (IR polymer, University of Tokyo,

Each item

●1C-5I-01: H. Segawa The University of Tokyo

Aiming at high efficiency. Development of new IR dyes. Tandem 11.3 %. 10%

●1C-5I-02: K. C. Ho. National Taiwan University

Aiming at low cost DSC. Pt-less electrode. Polymer conductor ::7.88 %:

●1C-5O-05: N. Kato Toyota Central R & D Lab.

Aiming at high stability. Ru complexes had better durability than organic dyes.

●1C-5O-06: H. Arakawa. Tokyo University of Science.

Aiming at high efficiency: Light confinement structure. 11.6 % efficiency.

●1C-5O-02: L. Han. NIMS

Aiming at high efficiency: Combination of dyes and co-adsorbent : 11.4% (certified)

(continued)

●4A-PL-01: Y.-B. Cheng. Monash University.

Aiming at plastic DSCs. Isostatic pressure method for plastic DSCs. 6.3% efficiency

●3C-5I-01: Tingli Ma, Dalian University of Science.

Aiming at low cost and durability: Pt free low cost counter electrode for DSCs: 7.5 %.

Establishing a venture company on DSC fabrication.

●2C-5O-08: R. Komiya, Sharp

Aiming at high efficiency modules: 8.1 % efficiency (24.2 cm²) monolithic.

●3C-5O-02: S. Moribe, Toyota Central R&D Center.

All solid dye sensitized solar cells with CuI. 6% Efficiency.

●3C-5O-08: H. Ookita, Kyoto University

Aiming at high efficiency: Concept on dye-sensitized OPV.

●3D-5P-27: M. F. Budiman Tohoku University.

Fabrication of 2D-array of Si Q-DOT.

●2D-5P-46: N. Watanabe Tokyo University of Science.

Fabrication of flexible DSCs by Roll pressure. 6.4%

●2D-5P-19: A. Kikuchi, Waseda University

Iodine free electrolyte, 7.9%

●2D-5P-40: Y. Okuyama, Tokyo University of Science

Surface passivation: 10.7%,

●4D-5P-42: L. He,

Si nanowires/organic hybrid solar cells. 10.3% efficiency.



Area 6

- Sources of uncertainty in energy rating have been shown to be the degradation rate, method of parametrization, and the in-plane irradiance estimation.
- The accuracy of different I-V curve translation methods has been demonstrated based on experimental I-V curves of various kinds of PV modules.
- Performance measurement of III-V multi junction PV devices, such as solar simulators, spectral responses, EL and spectrometry, has been demonstrated.
- Issues in PV integration to the grid are discussed and solutions are presented in the areas of ;
 - Voltage control in distribution network
 - Fluctuation and smoothing effect
 - Forecast
 - Islanding protection
 - Fault-Ride-Through
- Reliability of PV modules are discussed. Novel module structures and materials for high reliability PV modules are proposed. Quantitative discussion on reliability of PV modules is carried out. Degradation mechanism by destructive analyses of PV modules exposed outside for long years is clarified. Novel reliability test methods are developed for judgment of real lifetime of PV modules or for shortening test time.



Area 7

PV Deployment

- **R&D programs:**
 - US Sunshot Initiative, M. Le, DOE
 - Germany R&D, L. Wissing, Project Management Jülich,
- **Market trends and cost analysis:**
 - 2011 installed capacity: 22GW, P. Mints, NAVIGANT
 - 2011 top3 countries: Italy:6-8GW, Germany:4.5-5.5GW, China : >2 GW
 - 2012 will be adjustment period, consolidation will advance
 - Significant price down → Grid parity is close!
 - Still x-Si has potential for cost down, T. Saito, TUAT
 - Local production of CPV, K. Araki, Daido Steel
- **Importance of sustainability – Environmentally friendly approach:**
 - Efforts of PV Cycle in EU, K. Wambach, Sunicon
 - Countermeasures for toxic material, J.H. Werner, University of Stuttgart
- **Special session on the industry: PV in Asia (TPVA, KOPIA, JPEA)**
 - Vertical vs Horizontal consolidation and differentiation
 - Government support is still important after grid parity: R&D, etc.
 - Strategies to survive in tough environment