The Introduction of High Efficiency Si Thin Film PV

NexPower R&D

Peter Bi

Outline

- NexPower Introduction
- High Efficiency Thin Film PV Concept
- Si Thin Film PV Competitors Benchmark
- High Efficiency Si Thin Film PV Development
- Summary

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NexPower milestones





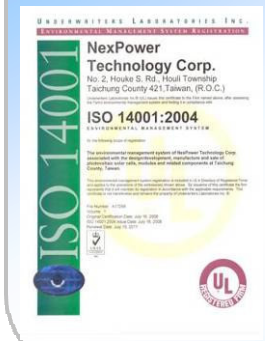

- 2007/06: Fab-1 Ground-Breaking
- 2008/05: Fab-1 Mass Production & Grand-Opening
- 2008/07: IEC & ISO certified
- 2009/04: Fab-2 Mass Production
- 2009/04: UL certified & CEC listed
- 2009/07: PV CYCLE Association Membership
- 2009/08: Product Insurance by Munich Re
- 2009/10: Tandem Module Mass Prod. (Eff.= 8.5%)
- 2010/09: Tandem Module Mass Prod. (Eff.= 9.4%)

Certificates

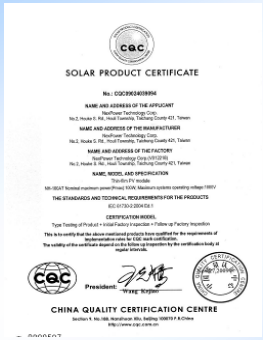
IEC CE

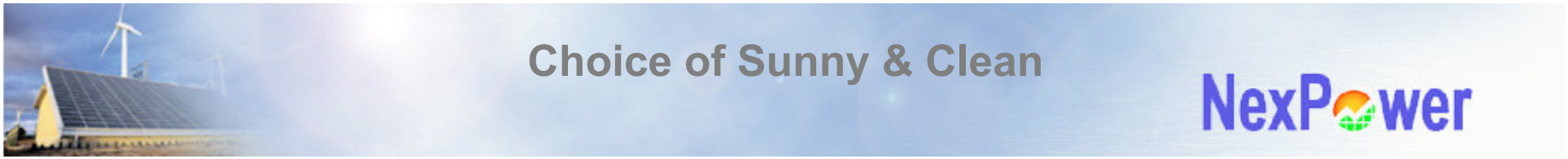
Underwriters Laboratories

ISO International Organization for Standardization



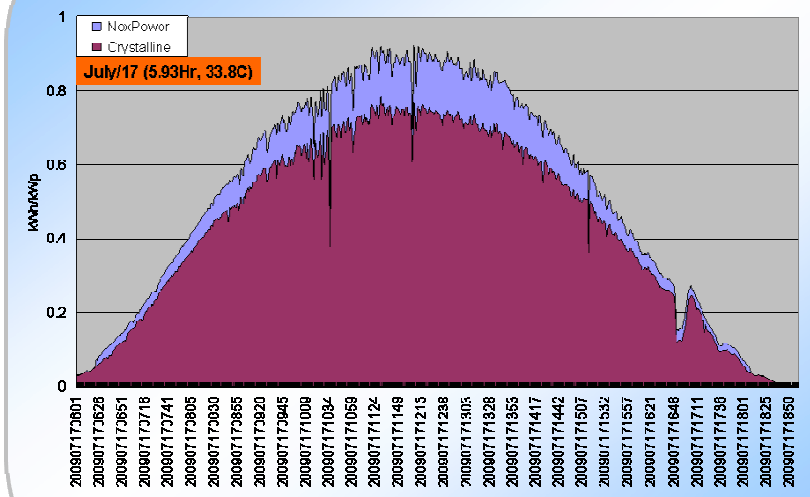
CQC





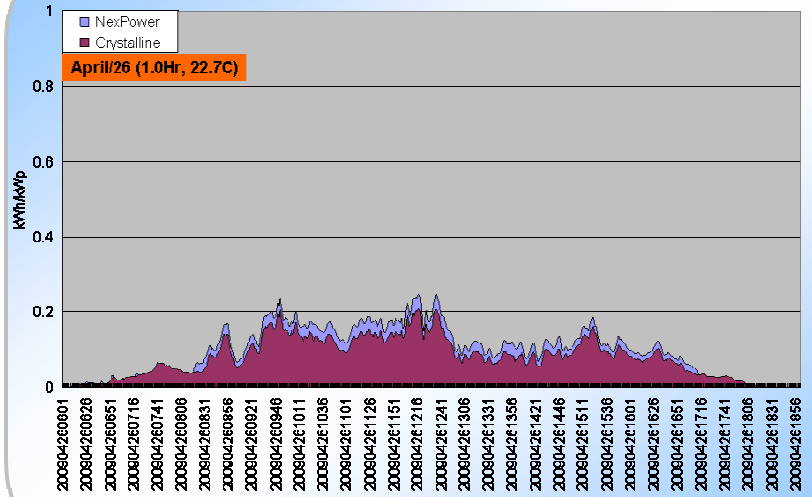
Field test

High °C (33.8°C)



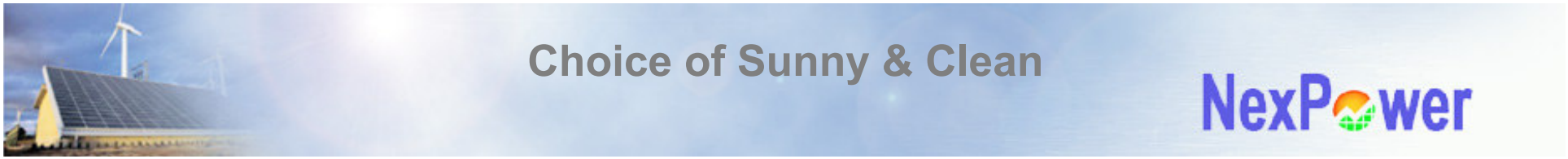
NexPower vs. Crystalline: 17.4% more

Cloudy (1.0Hr)



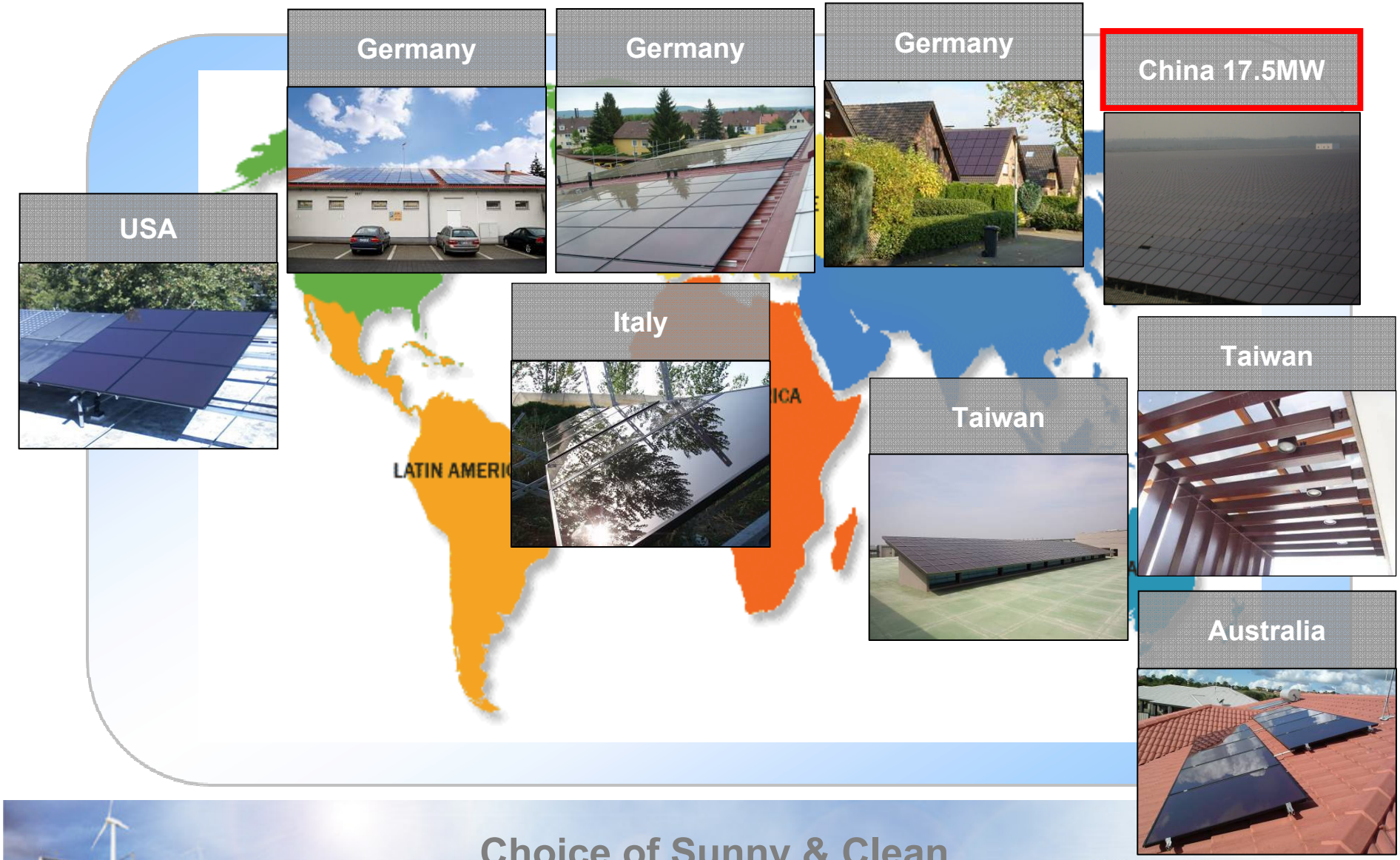
NexPower vs. Crystalline: 17.9% more

1. **Thin-film performance is better than crystalline at the higher temperature area.**
2. **Thin-fim performance is better than crystalline at weak light condition.**



PV module installations _ Europe

PV module installations _ Worldwide



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For Further Information

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www.nexpw.com

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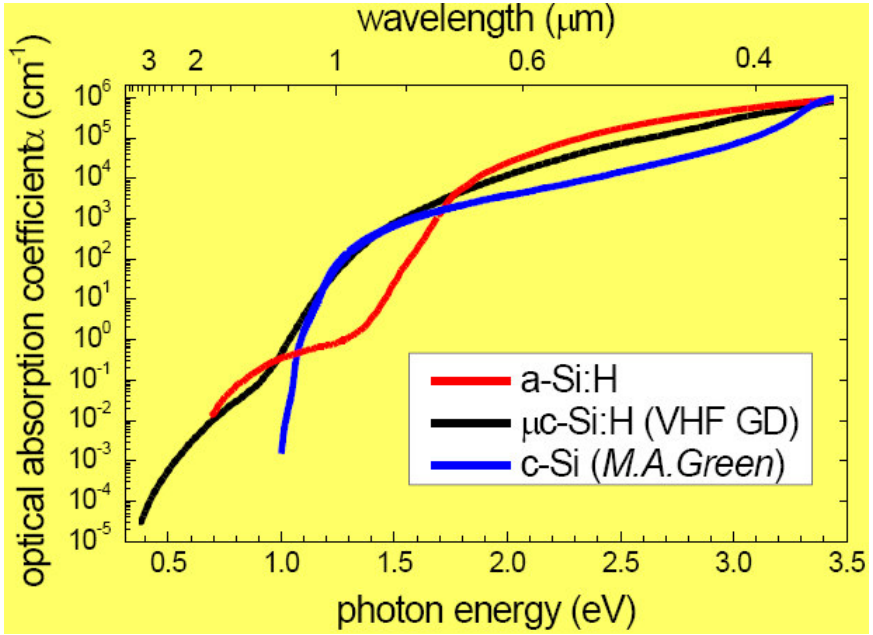
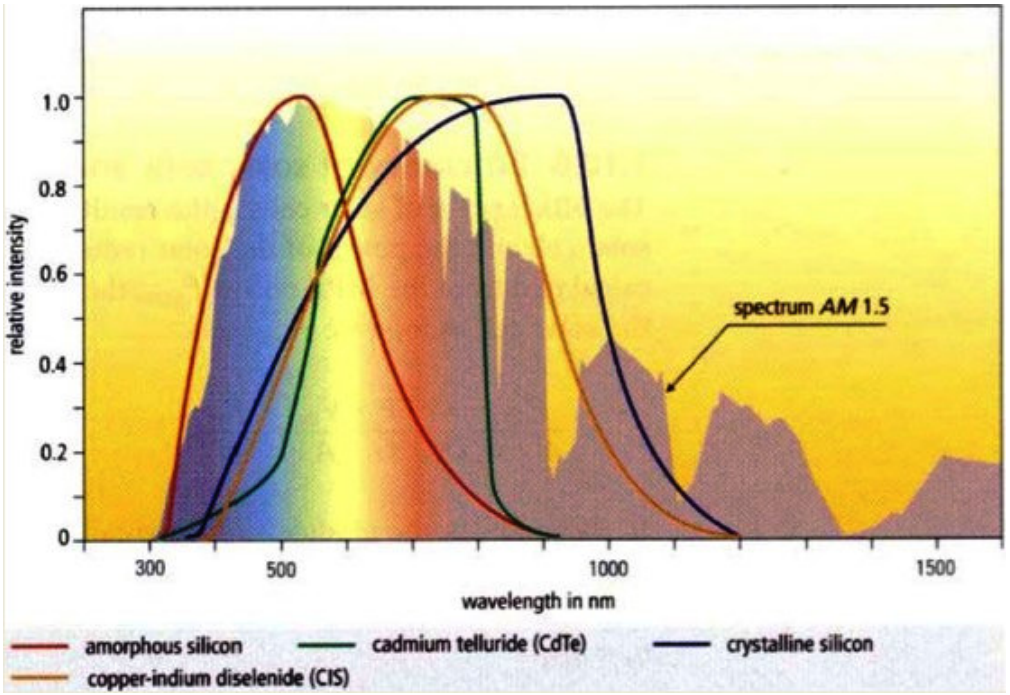
PV absorber characteristics

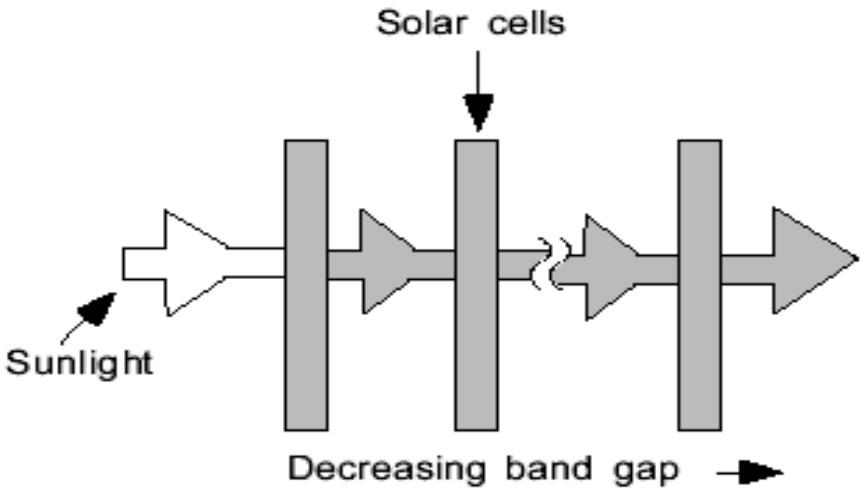


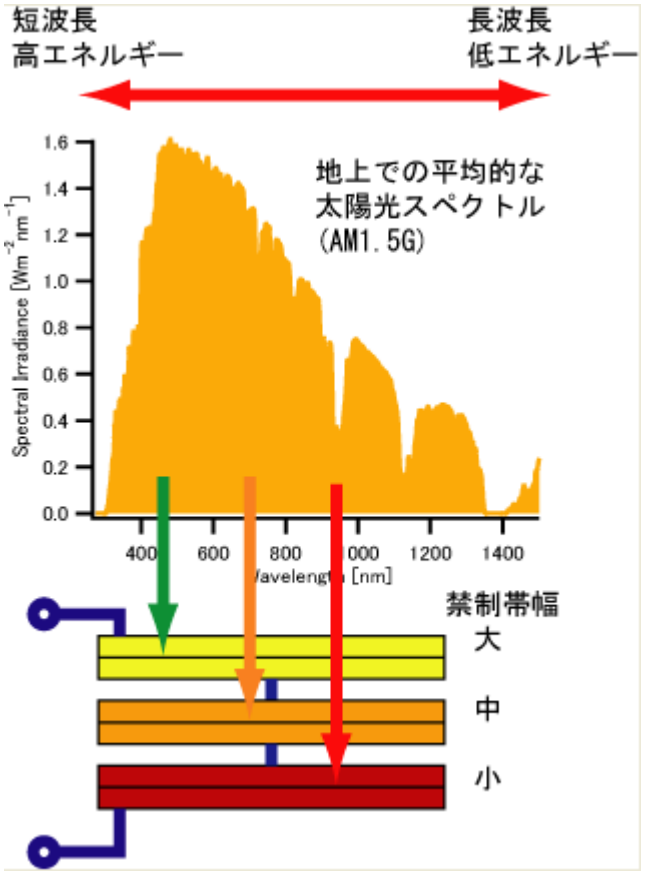


Why Si thin film material

- **No material shortage issue**
- **Eco-friendly**
- **Low cost**
- **Easy adjustment of band gap by PECVD process (a-SiC, a-Si, a-SiGe, uc-Si & uc-SiGe)**

High efficiency thin film PV concept _ Multi-junction design

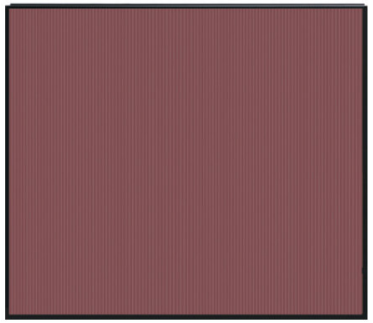




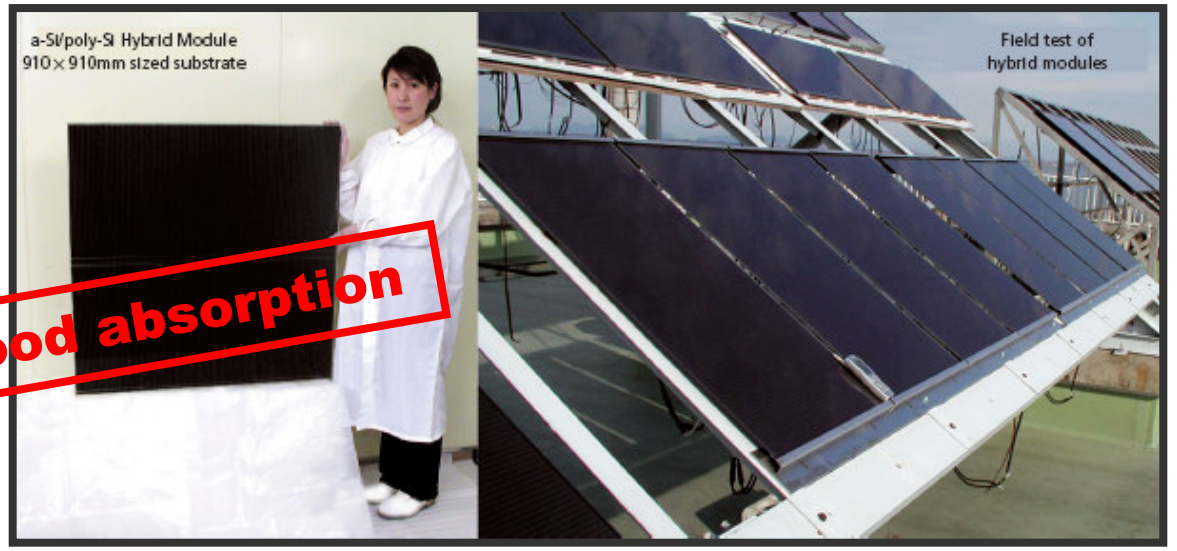
☞ **The efficient use of the solar light - - > Efficiency upgrade**

Single junction vs. double junction PV module

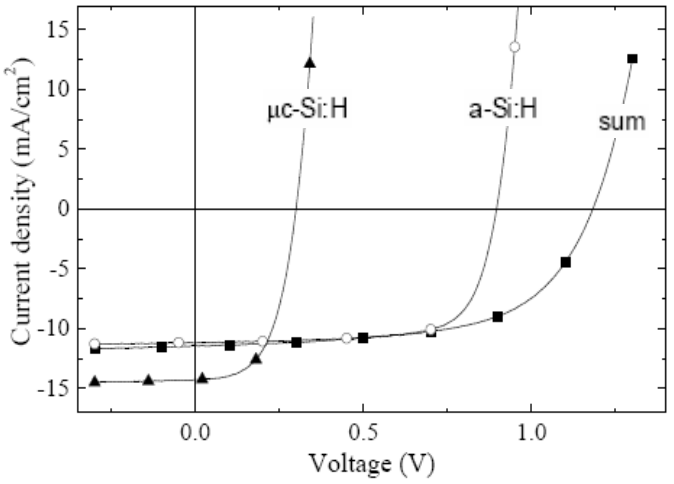
Single a-Si

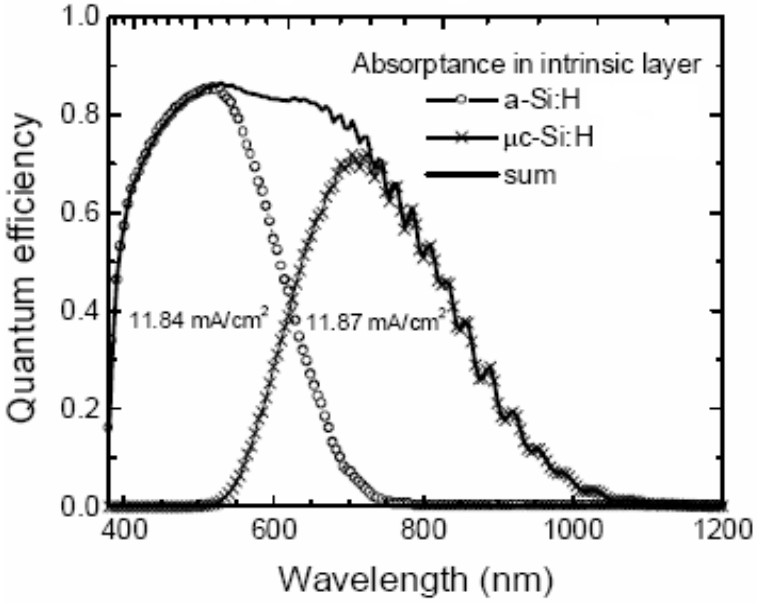


Double a-Si/uc-Si



High efficiency thin film PV concept _ Current matching





☞ **Multi-junction PV Jsc ~ the cell with the smallest Jsc**

☞ **Current matching - - > Efficiency upgrade**

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Competitors benchmark

Maker	MHI	Kaneka	Sharp	NexPower
Structure	a-Si/uc-Si	a-Si/uc-Si	a-Si/uc-Si	a-Si/uc-Si
Product Type	MT-130 ~ 135	U-EA100 ~ 120	NA-F121 ~ 135	NT-135 ~ 145AX
Module Size	1400x1100	1200x1000	1400x1000	1400x1100
Efficiency	8.4 ~ 8.8%	8.2 ~ 9.8%	8.5 ~ 9.5%	8.8 ~ 9.4%
Main product	MT-130 8.4%	U-EA110 9.1%	NA-F128 9.1%	NT-140AX 9.1%
Status		Next G : 1400x1100 2J 160W 10.4%	2011 3J 140W 10%	2011 2J 154W 10%

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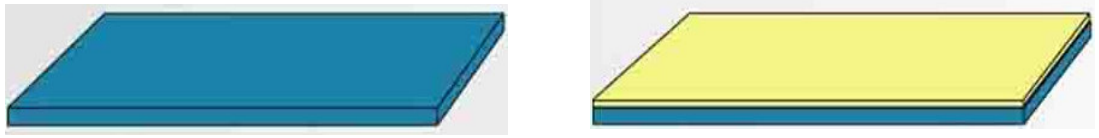
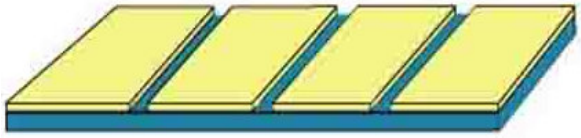
PV module process flow

Step 1: Glass Preparation
One sheet of clear float glass (the "cover glass"), and one sheet of tin oxide coated glass (the "plate glass") are seamed and washed. A hole for the electrical leads is drilled in the cover glass.

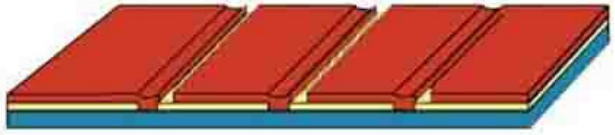


Step 2: Tin Oxide Patterning
A laser scribes the tin oxide layer on the plate glass.

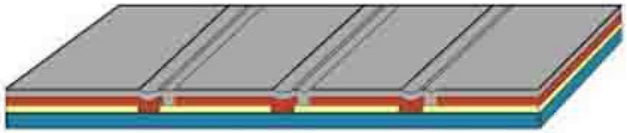


Step 3: a-Si Deposition
Six active thin-film semiconductor layers are deposited.

Step 4: a-Si Patterning
A laser scribes the deposited silicon layers.

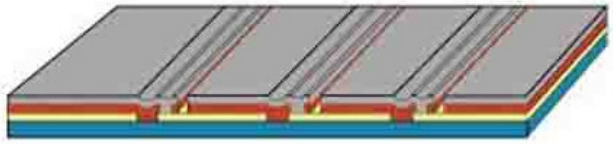


Step 5: Aluminum Deposition
The aluminum rear electrode is deposited.



PV module process flow

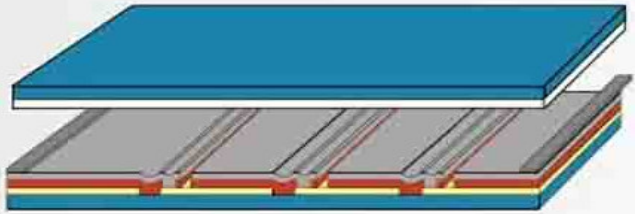
Step 6: Aluminum Patterning
A laser scribes the deposited aluminum layer.



Step7: Plate Testing
Plates are sampled and light tested for quality control purposes.

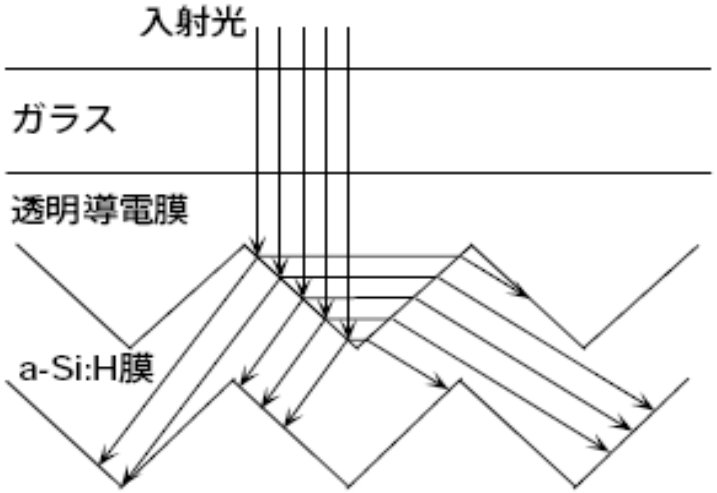
Step 8: Heat Aging
Plates are sampled and heat aged for quality control purposes.

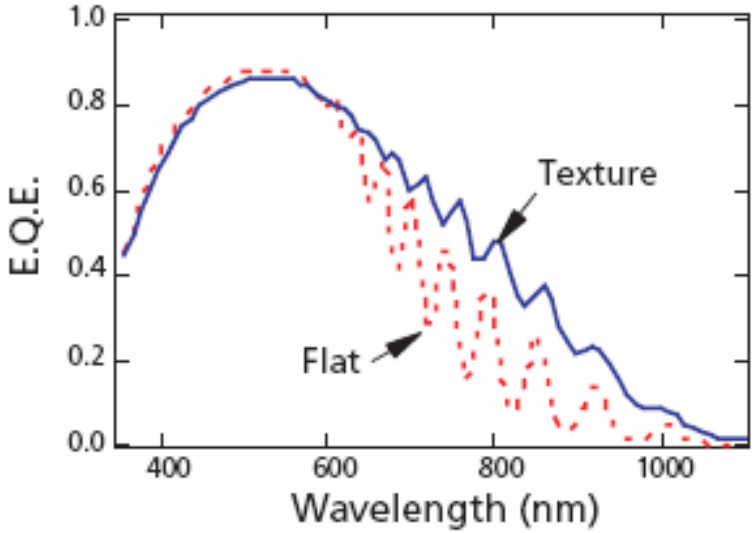
Step 9: Encapsulation
The active thin-film area on the edge of the plate is removed, and aluminum foil strips are bonded to the deposited aluminum layer. A layer of ethyl vinyl acetate (EVA) and the cover glass are added to the plate to protect it from the environment. Electrical connections and mounting brackets are also added.



Step 10: Module Testing
The light tester is used to test the finished modules.

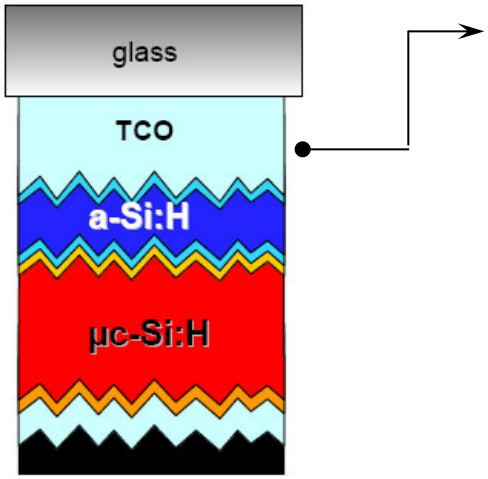
Light management _ TCO glass





- **Light path increase**
- **Second incidence**

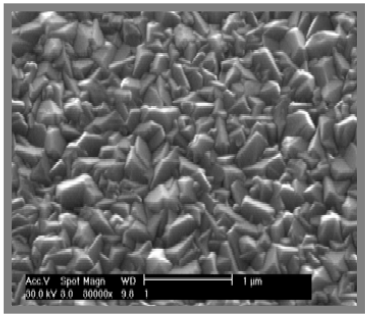
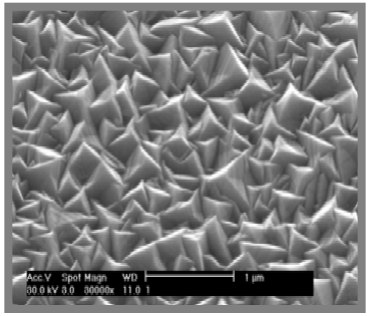
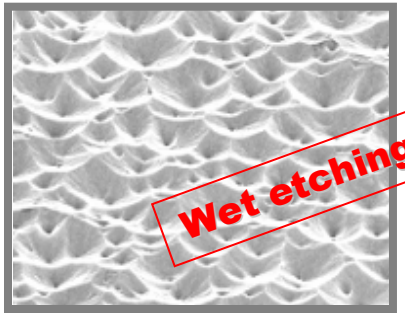
Light management _ TCO glass



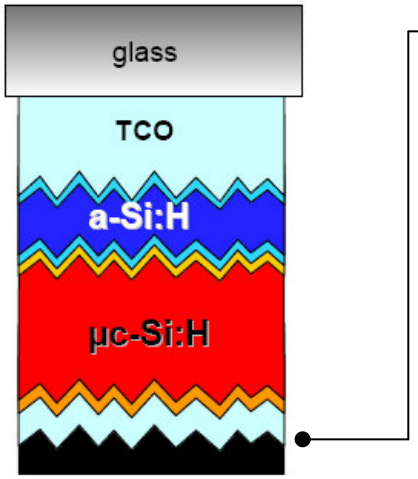
Quality request

- VIS-IR light transmittance
- Film sheet resistance
- Haze & ADF
- Device match

MP Technology

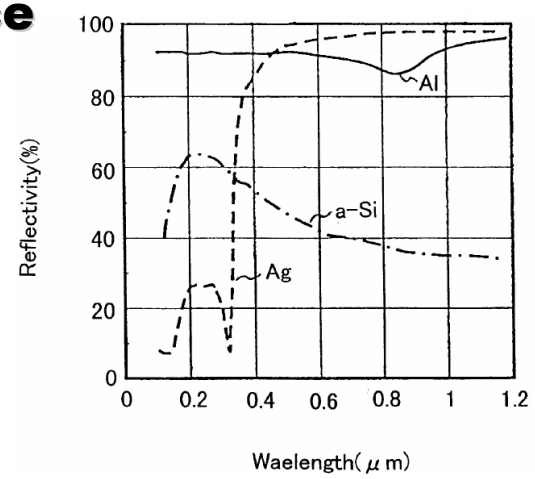
APCVD	LPCVD	Sputter
		

Light management _ Back electrode

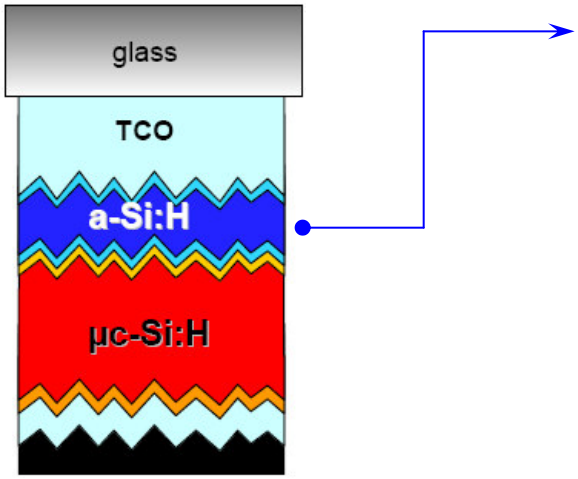


Quality request

- **TCO layer**
  - ✓ **Low absorption**
  - ✓ **Suitable morphology (light scattering)**
- **Back electrode**
  - ✓ **Reflection performance**
  - ✓ **Good coverage**



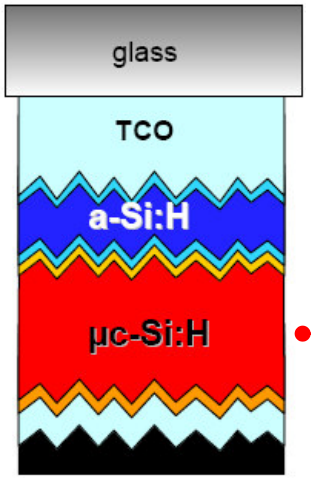
Absorber quality _ Top cell



Quality request

- ☞ **p window layer**
  - ✓ **Low absorption (band gap > 2.0)**
  - ✓ **Multi-layer structure**
- ☞ **i layer (200~250nm)**
  - ✓ **Good absorption (band gap < 1.75)**
  - ✓ **Better LID (10 ~ 13%)**
- ☞ **n layer**
  - ✓ **uc-Si structure**
  - ✓ **Tunnel junction**

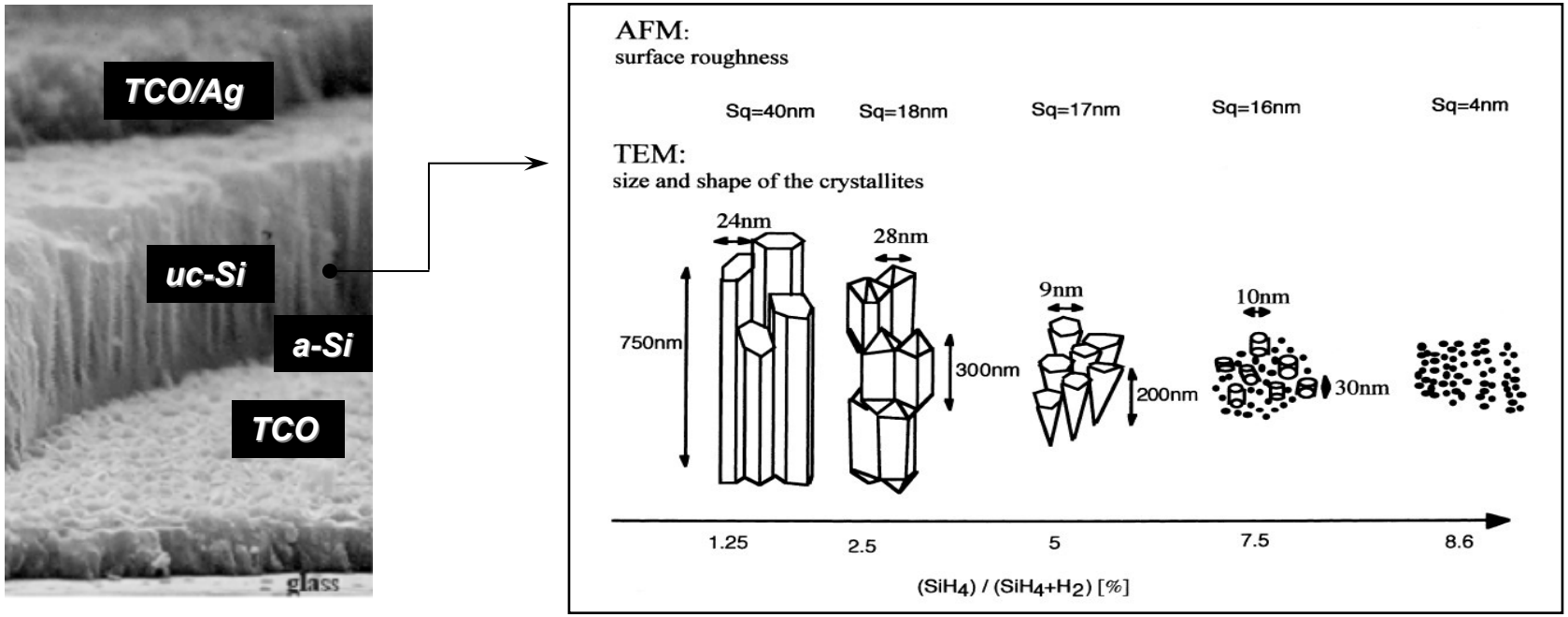
Absorber quality _ Bottom cell



Quality request

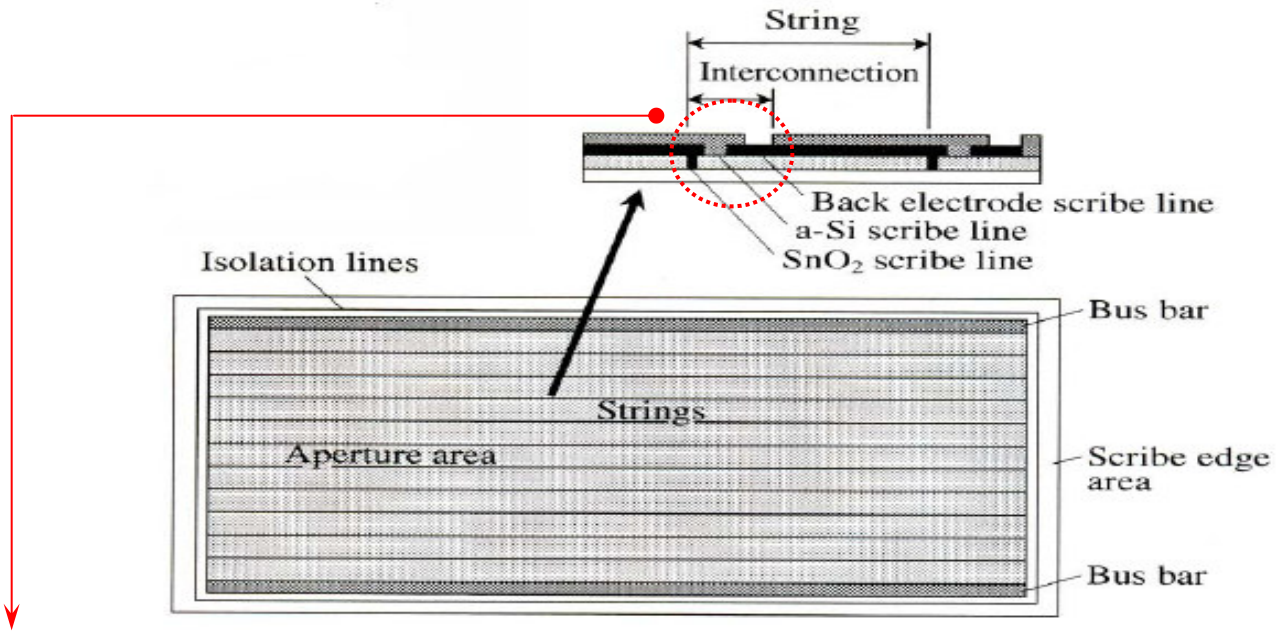
- ☞ **p layer (< 20nm)**
  - ✓ **Tunnel junction**
  - ✓ **Enough crystallinity**
- ☞ **i layer (1.8~2.2um)**
  - ✓ **Crystallinity control**
  - ✓ **Better orientation**
  - ✓ **DR upgrade (> 5Å/sec)**
- ☞ **n layer**
  - ✓ **Multi-layer structure**

Absorber quality _ Bottom cell



- ✓ **Crystallinity & orientation control of uc-Si layer**
- ✓ **a-Si-incorporated uc-Si (defect passivation)**

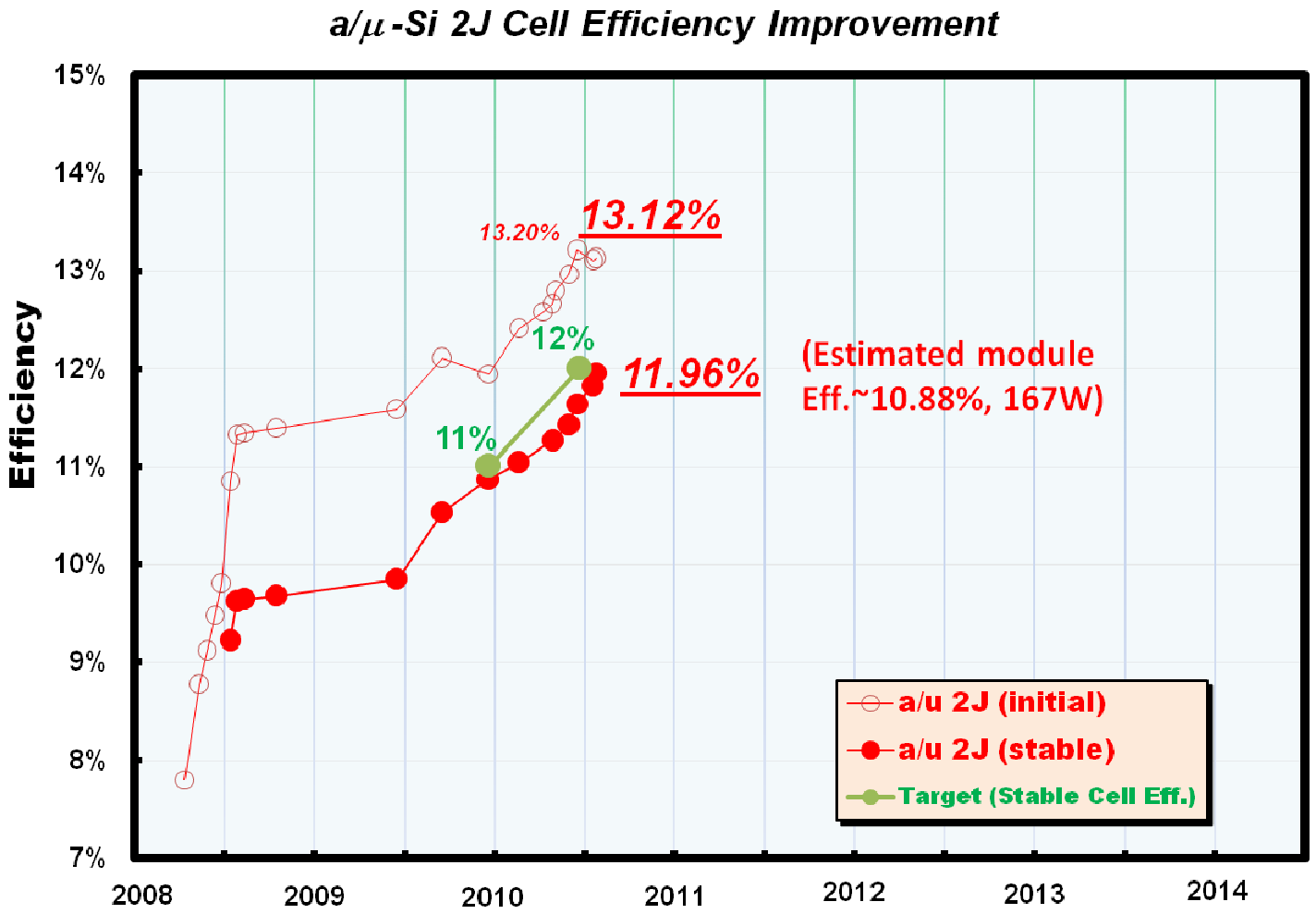
Laser scribing control



Laser dead area reduction

- **Accuracy upgrade**
- **Linearity improvement**

NexPower R&D development status



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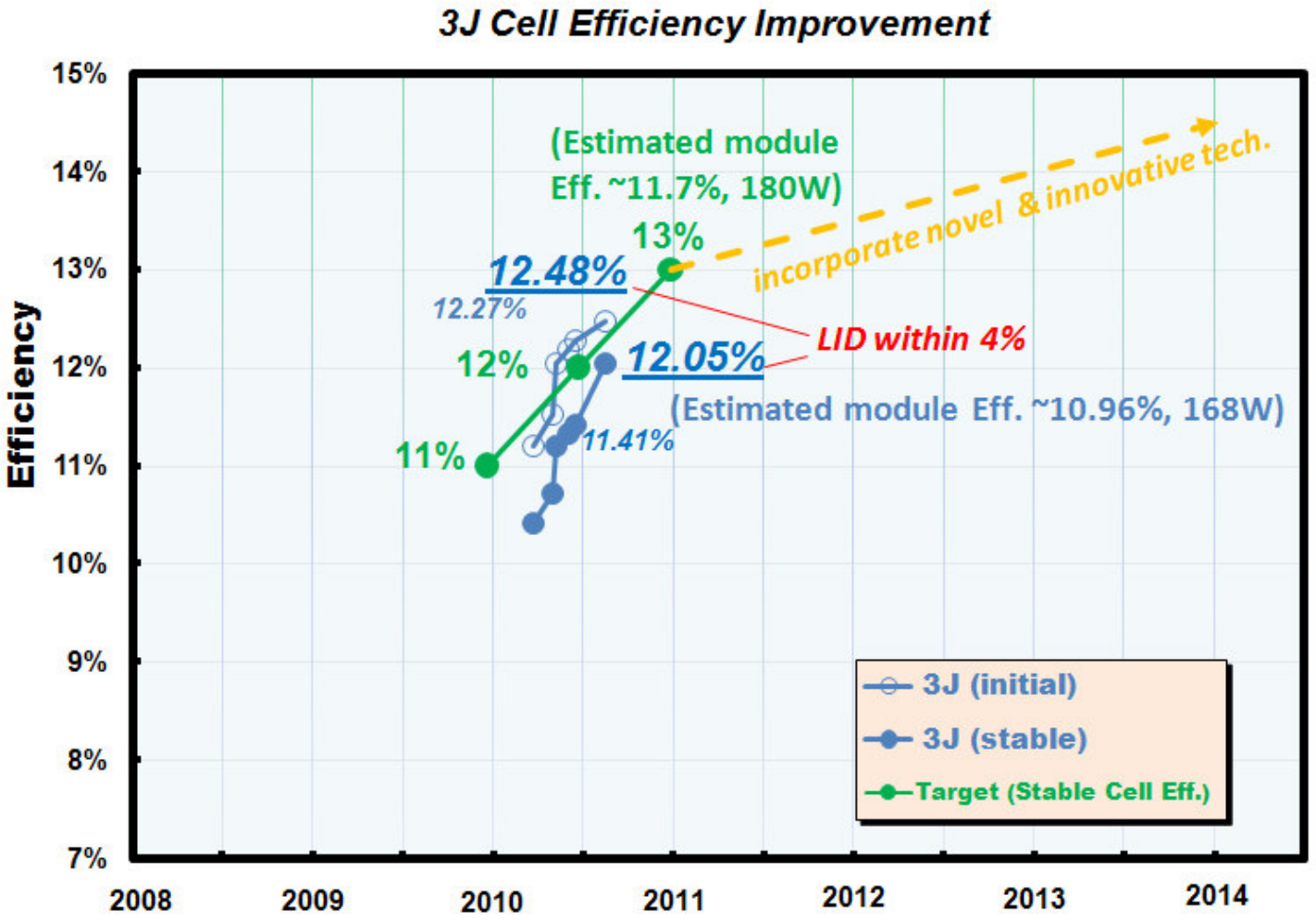

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NexPower development status

- a-Si/uc-Si tandem cell stable Eff. 11.96%
- Triple junction cell stable Eff. 12.05%
- a-Si/uc-Si tandem module stable Eff. 9.6%

Future work

- Cell function transfer to module
- HDR uc-Si (> 7Å/sec)
- Light trapping structure development

~ END ~

Thank you for your attention & patience

Welcome to Join NexPower