




I' REE 에너지환경연구소 | Thin Film Technology Chances and Risks

General Market trends

- PV market shows still a very attractive growth rate (>40%) in the next years
- Solar panels tend to lower prizes in 2009
- Market forecast shows trend for overcapacity in 2011/12
- Market growth for thin film shows huge upside potential
- Many new subsidy programs started or are revised in different countries
- Due to lower manufacturing cost grid parity is expected in 2011/12

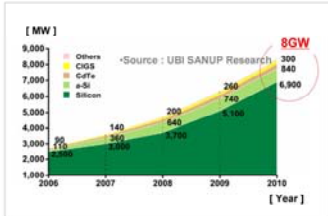
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Thin Film Technology Chances and Risks

Global Market forecast



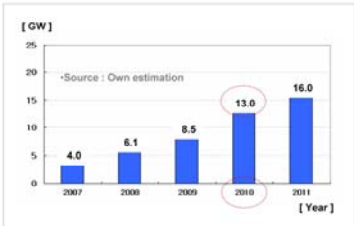
[MW]

-Source : UBI SANUP Research

8GW

300 840 6,900

2006 2007 2008 2009 2010 [Year]



[GW]

-Source : Own estimation


4.0 6.1 8.5 13.0 16.0

2007 2008 2009 2010 2011 [Year]

- Wide spread of market forecast data from 8 to 18 GW
- Very difficult to verify a prediction

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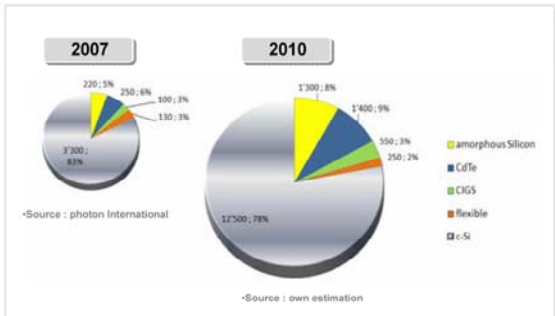
03



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Thin Film Technology Chances and Risks

Market share Thin Film and crystalline technology



2007

220 : 5%
250 : 6%
500 : 8%
130 : 3%
3,300 : 83%

-Source : photon International

2010

1,300 : 8%
1,400 : 9%
550 : 3%
250 : 2%
12,500 : 78%


-Source : own estimation

- amorphous Silicon
- CdTe
- CIGS
- flexible
- c-Si

- Crystalline silicon will remain the main stream
- Market share of thin film is expected in a range of 20-25% in 2010
- Demand for thin film panels is still difficult to estimate

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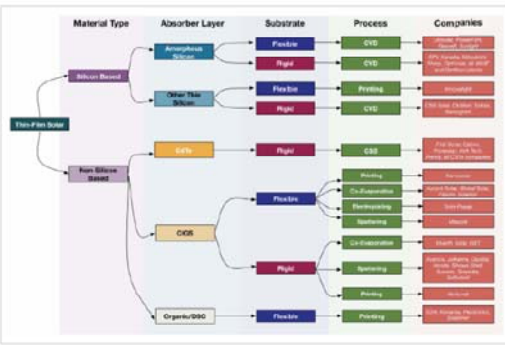
04



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Thin Film Technology Chances and Risks


Classification of Thin Film Technology



- Thin Film technology is divided three main technologies CIGS, CdTe, a-Si
- Organic cells are still in R&D Phase
- Flexible cells becomes more and more important

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05



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Thin Film Technology Chances and Risks

Market share Thin Film technology

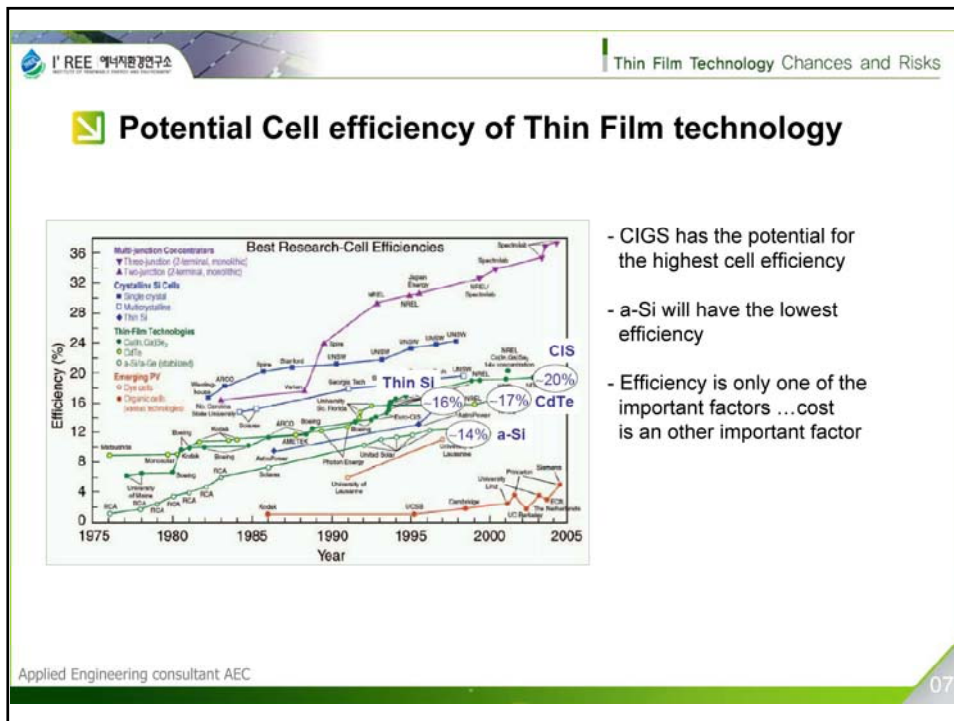
		2007 Production (MW)	2008 Estimated Production (MW)	2010 Estimated Production (MW)	2012 Estimated Production (MW)
Projected	CdTe Projected Production	206	455	1,096	1,173
	a-Si Projected Production	204	434	2,192	5,201
	CIGS Projected Production	27	142	912	3,088
	Emerging 3rd Gen Projected Production	5	15	58	145
	Total Thin Film Projected Production	442	1,046	4,258	9,607
Potential	CdTe Potential Production	206	466	1,279	1,553
	a-Si Potential Production	204	708	4,809	11,700
	CIGS Potential Production	27	204	1,556	5,018
	Emerging 3rd Gen Potential Production	5	73	257	540
	Total Thin Film Potential Production	442	1,450	7,901	18,819

*Source : Greentech Media Inc.

- Amorphous Silicon has the highest growth potential => Technology synergy from LCD
- CIGS and CdTe still need dedicated R&D teams => very view synergy form other technology
- CIGS and CdTe has today a limited scalability
- Huge upside potential

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06




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Technology comparison

	a-Si/mc-Si	CdTe	CIGS
Efficiency %	5 / 9	9.5 - 10.5	12
Manufacturing cost	Low / Medium - High	Low - medium	High
Technology	- a-Si easy => synergy form LCD - mc-Si difficult => scalability	- difficult for scalability - only FS with mass production experience - high temp. Process steps	- difficult for scalability - several company start with mass production - high temp. Process steps
Equipment Supplier	Up to 8 turn key supplier	Only single Equipment supplier	Single supplier, one turn key supplier
Material supplier	Easy access, almost no limitation	Cd Toxic material, limitation Tellurium supply	CdS, limitation Indium supply
Chances	Lower cost, synergy from LDC, easy scalability	Potential for lowest cost, efficiency up to 12%	Highest efficiency >14%
Risk	mc-Si layer to achieve 10% eff. , too high investment cost for mc-Si	Recycling of panels, supply Tellurium, scalability	High manufacturing cost, scalability

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08



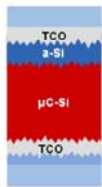
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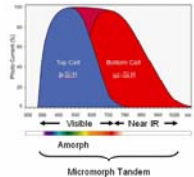
Amorphous silicon



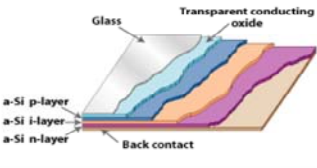
Amorph Single Junction



Micromorph Tandem Junction




Up to 50% More energy absorbed



- 8 Supplier can offer this technology as turn key (AMAT, OC, Ulvac, Energo, JEL, LO, EPV, Anwell)
- Sharp, Kaneka, Mitsubishi develop their own equipment
- Tandem or triple Junction are under development => target is 10% Eff. or higher

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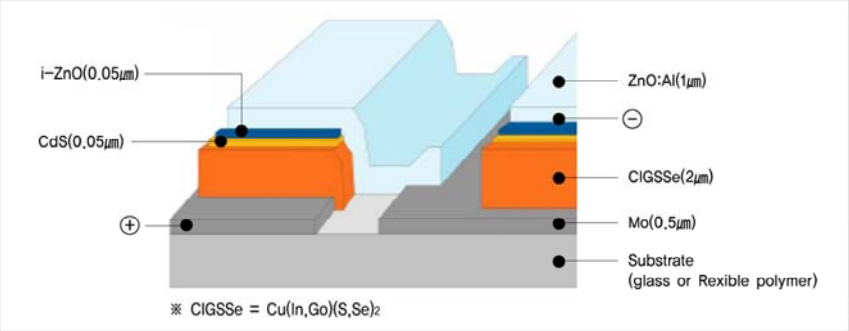
09



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Copper Indium Gallium Selenium (CIGS)




※ CIGSSe = Cu(In,Go)(S,Se)₂

- 1 Supplier can offer this technology as turn key (Centrotherm)
- Most of the panel producer today has their own Equipment supplier
- Today the manufacturing cost are too high

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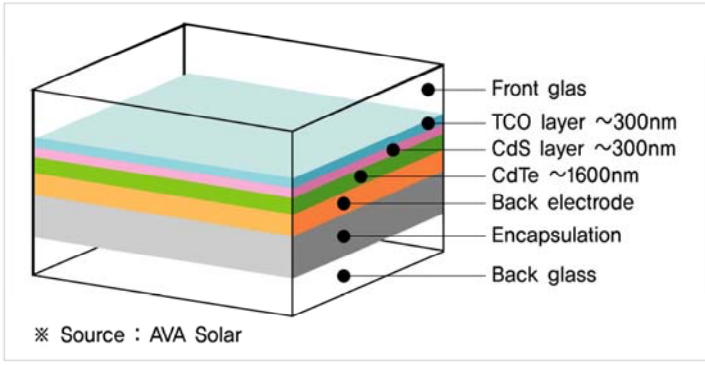
10



Thin Film Technology Chances and Risks

Thin Film Technology Chances and Risks

Cadmium Telluride (CdTe)




※ Source : AVA Solar

- No Supplier can offer this technology as turn key
- First Solar today is the only company with successful mass production experience
- Many new start up companies try to enter the market

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11

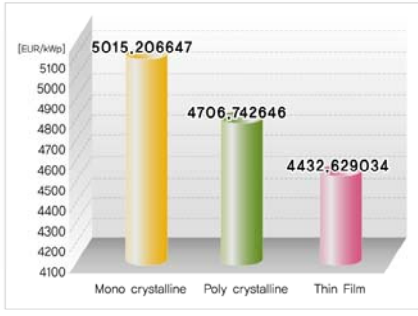


Thin Film Technology Chances and Risks

Thin Film Technology Chances and Risks

Why Thin Film is attractive

Specific Investment costs



Technology	Specific Investment costs [EUR/kWp]
Mono crystalline	5015.206647
Poly crystalline	4706.742646
Thin Film	4432.629034

FIRR



Technology	FIRR
Mono crystalline	0.0585
Poly crystalline	0.0687
Thin Film	0.0937

- Lower investment cost leads to higher financial Internal Rate of Return
- Lower temperature coefficient leads to higher output (~0.2%/°C compare to ~0.4%/°C)
- Better low light condition behavior

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12

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Why Thin Film is attractive

Crystalline Silicon Module

Shade

None of the circuits function when any of module's cells fail to generate electricity.

CIS Thin-Film Module

Shade

Output is temporarily reduced by partial shade, but the effect on the entire module is slight.

- Less sensitive to shadows

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13

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Conclusion

- Thin Film Technology becomes very attractive for large areas and low light condition
- a-Si technology will have the highest growth in the next 3 years
- CIGS has a high chance to compete with a-Si
- The manufacturing and investment cost today are far too high but there is a realistic potential to lower the cost significantly
- New technologies like flexible cells or organic cells becomes more attractive
- Crystalline Silicon will remain the main stream technology in absolute numbers

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14