Solar Photovoltaics

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Materials Supply Chains in the UK Power Generation Sector 1st May 2008
Summary of presentation

- The global expansion in PV industry
- The cost barrier to adoption
- The industry supply scene in PV Solar Energy – do we have a PV industry in the UK?
- The PV Supergen research project and second generation thin film PV
- Conclusions
Quote from European PV industry road map

• Solar cells, the basic elements of photovoltaics (PV), convert light energy directly into electric energy. This one step process is clean and absolutely emission-free: it is a modular electricity source that can be installed in every power size from microwatt to multi-megawatt scales. Therefore, it is ideally suited for distributed generation of electricity near the user, everywhere around the globe.
The global expanding PV industry

Over 90% current PV production is crystalline Si, thin film is set to take a larger share.

In 2001 46% was on grid domestic. Predicted to become 66% in 2010.
Who is buying PV?

2006 PV Installations By Market
Total: 1744 MW

- USA: 8%
- Japan: 17%
- Germany: 55%
- ROE: 11%
- ROWW: 9%

Source: Marketbuzz 2007

Large adopters use favourable feed-in tarriffs

Sales in 2005
- Japan, 30%
- USA, 9%
- Europe (ex Germany), 8%
- Rest of World, 14%
- Germany, 39%
The energy price profile

From European PV Industry Association Road Map
How to reduce cost of PV production

Current thin film

Current wafer silicon

Very large scale – materials cost dominate

Cost model of Dieter Bonnet for thin film CdTe solar modules PV21
Wales as a centre for PV industry

- **Sharp** (crystalline silicon) in North Wales; [www.sharp.co.uk](http://www.sharp.co.uk)
- **G24i** (dye sensitised) in Cardiff-capital of Wales: [www.g24i.com](http://www.g24i.com)
- **Solar Century** (PV roof tiles and installation) in south Wales: [www.solarcentury.co.uk](http://www.solarcentury.co.uk)
- **Dulas** (PV systems and installation) in West Wales: [www.dulas.org.uk](http://www.dulas.org.uk)
- **Epod Solar Wales** (thin film silicon) South Wales: [www.epodsolar.com](http://www.epodsolar.com)
- **PV Systems** (Installers) South Wales: [www.pvsystems.com](http://www.pvsystems.com)
- **Dysol** (dye sensitised) European Centre in OpTIC Technium
- **Corus Colours** (PV coatings on sheet steel)
Sharp the world’s leading manufacturer

Sharp module factory near Wrexham now manufacturing 220 MW per year for the European market.

Eden Centre, Cornwall

CIS Tower, Manchester
Solar Century PV roof tile
The PV façade at OpTIC Technium demonstrates novel thin film CIGS technology 1000 m² generating up to 85 kWp of completely clean energy. Largest of its kind outside US.

In the first 12 months of operation a total of 65,000 kWh of clean electricity was generated, saving 28 tonnes of carbon emissions from fossil fuelled power stations.
PV Road map for Wales

• Recognises importance of developing PV industry while increasing PV adoption.
• The WOF Photovoltaics group believes that a target of at least 10% of renewable energy generated via PV in Wales by the year 2020 is a realistic expectation.
• 875MW installed capacity is equivalent to around 437,000 houses each with small 2kW rooftop installations
WERC PV TASK GROUP

- Aims to enable large scale PV adoption through innovative systems level technology, the PV TG membership includes:
  - Sharp
  - Wales school of architecture
  - Corus(Tata) steel roofs
  - Redrow - house builders
  - Dulas – PV systems integration
  - Optic technium - innovation centre
  - University of Wales - centres of excellence at NEWI, Swansea and Cardiff
  - Welsh Assembly Government

Aim to accelerate innovation through supply chain teaming
Proposed OpTIC Technology Park with dedicated Solar Energy Technology Centre
Challenge for UK research programme on PV materials

• Find ways of using thinner wafers of crystalline silicon.
• Pave way for high volume, in-line processing.
• Improve efficiency of thin film polycrystalline materials.
• Investigate ultra-thin absorbers.
EPSRC funded PV Supergen project “PV Materials for the 21st Century” Renewal Project started April 2008

Mission statement: *to make a major contribution to achieving competitive PV solar energy.*
PV SuperGen Renewal £6.2m over 4 years

**STRATEGY**
- Build on achievements in Phase I
- Sharpen focus on thin film PV
- Contextualize research within the framework of long term sustainability
- Exploit UK strength in nanotechnology for novel PV concepts

**EXPECTATIONS**
- Establish internationally leading position in PV based on sustainable materials
- Consolidate world leading position in novel approaches to light management
- Transfer IP to industry as technologies move towards maturity
- Develop a deeper understanding of the techno-economic context of the research
PV21 Renewal project team members

- Ken Durose, Durham
- Stuart Irvine, Bangor
- Laurie Peter, Bath
- Tom Markvart, SES Southampton
- Darren Bagnall, ECS Southampton
- Ian Forbes, Northumbria
- Robert Gross, IC - new
- Mark Winskel, Edinburgh - new
- Hari Reehal, Southbank - new
- David Lane, Cranfield - new

- Pilkington - new
- First Solar - new
- SemiMetrics - new
- Kurt J Lesker Company
- Plasma Quest - new
- SAFC Hitech
- Millbrook
- CSMA Mats
- Sharp – new public awareness and engagement
<table>
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<th>Industrial Exploitation route</th>
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<td>First Solar, NAREC, (BP Solar, EPOD Solar Wales)</td>
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Stronger links needed to technology exploitation

- Research
- Development
- Demonstration
- Pilot production

- Low investment
- Focus on limited range
- High uncertainty
- Low range of experiments

PV21 renewal programme
CdTe/CdS thin film solar cells

Conventional processing | MOCVD
---|---
Deposit CdS from chemical bath | Deposit CdS
Anneal | Deposit As doped CdTe
Deposit CdTe by CSS | Deposit high As cap CdTe layer
Deposit CdCl₂ layer | Deposit CdCl₂ layer
Anneal | Anneal
Chemical etch | Deposit metal back contact
Deposit metal back contact | 
Anneal |
MOCVD is enabling thinner CdTe solar cells than those currently in production.

SEM of cross section of Sb$_2$Te$_3$/CdTe/CdS/TCO/glass solar cell structure.
SEM by Dr Mike Cousins, Durham University
Material from ANTEC GmbH

SEM of CdTe/CdS/ITO/glass from MOCVD grown devices

2 µm
10-12% AM1.5
Potential for increasing the capture of solar radiation in CdTe solar cells

A graph of the Standard AM1.5 global irradiance 100mW/cm²

Cut off at 500nm due to CdS band gap

Max Jsc = 30.8 mA/cm²

Extend λ
Replace CdS layer with CdZnS to increase band gap

Optical transmission measurements

Increasing \((x)\) in \(\text{Cd}_{(1-x)}\text{Z}_x\text{S}\) by increasing \(\text{DEZn}/\text{DMCd}\) ratio

\(Eurig\ Jones\ et\ al\ presented\ at\ MC8\ conference\)
Improved Spectral response of CdZnS/CdTe PV devices

This shows that the blue-end is heavily absorbed by the CdS, dropping rapidly at 500nm to less than 10% QE.

- Blue is not as heavily absorbed as in CdS, the CdZnS has approx. 25% QE even at 425nm.
Conclusions

• Rapid growth of PV installations is driving manufacturing industry.
• Large scale adoption is being stimulated by feed-in tariff
• Need for production scale and innovation to reduce system costs
• Supply chain opportunities to drive UK PV industry
• PV21 consortium increasing UK profile with innovative materials science that can drive supply chain opportunities.
• The future of PV will be more efficient, less material and lower cost!
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- Dr Andy Clayton
- Dr Anne Stafford
- Mrs Rachael Rowlands-Jones
- Mr Eurig Jones
- Mr William Brooks
- Mr Steve Jones
Thank you for listening