Solar Photovoltaics

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

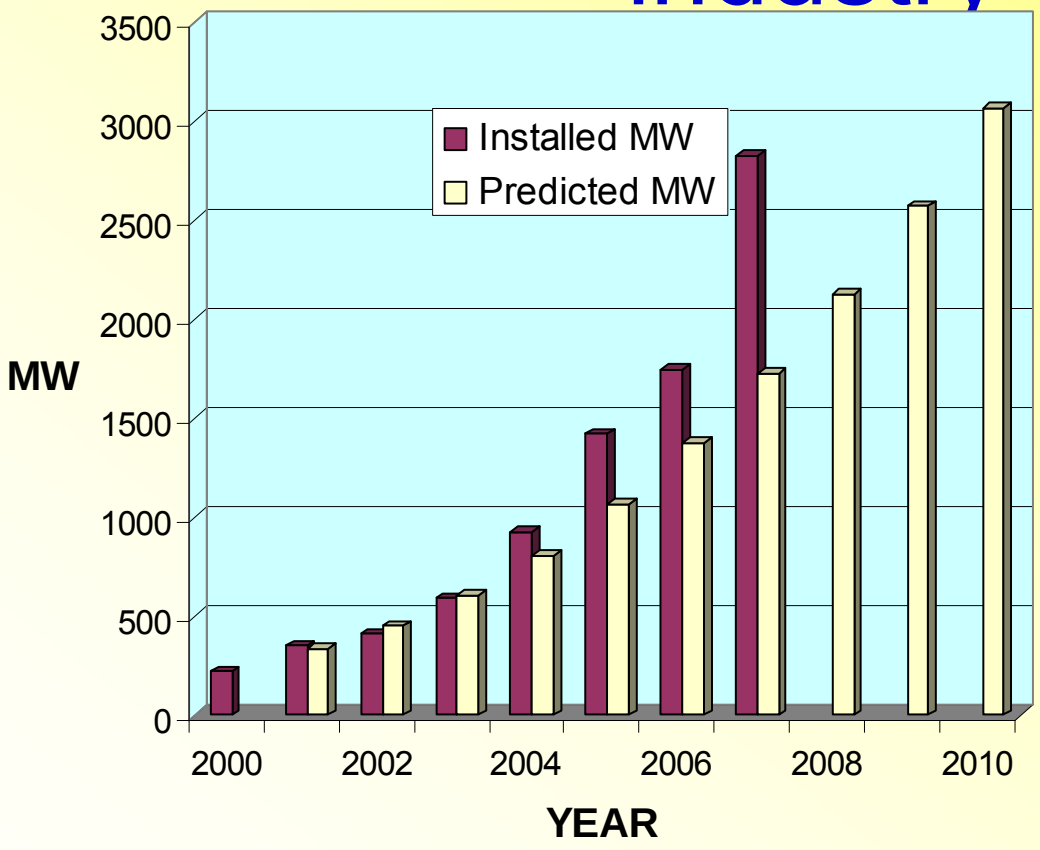
Summary of presentation

- 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.

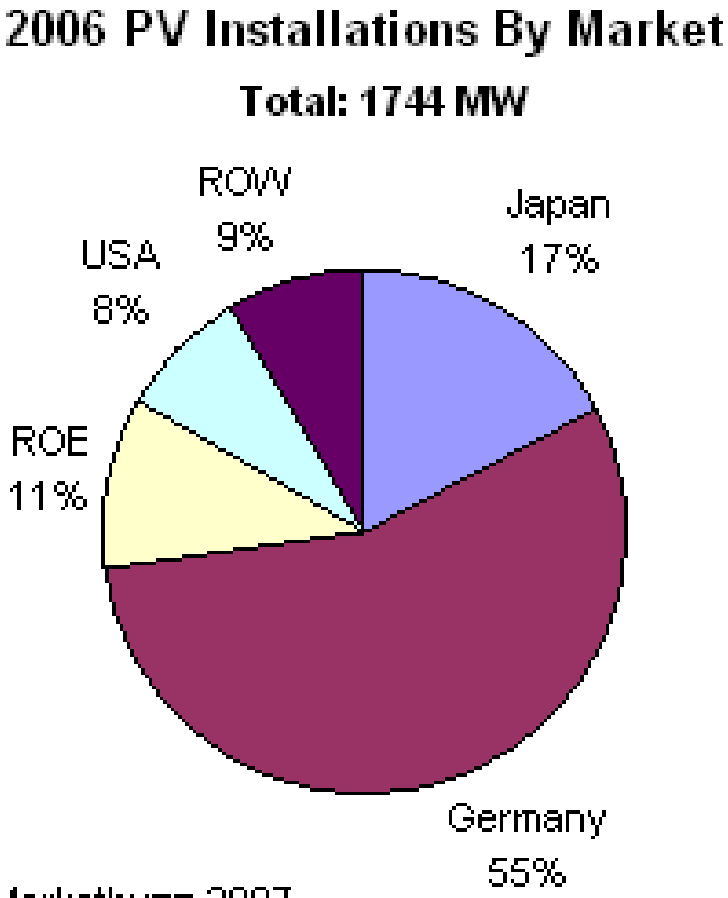
The global expanding PV industry



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

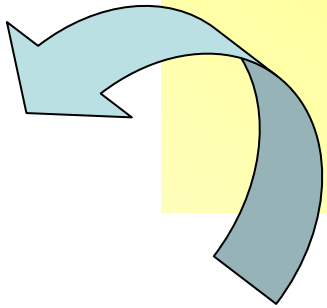
In 2001 46% was on grid domestic. Predicted to become 66% in 2010

Who is buying PV?

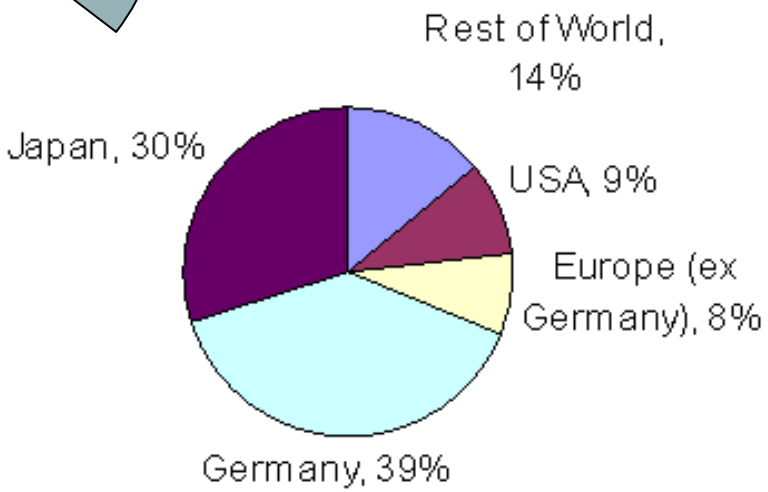


Source: Marketbuzz 2007

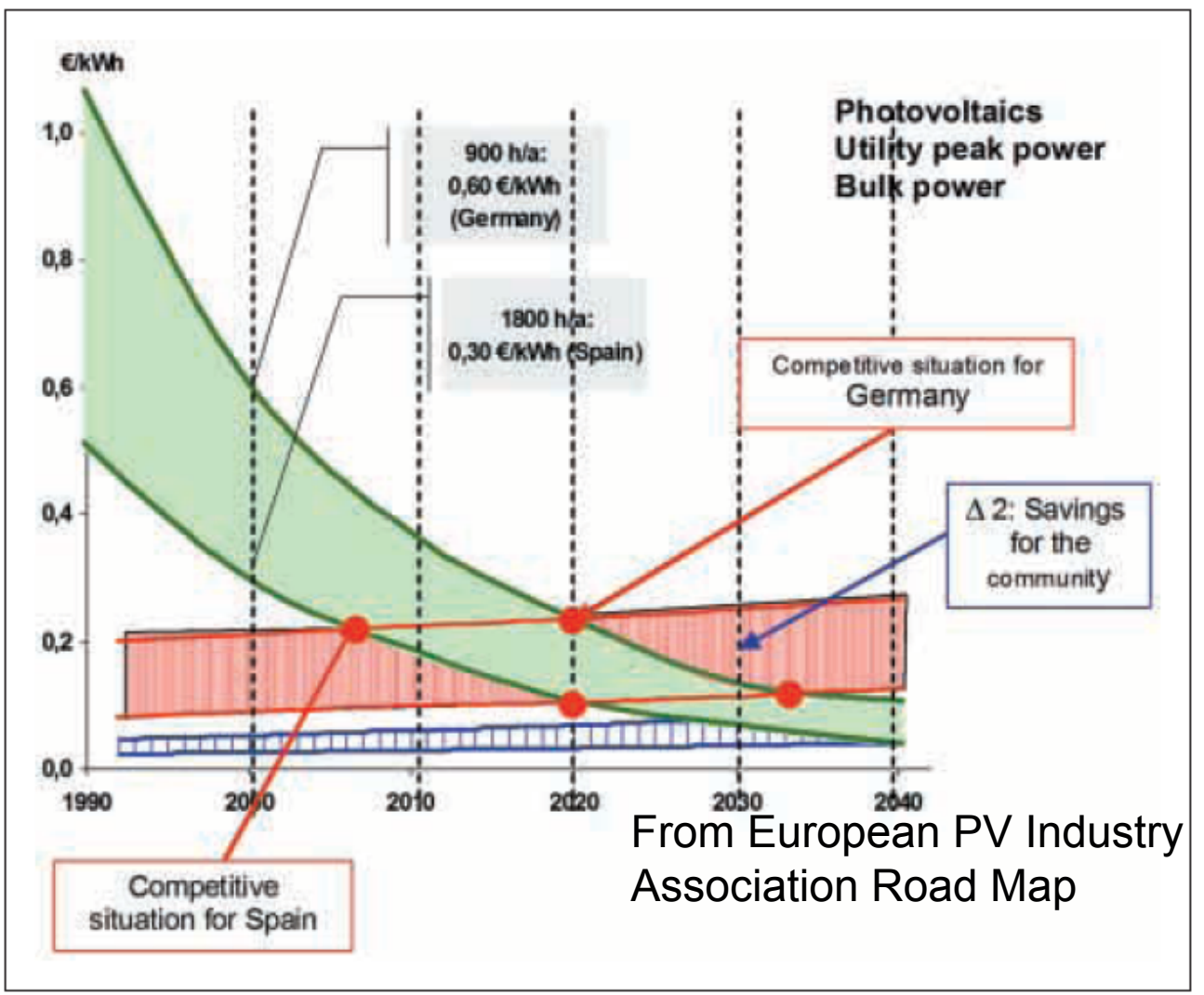
Large adopters use favourable feed-in tarriffs



Sales in 2005



The energy price profile

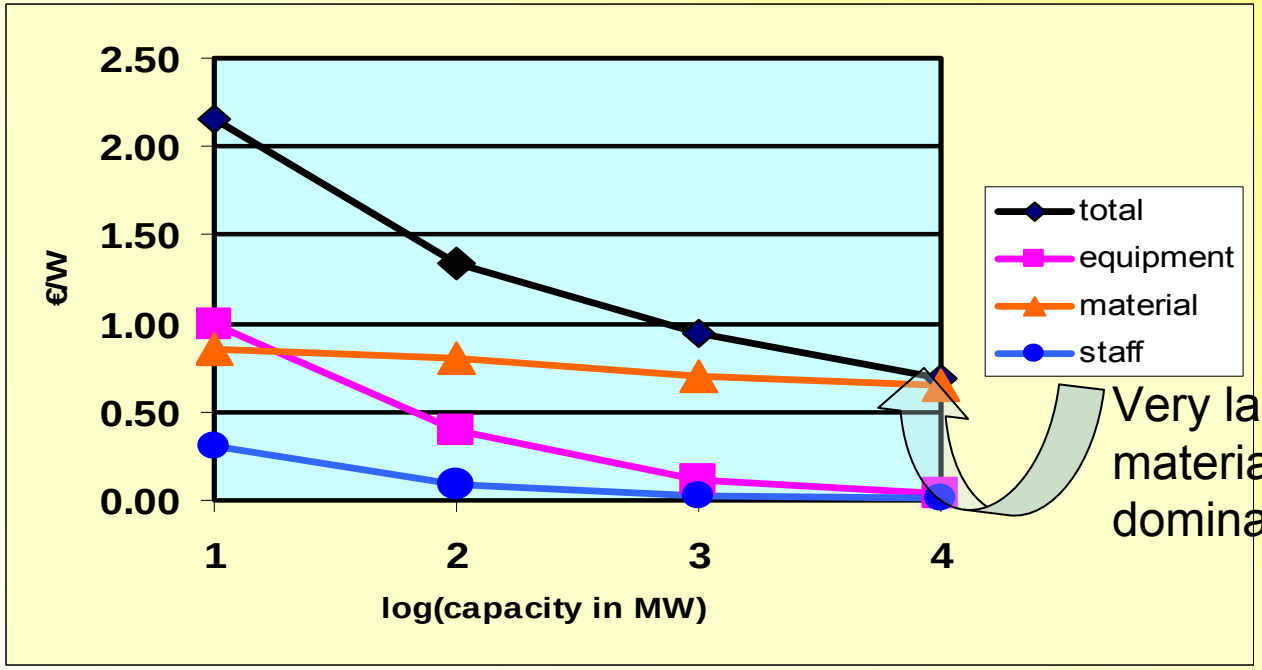


From European PV Industry Association Road Map

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*
- **G24i**(dye sensitised) in Cardiff-capital of Wales: *www.g24i.com*
- **Solar Century** (PV roof tiles and installation) in south Wales: *www.solarcentury.co.uk*
- **Dulas** (PV systems and installation) in West Wales: *www.dulas.org.uk*
- **Epod Solar Wales** (thin film silicon) South Wales: *www.epodsolar.com*
- **PV Systems** (Installers) South Wales: *www.pvsystems.com*
- **IQE** (III-V epitaxy for concentrator cells) South Wales: *http://www.iqep.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

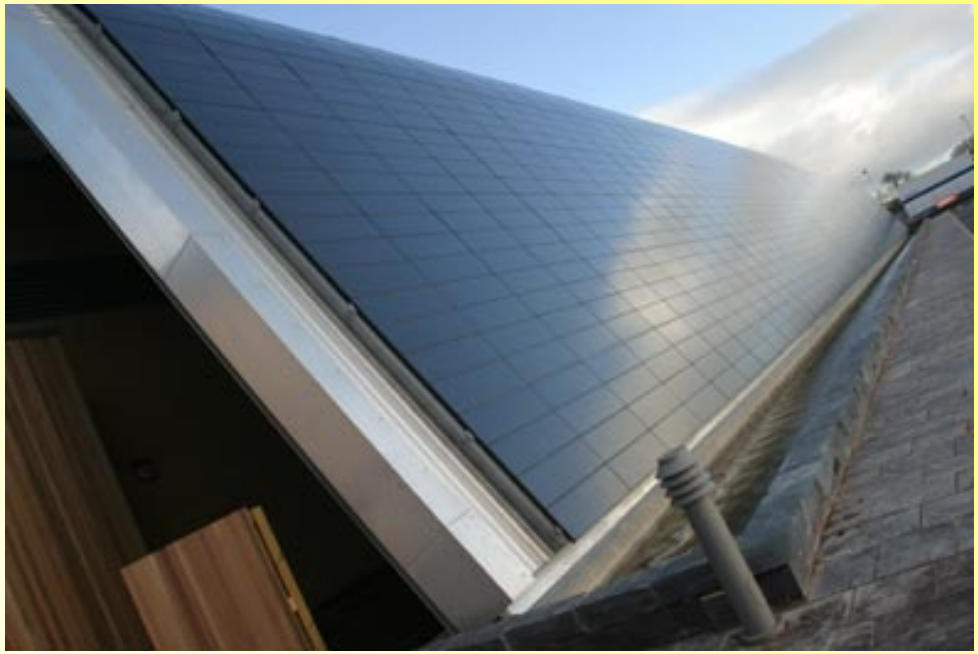
CIS Tower, Manchester

Solar Century PV roof tile

Example of thin film PV façade at OpTIC Technium, St Asaph

The PV façade at OpTIC Technium demonstrates novel thin film CIGS technology

- 1000 m^2 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

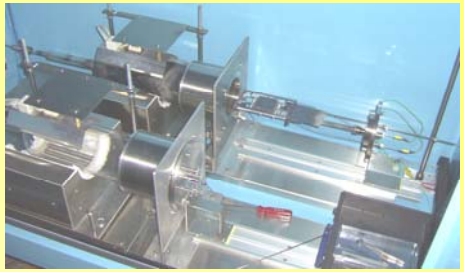
- Find ways of using thinner wafers of crystalline silicon.
- Pave way for high volume, in-line processing.
- Improve efficiency of thin film polycrystalline materials.
- Investigate ultra-thin absorbers.

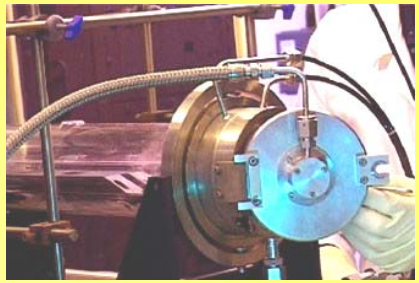
EPSRC funded PV Supergen project "PV Materials for the 21st Century"

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 SUPERGEN

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*

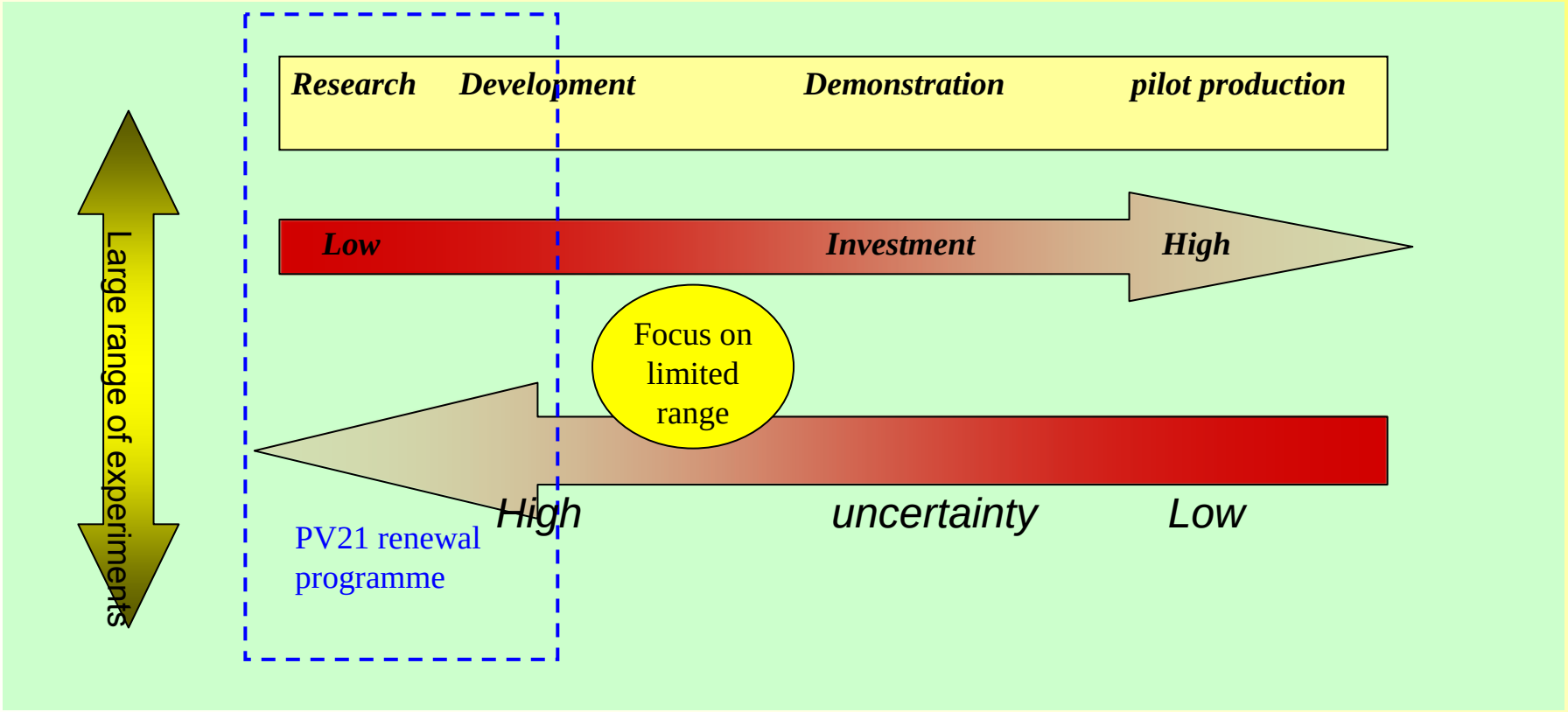
PV21 SUPERGEN

Integration of Industrial partners

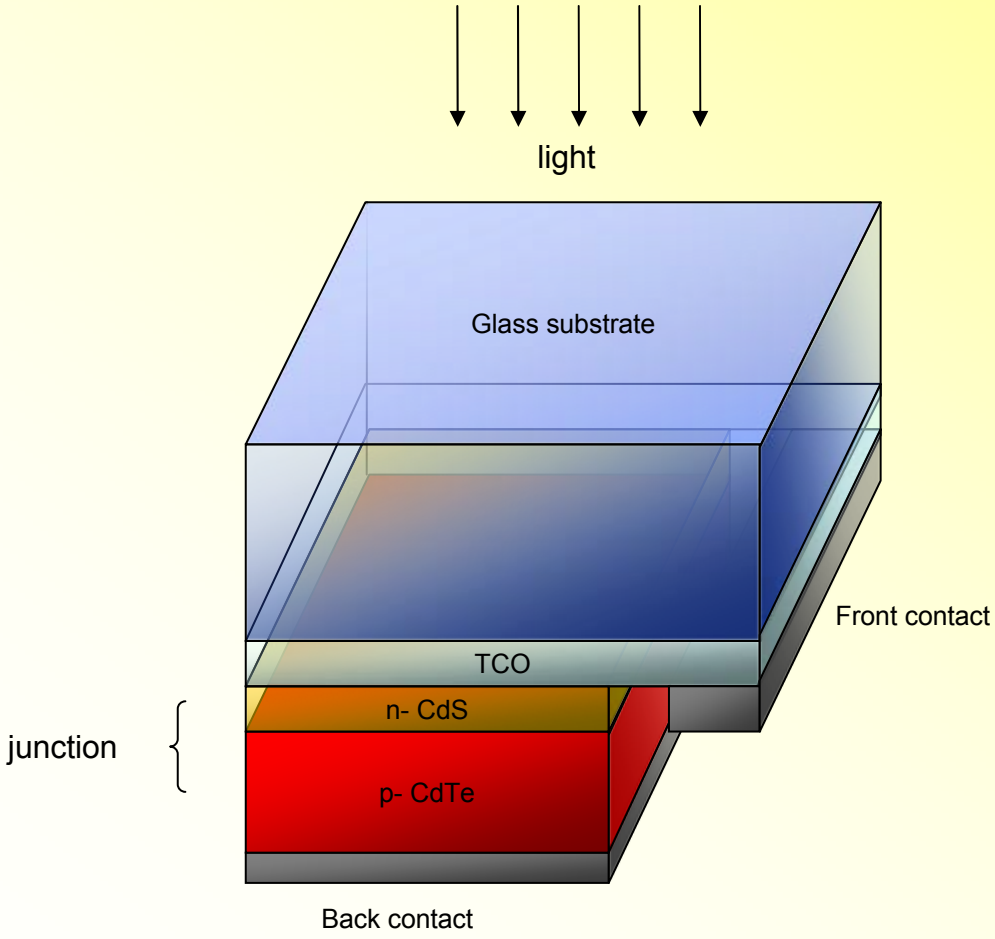
Industrial Exploitation route	Participating company
Materials Supply	Pilkington, SAFC (Epichem)
Materials Characterisation	SemiMetrics, MATS CMS, Millbrook
Processing tools	Kurt J Lesker, Plasma Quest
PV Production	First Solar, NAREC, (BP Solar, EPOD Solar Wales)

PV21 SUPERGEN

Stronger links needed to technology exploitation

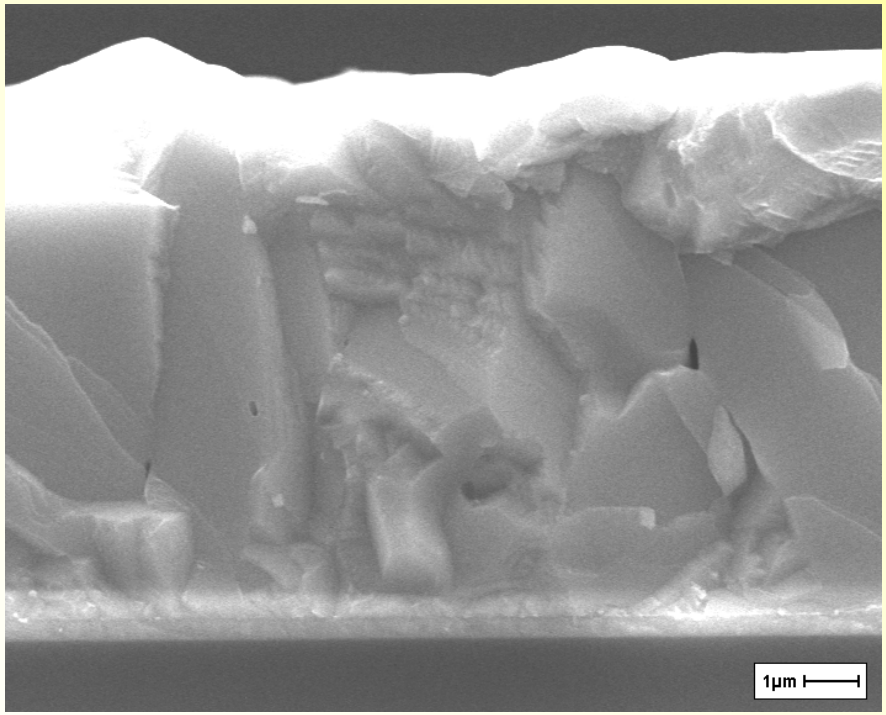


CdTe/CdS thin film solar cells

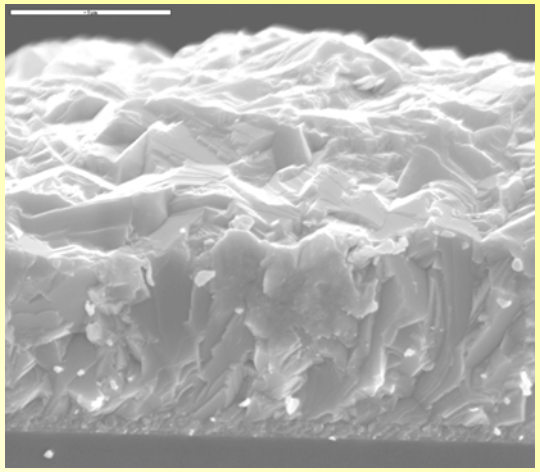


Conventional processing	MOCVD
Deposit CdS from chemical bath	Deposit CdS
Anneal	Deposit As doped CdTe
Deposit CdTe by CSS	Deposit high As cap CdTe layer
Deposit $CdCl_2$ layer	Deposit $CdCl_2$ layer
Anneal	Anneal
Chemical etch	Deposit metal back contact
Deposit metal back contact	
Anneal	

MOCVD is enabling thinner CdTe solar cells than those currently in production



SEM of cross section of Sb_2Te_3/CdTe/CdS/TCO/glass solar cell structure.
SEM by Dr Mike Cousins, Durham University
Material from ANTEC GmbH



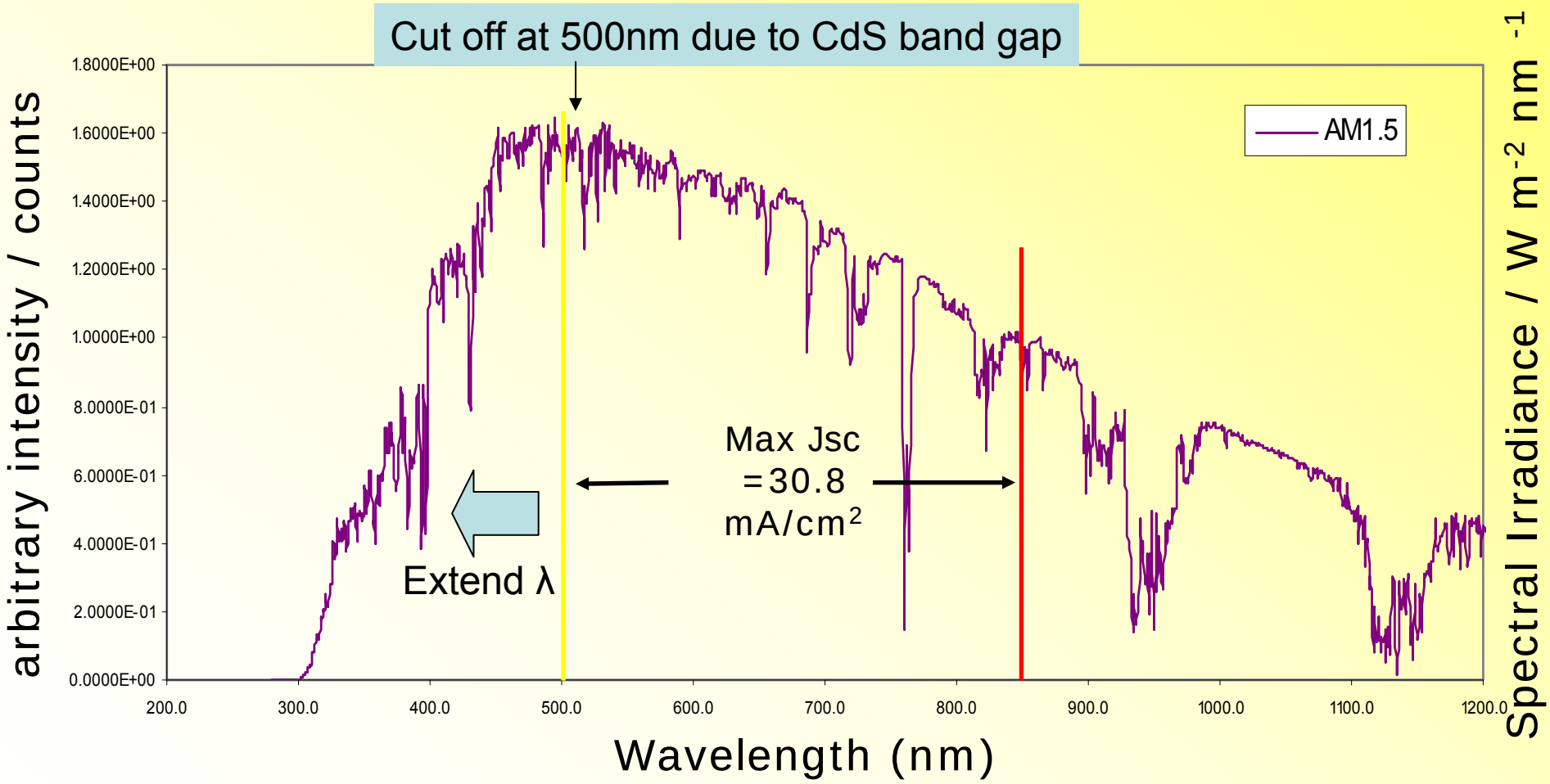
10-12%
AM1.5

2 µm

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

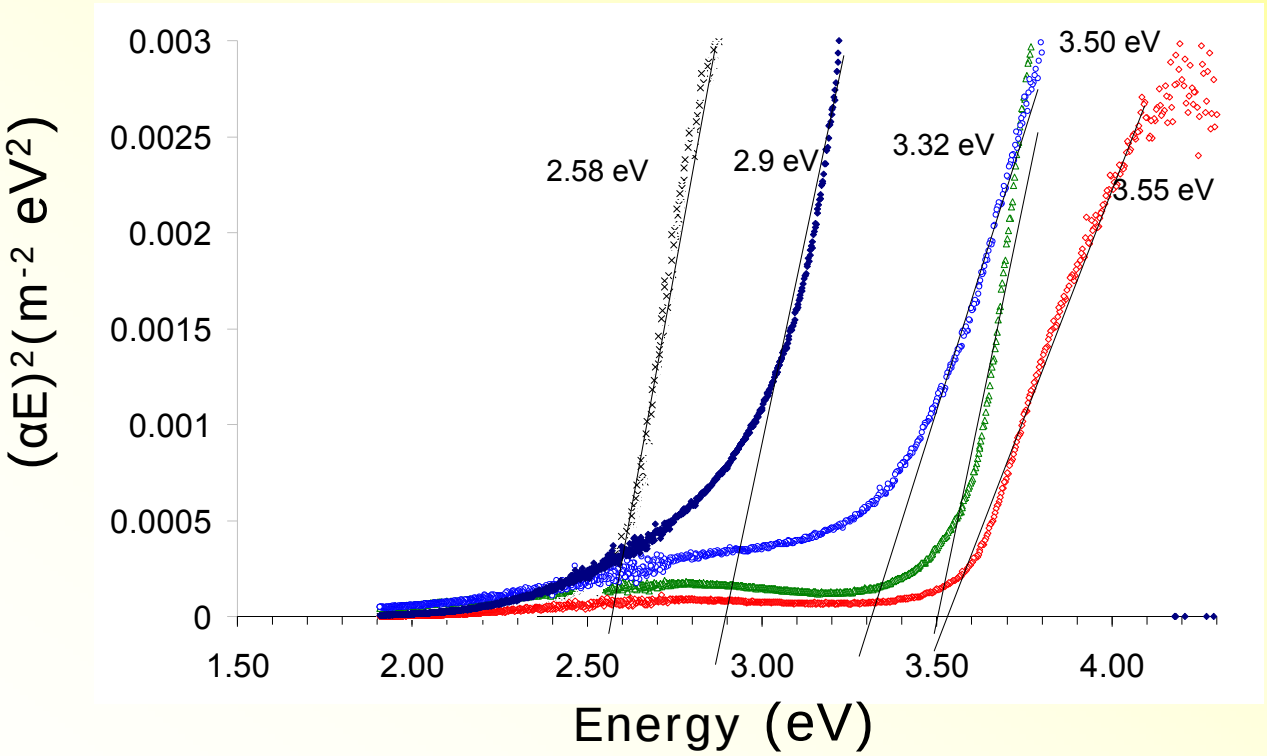
Potential for increasing the capture of solar radiation in CdTe solar cells

A graph of the Standard AM1.5 global irradiance 100mW/cm^2



Replace CdS layer with CdZnS to increase band gap

Optical transmission measurements

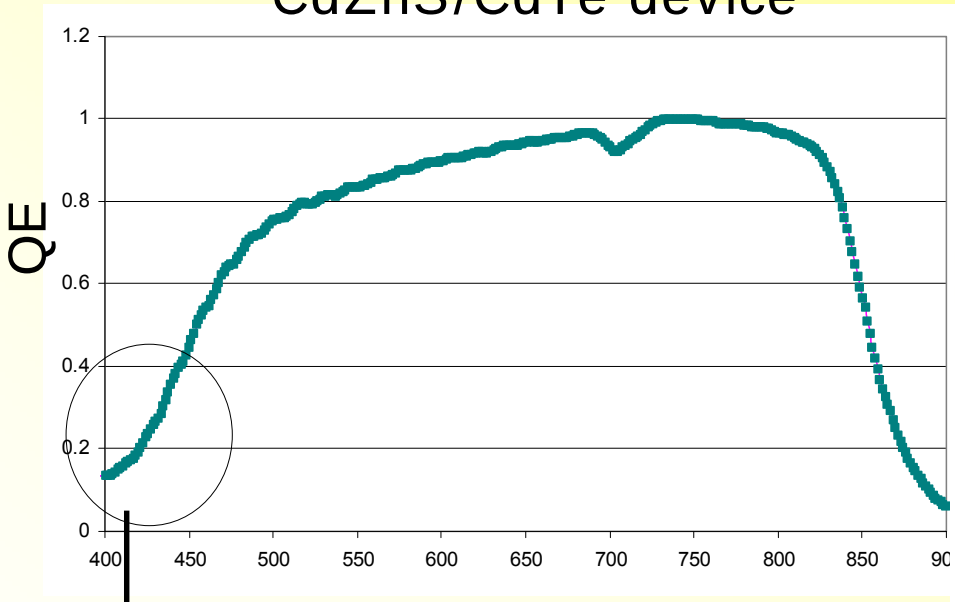


Increasing (x) in $Cd_{(1-x)}Z_{(x)}S$ by increasing DEZn/DMCd ratio

Eurig Jones et al presented at MC8 conference

Improved Spectral response of CdZnS/CdTe PV devices

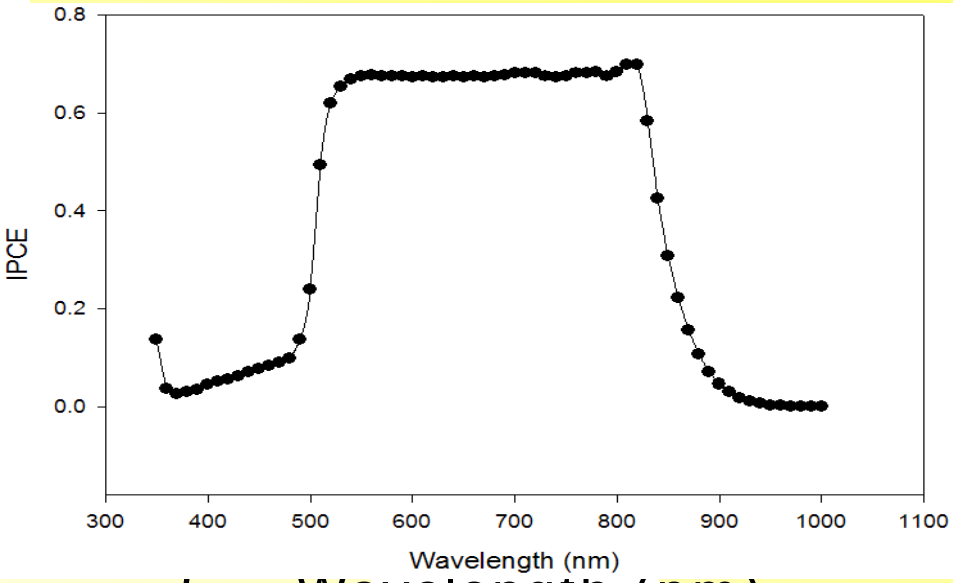
CdZnS/CdTe device



PV21 Durham

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

CdS/CdTe device



PV21 Bath

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

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!

Acknowledgements to the team at CSER

- Dr Vincent Barrioz
- Dr Dan Lamb
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- Mr William Brooks
- Mr Steve Jones

Thank you for listening