# Challenges in photovoltaic materials and devices

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CREST

Loughborough University

# Introduction

- Photovoltaic (PV) absorber materials
- Materials challenges in photovoltaics
- PV research in the UK
- CREST PV materials and devices group

# Materials for photovoltaics

- Crystalline silicon
- Thin films
  - a-Si:H
  - Cu(In, Ga)$Se_2$
  - CdTe
  - III-V
- Dye sensitized materials
- Organic materials

# Materials challenges in photovoltaics

- Goal: low cost per kWh
- Requirements of materials research:
  - Increase quality and/or reduce cost of PV product
  - Enable high production capacity and high installed capacity
  - Increase desirability of  product

# Quality and cost

- Increasing efficiency, stability
  - Reducing window absorption in Cu(In, Ga)$Se_2$
  - Stability in a-Si:H or DSCs
- Reducing costs
  - Elimination of hazardous materials
  - Improvement of production processes
  - Reduction in material consumption
- Encapsulation
  - Protective coatings
  - Spray on encapsulation

# Enabling high capacity

- Economies of scale and learning curves
- Production capacity
  - Process rates
- Generation capacity
  - Known reserves used to estimate potential production limits
  - Recycling

# Desirability of product

- Reliability
  - Of production process
  - Of product
- Material issues
  - Legal: Cd products illegal in some countries
  - Perception: “Cd in batteries is bad so CdS is bad”

# PV in UK Universities

- 19 universities involved in PV materials research across wide range of topics:
  - Bangor, Bath, Cambridge, Cranfield, Durham, Edinburgh, Herriot-Watt, Hull, Imperial College, Loughborough, Manchester, Northumbria, Nottingham, Oxford, Sheffield, Sheffield Hallam, Southampton, St. Andrews, South Bank
  - www.ukerc.ac.uk
- 2 SUPERGEN projects to coordinate research:
  - PV Materials for the 21st Century (Si, CdTe, CIGS)
  - Excitonic Solar Cells Consortium (DSC, organic)

# Crystalline silicon at CREST

- Laser-grooved buried contact
  - Replace Nd:YAG with copper-vapour laser
  - Aim to increase throughput
- Anti-reflection coating
  - Hydrogen passivated silicon nitride
  - High target utilisation sputtering
  - Reduce hazardous material usage

# Dye-sensitized $TiO_2$ at CREST

- High transmission solar cells
  - Top cells in tandem structures
  - Increase transmission to improve current generation in bottom cell
- Quasi-solid state electrolyte
  - Improve solar cell stability

# $Cu(In, Ga)Se_2$ at CREST

- Alternative buffer layers
  - Improve acceptability of technology
  - Reduce usage of hazardous materials
  - Ultrasonic spray pyrolysis of indium sulphide
- Alternative absorber formation methods
  - Reduce capital and maintenance costs
  - Patented ion-exchange method

# Summary

- Many challenges remain in PV material research, with potential for:
  - Increased PV energy conversion efficiency
  - Stability improvement
  - Cost reduction through process improvement
  - Reduction in material consumption
  - Elimination of hazardous materials

# Thank you