

Is a Photovoltaic Roadmap different than an ITRS Roadmap?

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Drivers

- Cost Reductions
 - Need to reduce material costs, specifically substrate
 - Reduce waste
 - Improve yield and efficiency
- Increase Conversion efficiencies
 - Full Spectra efficiency
 - Improve performance and tighten distribution
- Improve Manufacturing and throughput
- Improve Quality and Reliability
 - Leakage / stability/lifetime/Environmental challenge
- Perceived to be environmentally green
- Achieve Grid Parity

PV Roadmap vs. ITRS Roadmap

PV

- Substrate
- Interconnect
 - Passivation
 - Contacts
- Manufacturing
- Metrology
- Absorber/Efficiency
 - Light trapping
 - Antireflection
- Packaging
- Testing
- ESH

ITRS

- FEOL
- Interconnect
- Factory Integration
- Metrology
- Lithography
- Packaging
- Testing
- ESH

NEDO Japan

Targets of PV R&D



(PV2030)

R&D Targets

Improvement of economic efficiency: Realization of similar cost as that for industrial use (7 yen/kWh)
 (Milestones) 2010: 23 yen/kWh; 2020: 14 yen/kWh; 2030: <7 yen/kWh

Enlargement of PV application area: Cost reduction and stand-alone capabilities of PV systems for inverter and accumulator battery

● Technological Targets Toward 2030

Item	Present Status	Target by 2010 - 2030
Production cost of PV module	Production: 250 yen/W (2003)	100 yen/W (2010) 75 yen/W (2020)
Conversion-efficiency of PV module	Expected development: 14 yen/W (2007)	<50 yen/W (2030)
Durability of PV module	20 years	Service life 30 years (2020)
Silicon feedstock consumption	10~13 g/W	1 g/W (2030)
Inverter (power conditioner unit)	~30,000 yen/kW	15,000 yen/kW (2020)
Accumulator battery	~10 yen/Wh (for automobile)	10 yen/Wh (2020) Durability: 10 years

High Efficiency

● PV module conversion efficiency targets (cell efficiency targets)

Solar Cell Type	Present Status	Conversion efficiency target (%)		
		2010	2020	2030
Crystalline silicon solar cell	13~14.8 (18.4)	16 (20)	19 (25)	22 (25)
Thin-film silicon solar cell	10 (14.7)	12 (15)	14 (18)	18 (20)
“CuInSe” solar cell	10~12 (18.9)	13 (19)	18 (25)	22 (25)
“III-V” solar cell	Concentrator (38.9)	28 (40)	35 (45)	40 (50)
Dye-sensitized solar cell	(10.5)	6 (10)	10 (15)	15 (18)

PV Technology

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May 6, 2009

Technology Areas (NREL PV Roadmap)	Core Application(s)	Concept	Prototype	Pilot/Early Comm.	Full Comm.
Wafer-Si/Monocrystalline	Solar panels – utility, commercial, resid.				•9GW/yr •3-4\$/W
Wafer-Si/Multicrystalline					
Film-Si/Amorphous	•Solar panels, •Building integrated PV (BIPV) materials			Amorphous/na noncrystalline tandem cells	•1.3GW/yr •\$3/W
Film-Si/Crystalline				Film on glass, potential near term Epi Si on Si	
Film -CdTe	Large scale PV platforms for utility and commercial				•1.6GW/yr •\$2/W
Film-CIGS	Broad, incl. Building Integrated PV materials (BIPV)			Numerous startups	
Organic PV	Evolving				
Concentrator PV	•Residential, BIPV				
Dye-Sensitized Solar Cells	•BIPV, incl. windows •Portable power				

Primary Position

Evolving Position/Pipeline



Emerging Technologies (Materials)

Laurence Lutsen
imec restricted 2008

Class	Technology	Materials synthesis	Materials analysis
Advanced inorganic solar cell technologies	Spherical CIS (on glass beads)	Efficient coating methods	Local analysis
	Polycrystalline Si solar cells	Low-cost seed layer procedures Reducing intra-grain defect densities Passivation of defects	Local intra-grain analysis (morphological and opto-electrical)
Organic solar cell technologies	Dye sensitized solar cells	Dye development for longer wavelengths QD's as sensitizer Solid state electrolytes Methods for control and reduction of interface recombination	Local morphological and opto-electrical analysis
	Full-organic bilayer and bulk donor-acceptor heterojunction structures	Low-bandgap organic materials QD's and metallic nanoparticles Improved intrinsic stability Improved stability of nanomorphology Low-cost deposition methods (printing, organic vapor phase deposition) Low-cost TCO's with controllable workfunction Low-permeability barriers (H ₂ O, O ₂)	Local morphological and opto-electrical analysis Exciton dissociation Interface recombination Metal-organic semiconductor interfaces and their stability
Thermophotovoltaics	TPV Cells & Modules (Ge, GaSb, ...)	Growth of low-E _g antimonide materials (InGaAsSb, ...) Window layers Ge with adapted specs Ge on Si with buried IR-reflector	Measurement systems to make comparable measurements under well-defined high IR-fluxes
	Selective emitters	Low-cost methods ceramic and selective rear-earth emitters containing Er ₂ O ₃ , Yb ₂ O ₃ , ... Photonic structures withstanding high temperatures	Standards to compare emission performance of selective emitters

Comments

- How do you measure performance?
- You can't fix what you don't measure
- Material cost driven but does that mean low quality materials.
- Impurities are similar but different
 - You are dealing with light
 - Optical impurities, Metallic Impurities,
 - Dislocation,
 - Interfacial problems.
- Any road is the right road when you don't know where you are going