



ARCHIVE EDITION

Connecting to Energy

Polymer connections to solar PV and energy

Suprit Pal Singh

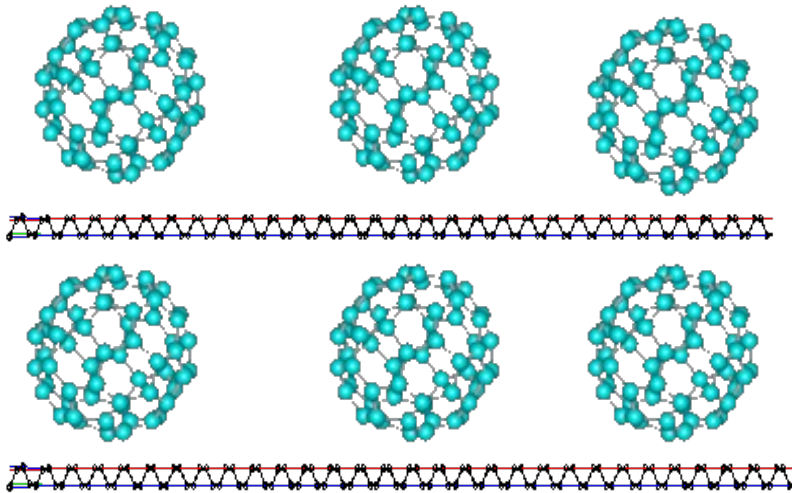
Investor presentation, June 2008, as Technology Advisor to Oerlikon

TECHNOLOGY- BINDING OF OERLIKON

CONNECTING TO ENERGY

energy to connect

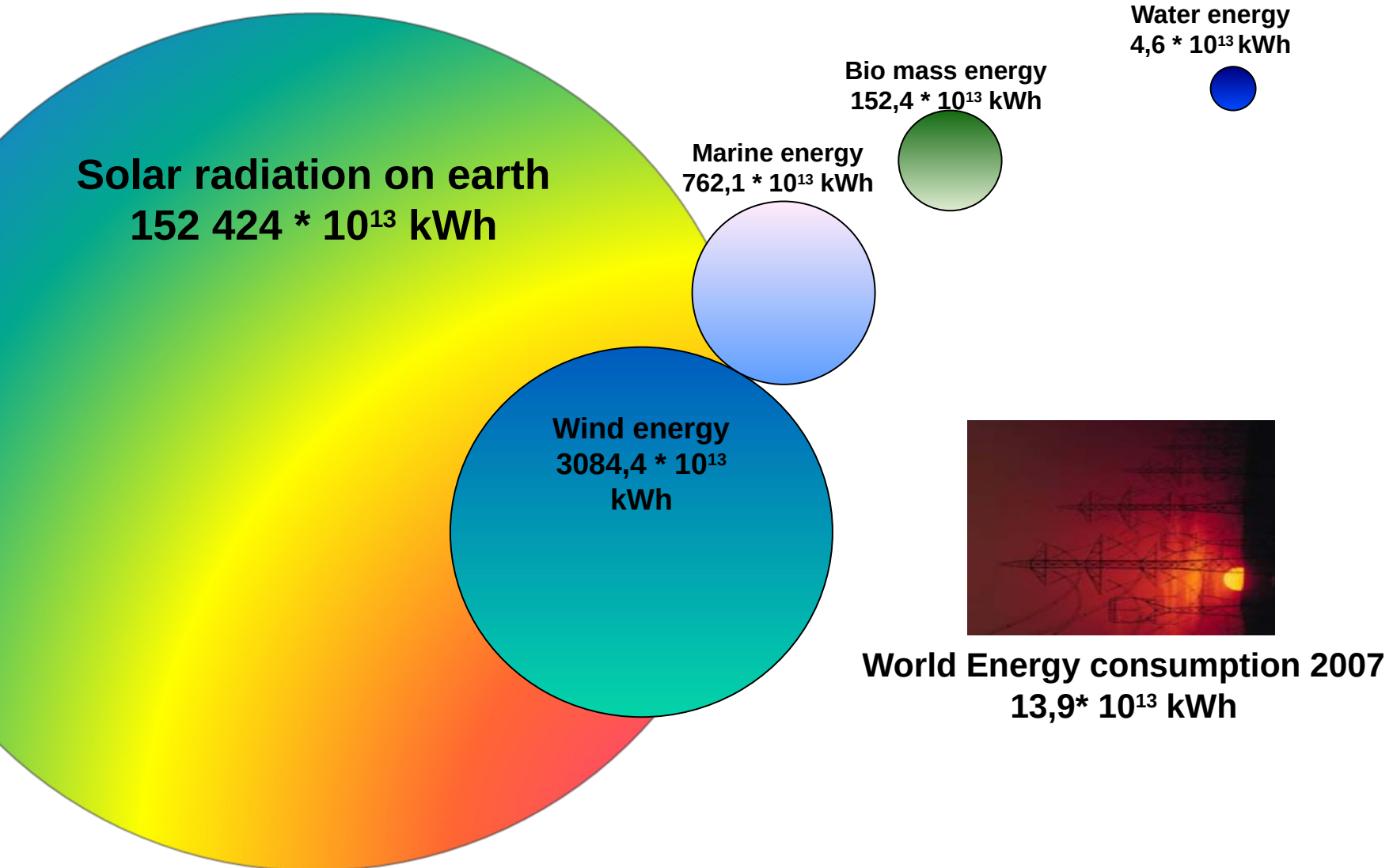
Nano to Glue us together



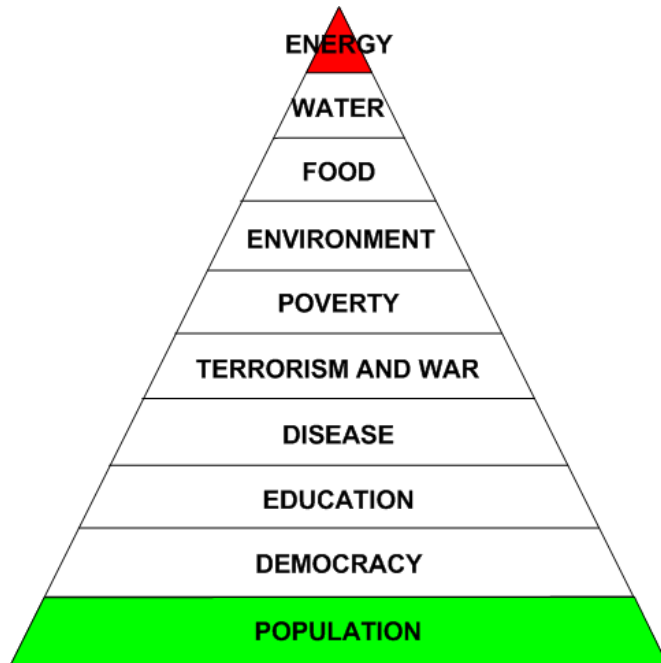
June , 2008
Investor presentation

Suprit Pal Singh

ENERGY : TOP PRIORITY FOR HUMANITY

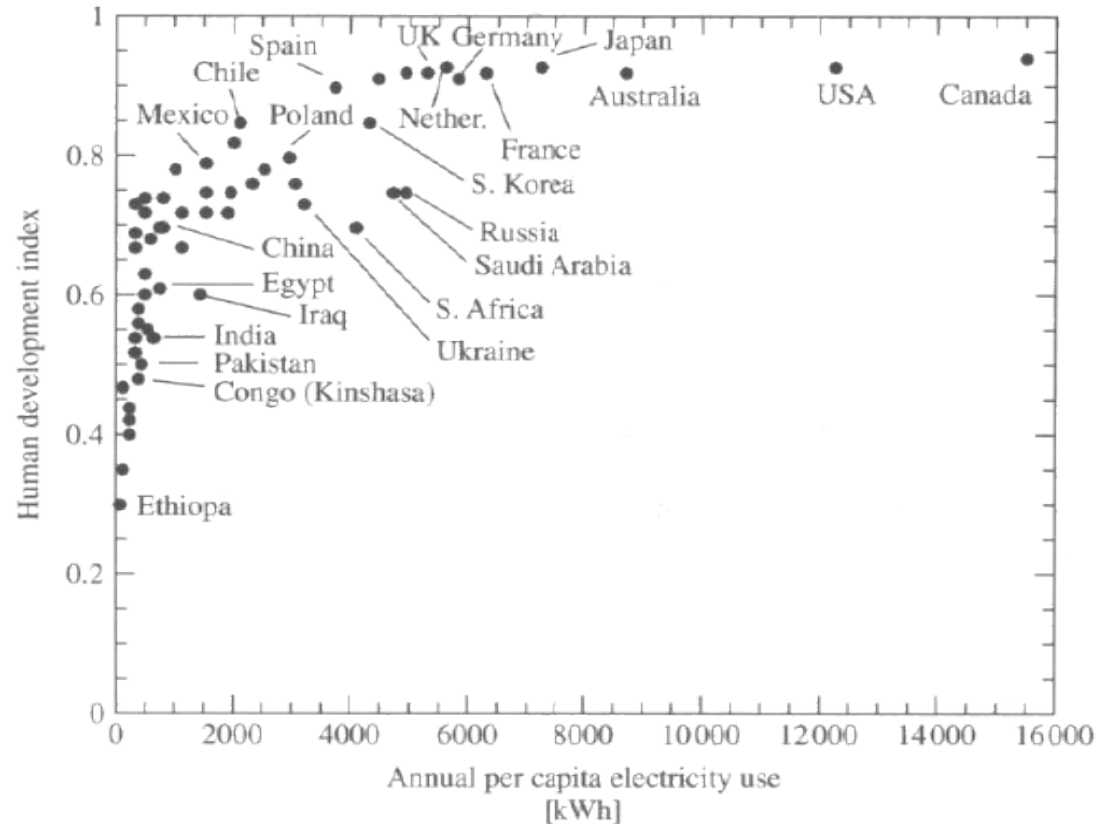


*Smalley's Pyramid Human
10 Greatest Global Issues*



From Richard Smalley, Rice University

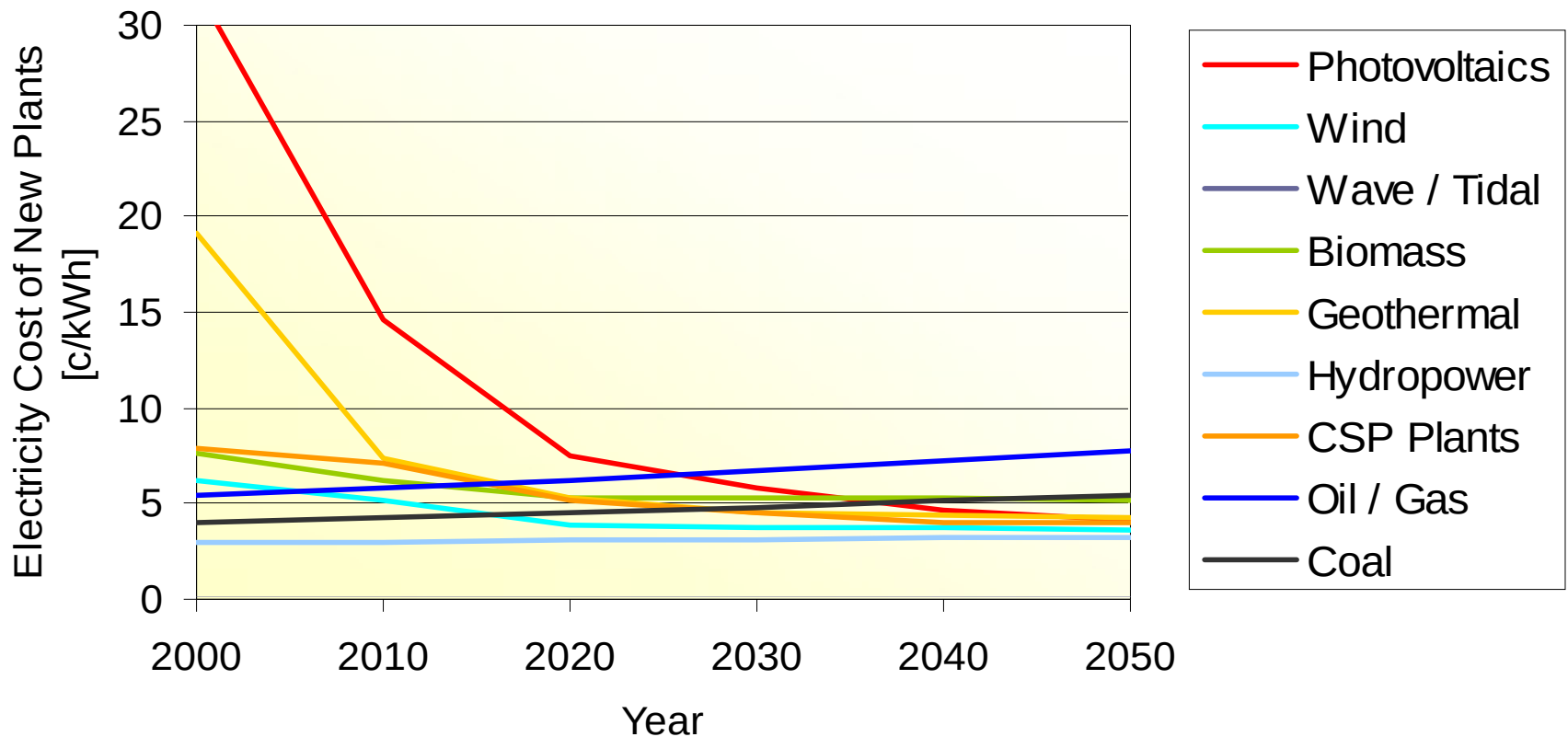
Development Index & Energy Consumption



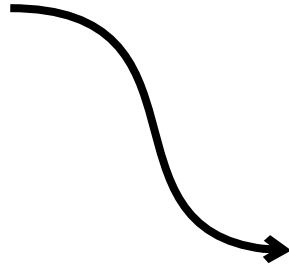
DLR Research Estimates New Plant Costs -Europe & North Africa

Discount Rate 5 %
2000-\$

LEC New Plants c/kWh	2000	2010	2020	2030	2040	2050
Wind	6.2	5.2	3.8	3.7	3.7	3.6
Photovoltaics	31.9	14.7	7.4	5.8	4.6	4.2
Geothermal	19.1	7.4	5.3	4.5	4.4	4.3
Biomass	7.6	6.2	5.4	5.3	5.2	5.2
CSP Plants	7.9	7.1	5.2	4.5	4.1	4.0
Wave / Tidal	0.0	0.0	0.0	0.0	0.0	0.0
Hydropower	2.9	3.0	3.1	3.1	3.2	3.3
Oil / Gas	5.4	5.8	6.2	6.7	7.2	7.8
Coal	4.0	4.2	4.5	4.8	5.1	5.5



It's a Party

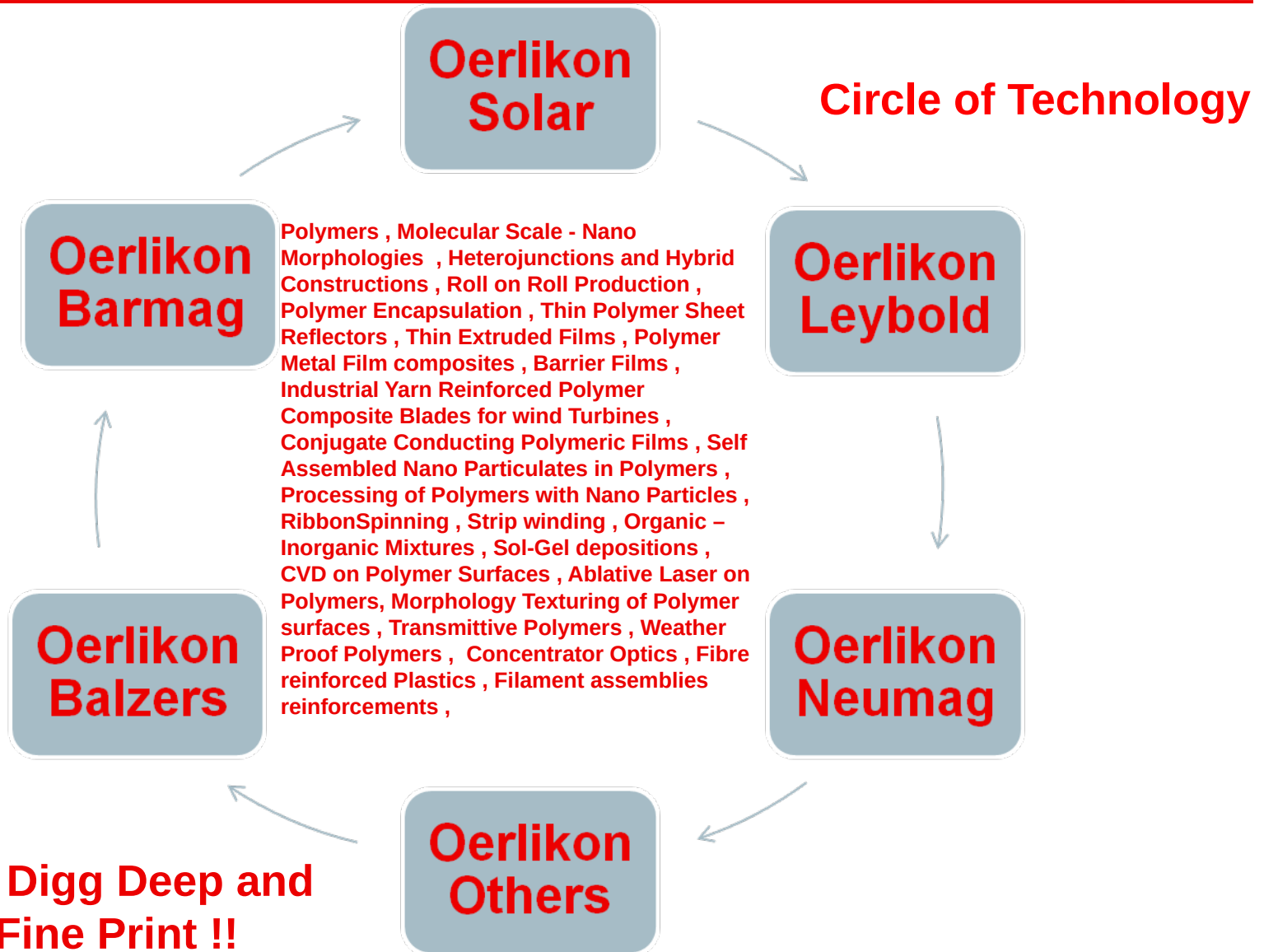


IEA and UNO Estimate \$ 45 Trillion Needed till 2050 to Solve Humanity Energy Needs in Environmentally Friendly Way

**Like All Party – Needs Diversity of Food
(Diversity of Technology)**

- **Synergistic Technology may be is present which connects Oerlikon Businesses.**
- **Oerlikon May possibly Utilize these Synergies by Taking up Development Projects.**
- **Nano-Technology Project Earlier is good Binding Starting Point as Per study at Barmag.**
- **Energy being the Focal Point several companies including Barmag are analysing how they can be part of the action.**
- **Several Technology competencies exist with in the Group where this can be done.**

What are the Materials and Technologies Connecting Solar Harvesting with in Oerlikon Partly or Completely ?



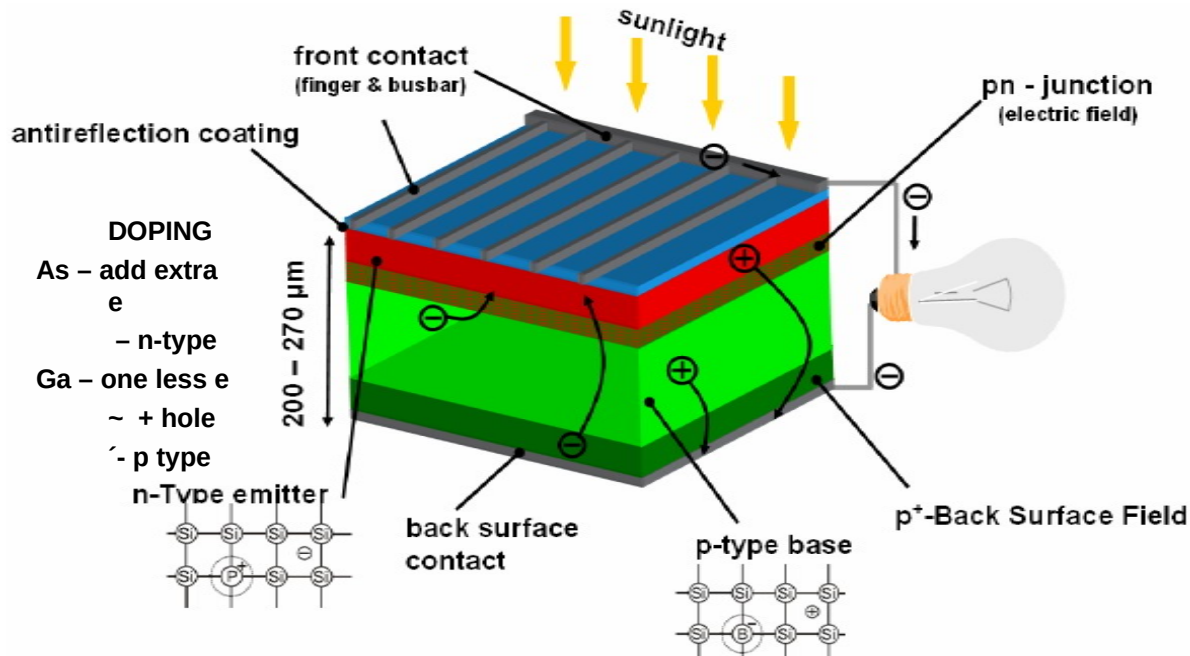
**It Pays to Digg Deep and
Read Fine Print !!**

It is not the Solar Cell Alone ?

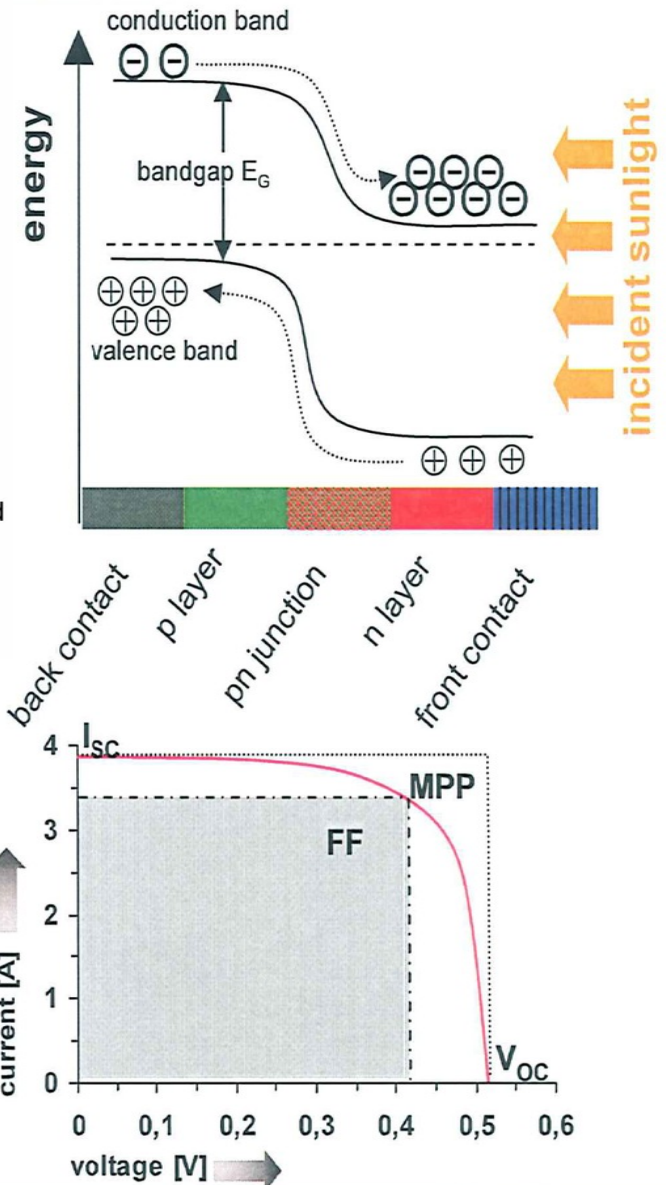
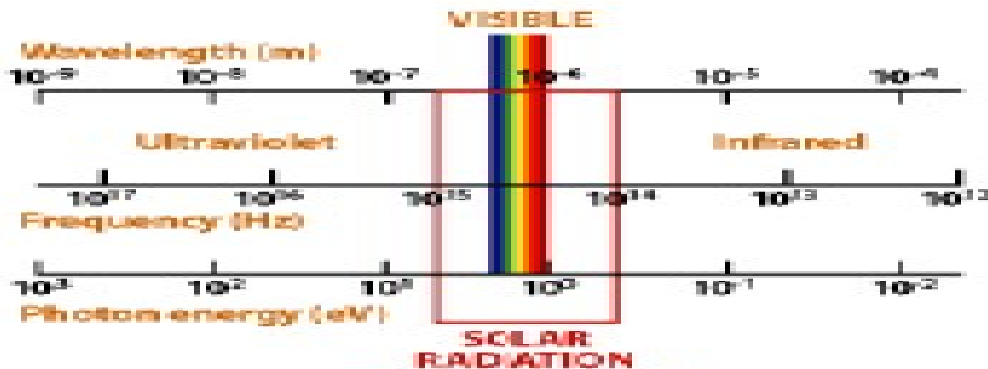
- **Photo Voltaics**
- **Solar Thermal Energy for Heat**
- **Solar Thermal Energy for Cooling**
- **Thermo Voltaic**
- **Solar Chemo-Synthesis**
- **Wind Energy**

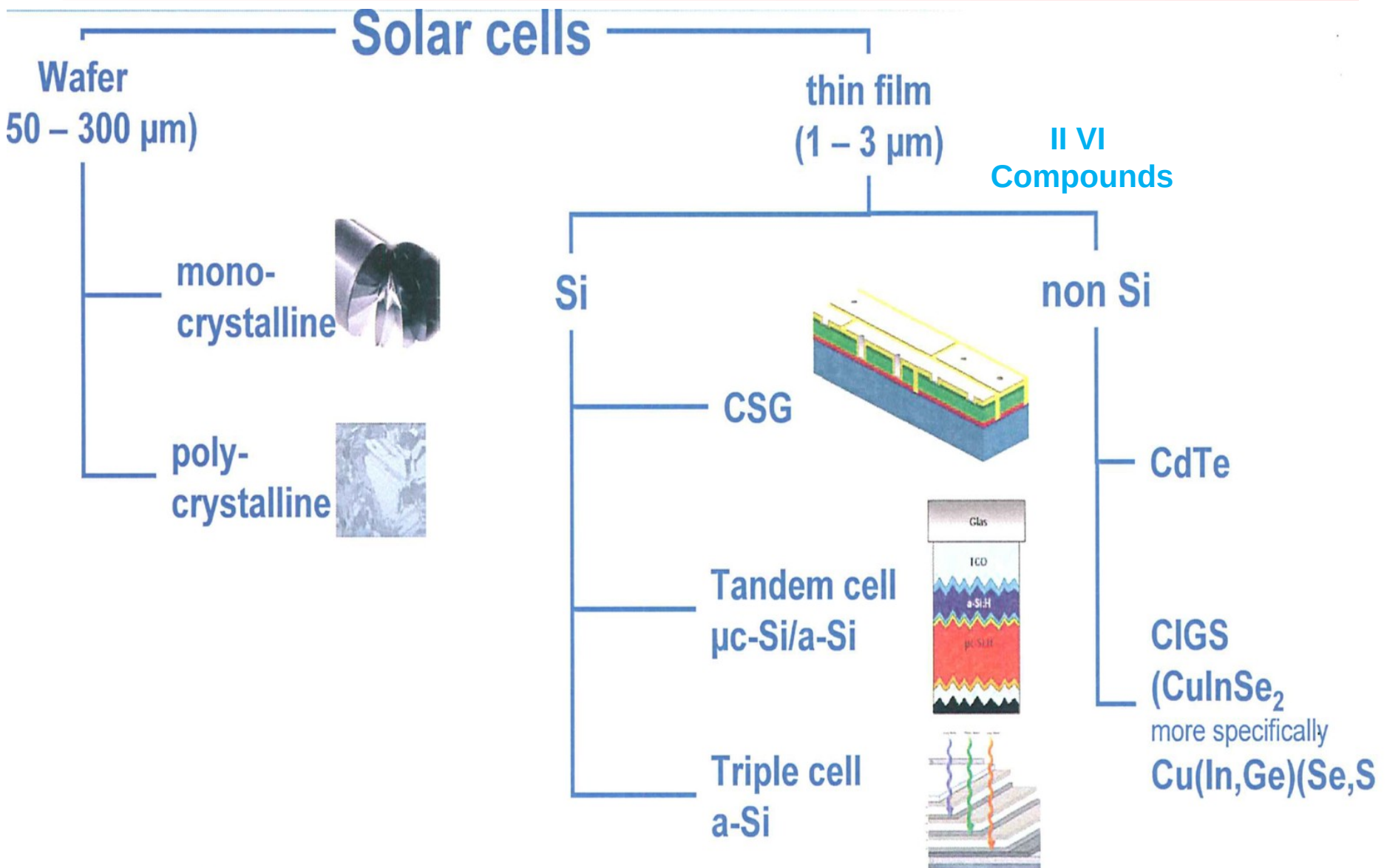
Research Needs ?

- **Fundamental Research**
- **Application Research**

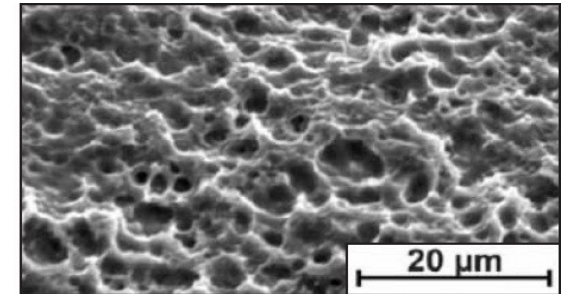
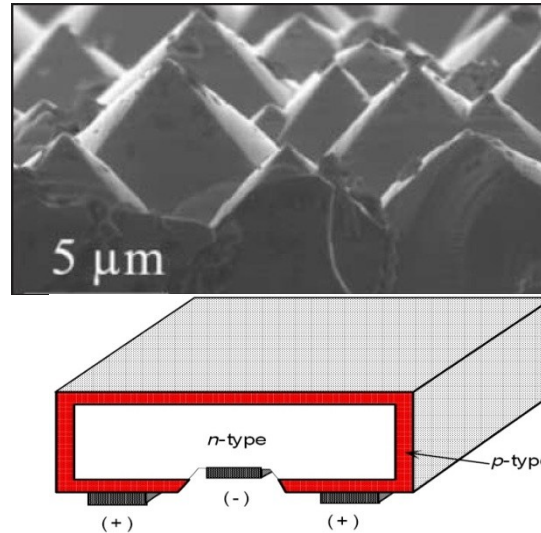
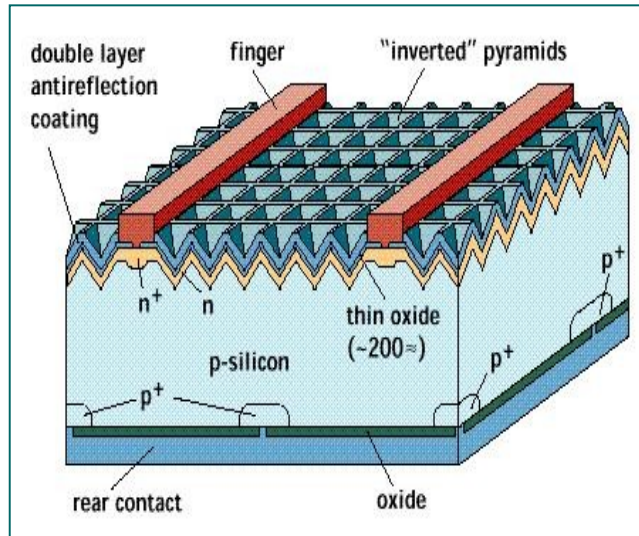


$$\text{efficiency } \eta = \frac{\text{electric power}}{\text{intensity of sunlight}} = \frac{I_{sc} * V_{oc} * FF}{A * P_{in}}$$

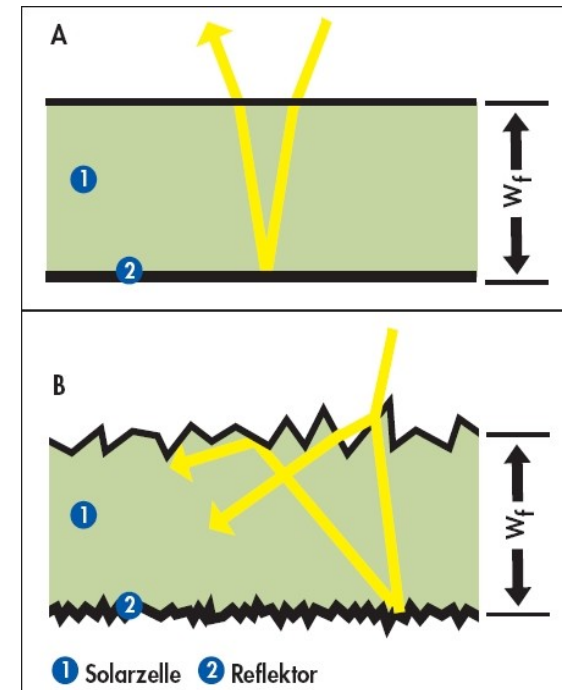




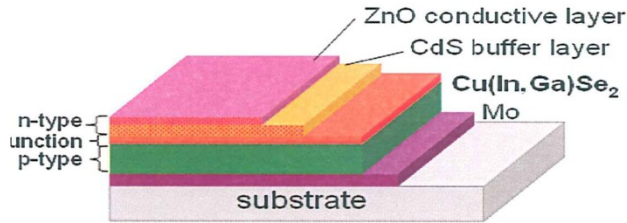
MONO CRYSTALLINE SOLAR CELLS – MICRO STRUCTURE BASED DEVELOPMENT



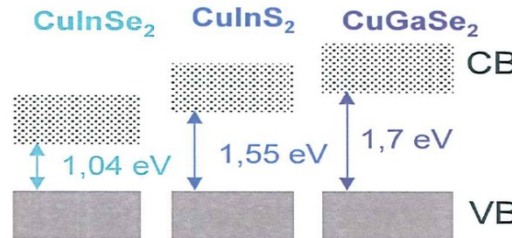
Encapsulation of the Wafers is a process requiring Polymers and is currently executed with bought out Films. Batch Process Back Layer can be a Tedlar Polymer or Weather Proof Polyester. Full encapsulation Machine and Process development possible from Oerlikon Barmag. Factories Buy sheets and then Bring them together between Glass and Cure. For Large Fabs a direct Small Extruder and Direct Film making machinery may be viable. Back Layer direct injection may be Possible and would be Cheaper Option. Also this Fab method brings capacity to be able to vary the Polymer to requirements. For High end applications Barrier Sheets need to be applied. Barrier sheets are Alternating Oxide and Polymer Layers. Possible technology for Making this IN SITU ??



- cell structure

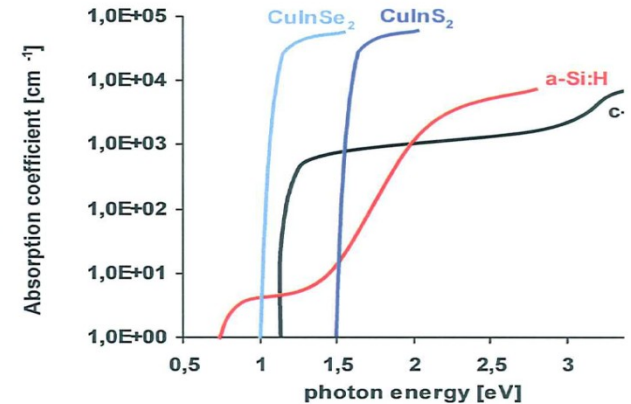


- band gap

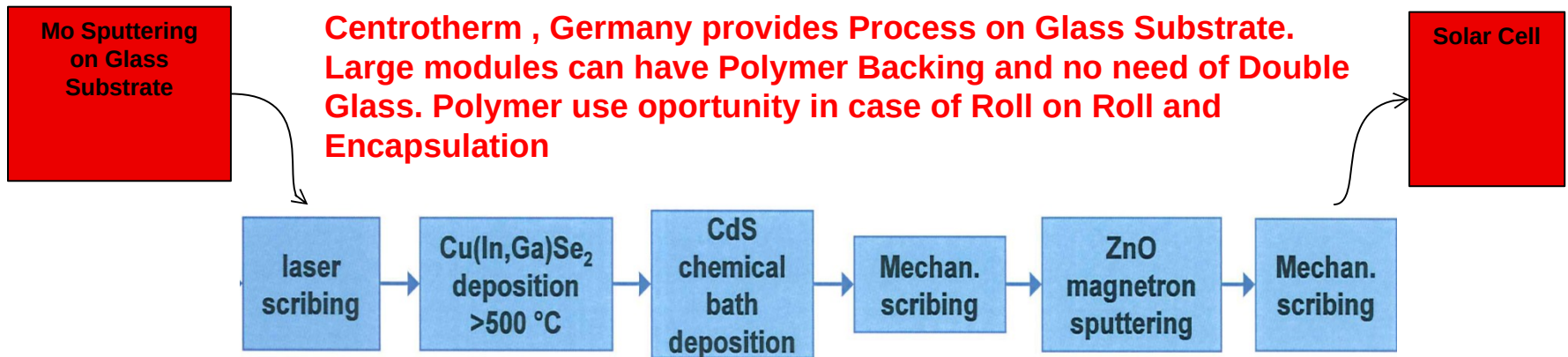


cell efficiency ~ 13 %

- absorption coefficient

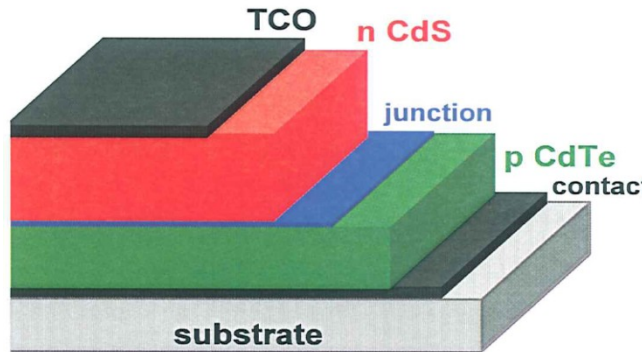


The process Can Be Roll to Roll on Polymer Substrate or Metal Sheet Substrate. Examples: Nano Solar, Ascent, Global Solar in USA (R on R), SolarFrontier Japan (Glass) .

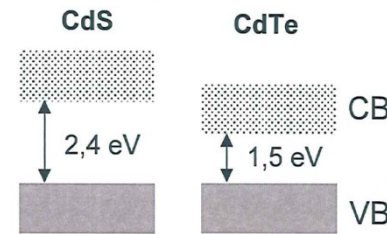


CdTe Process Requiring High Temperature Sintering

- cell structure



- band gap

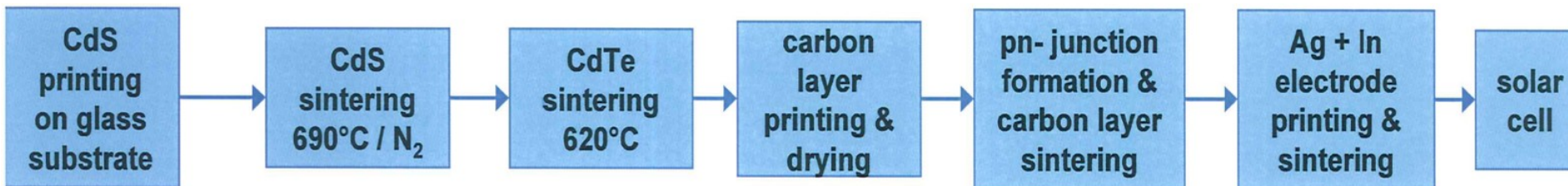


cell efficiency ~ 8.5 %

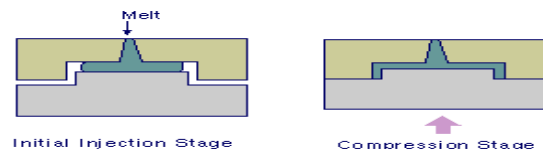
Possible Deposition Methods

- Closed Space Sublimation (CSS)
- Atomic Layer Epitaxy (ALE)
- Physical Vapour Deposition (PVD)
- Chemical deposition
 - Spraying
 - Electro-Chemical deposition
 - Metal Organic Vapour Deposition

Possible to Use Screen Printing Process



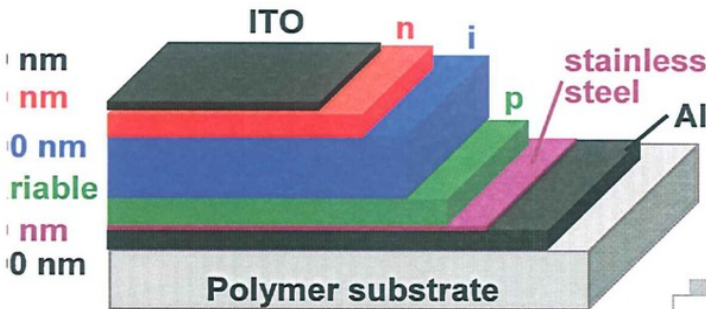
- Both Side Glass Modules from Market Leader FIRST SOLAR
 - Middle Layer is EVA (ethyle Vinyl Acetate)
- Some Manufacturers Use EVB (Ethyle Vinyl Butyrate)



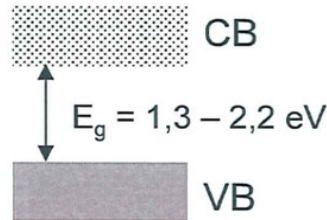
In Batch Process Back Layer can be a Tedlar Polymer or Weather Proof Polyester. Full encapsulation Machine and Process Possible from Oerlikon Barmag. Factories Buy sheets and then Bring them together between Glass and Cure. For Large Fabs a direct Small Extruder and Direct Injection Molding of Back Layer Possible

Amorphous Silicon to Multi-Component Morphology -Glow discharge with Roll on Roll

- cell structure

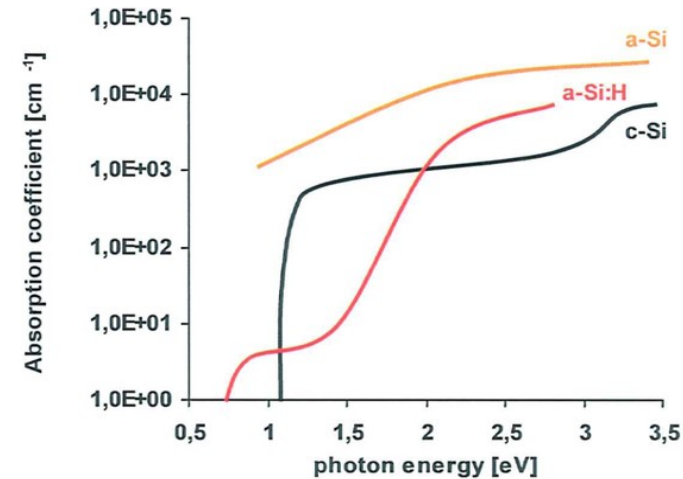


- band gap



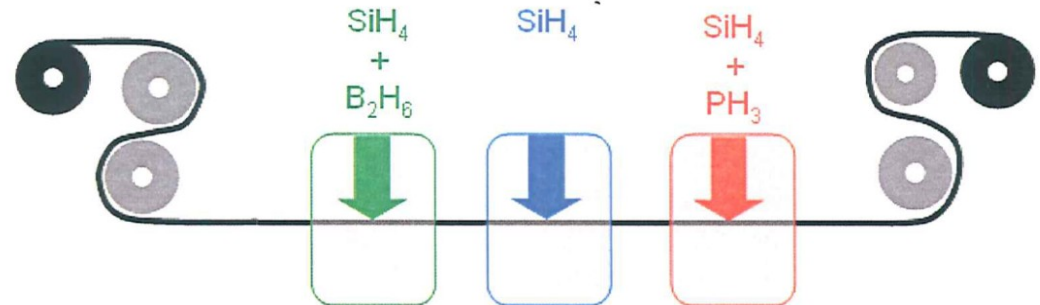
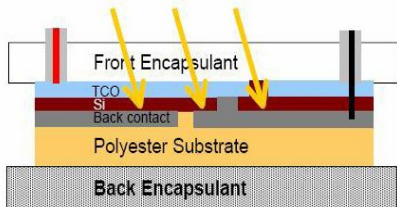
cell efficiency = 9 %

- absorption coefficient



- deposition process

- Roll-to-Roll Pilot Line
- 30 wide Al foil
- APCVD TCO: $\text{SnO}_2:\text{F}$
- PECVD: a-Si:H
- Temporary Superstrate Concept:



R.F. glow discharge under vacuum

UNISOLAR USA

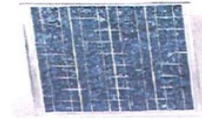
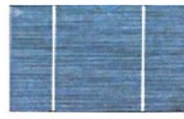
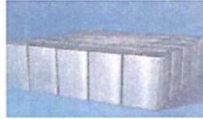
a-Si / a-SiGe / $\mu\text{c-Si}$

- stable mid-Layer a-SiGe
- a wide range of light absorption
- a higher efficiency, theoretic ~ 17%

Swiss Uni. of Neuchâtel
FlexCell

- aSi $\mu\text{c-Si}$ Micromorph
- on PET Sheet
- PET Sheet Textured

Roll On Roll Technology On Flexible Substrate - Polymer Sheet ,Thin Metal Sheet



electronic
grade Si

ingot

wafer

solar
cell

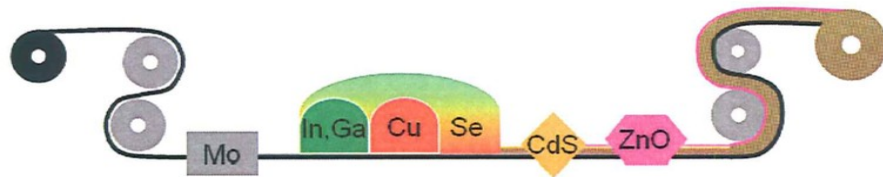
PV
module

system

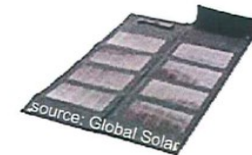
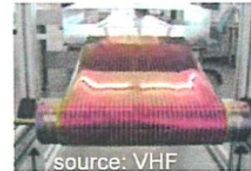
Solar cell by thin film technology in
a roll-to-roll process

PV
module

system



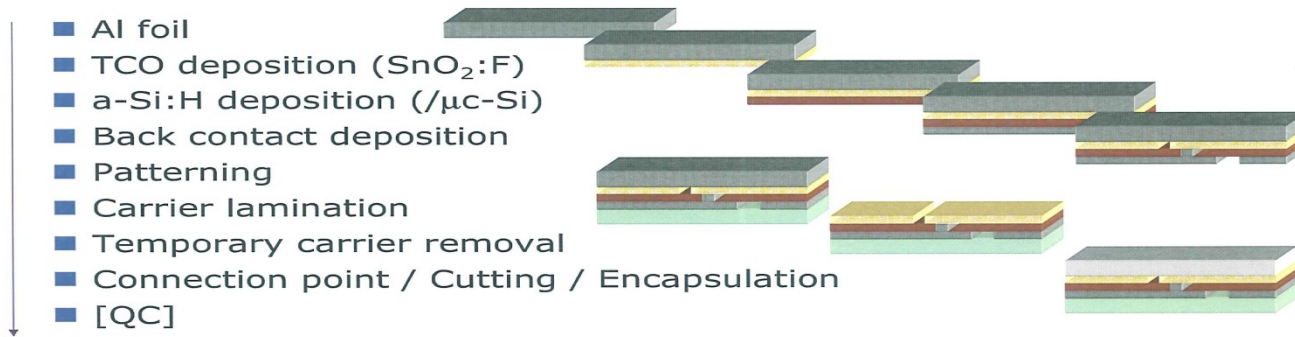
- Chemical Vapor Deposition
- Physical Vapor Deposition
- Plasma Technology



Oerlikon Barmag Has Plastics experiance and has the Necessery Machinery Film Production Line experiance for Roll on Roll for Polymeric Substrates. Special Textured Morphology Films Can Be Made Which enhance efficiency of Light Harvest!! This is some way similar to the increased efficieny acheived in Thin Film Si technology with different surface textures at Nano or micro scale. Glow Discharge systems can from sister Oerlikon Companies

Roll on Roll Process Sequence on PET

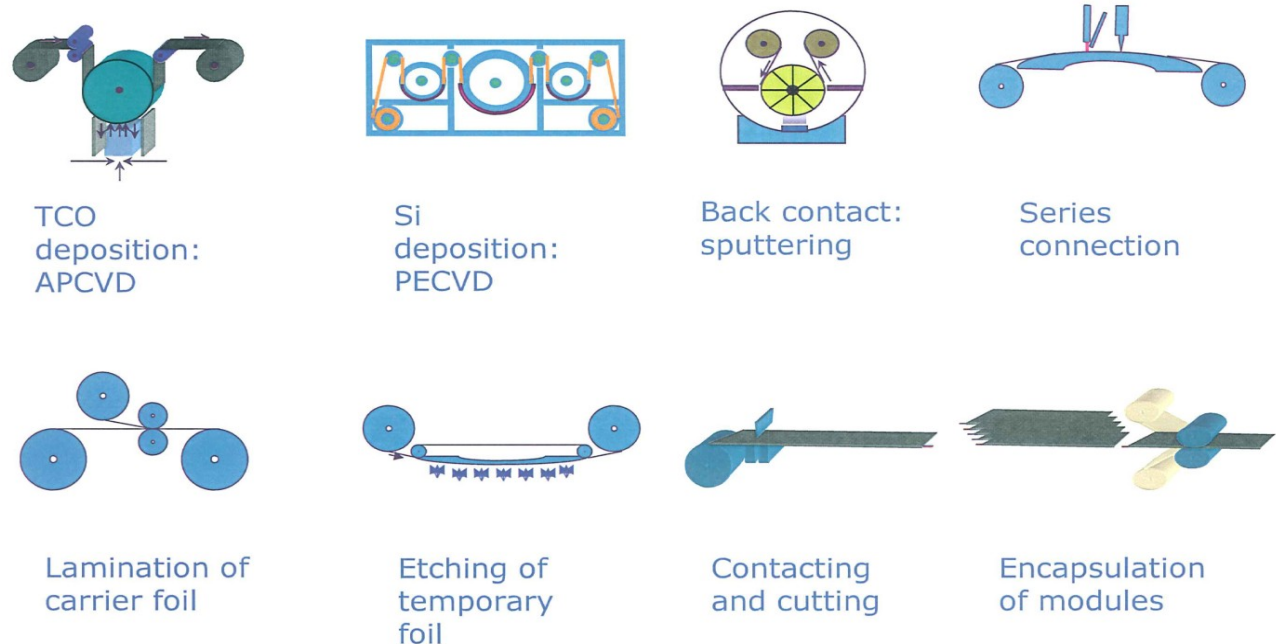
Temporary 'superstrate': schematic processing sequence



Swiss Flexicellence



Helianthos process sequence

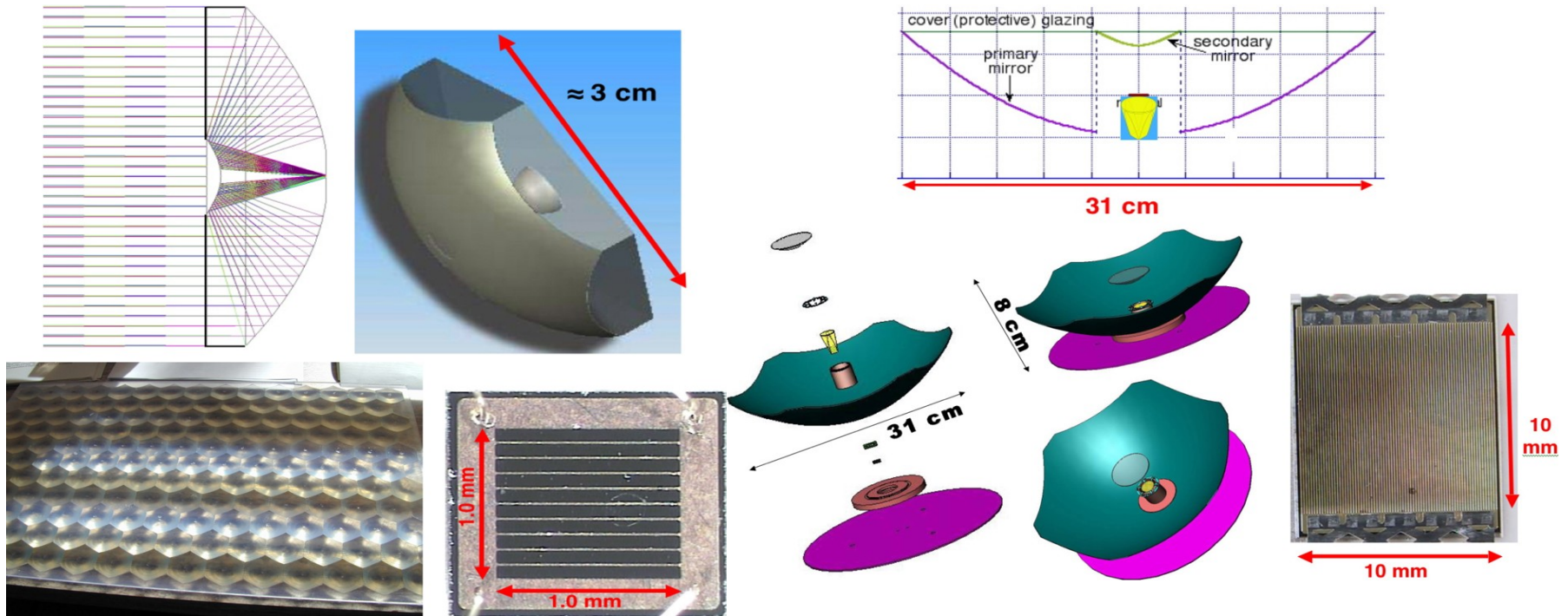


Helianthos is Small Company in Netherlands . Should we Buy this Company??

The Process sequence avoids the problem of depositing on PET at High temperature by using a special Carrier Lamination which can be removed later !!!

It is possible to automate and improve this process as a development between Barmag and sister Oerlikon Solar companies

Less Silicon per Watt in Another Way



SolFocus makes Concentrating solar Cell Modules with efficiency of 24% at 500 Sun.
PARC, Palo Alto lab initiative of single Cells

500 Sun on the 1 square Cm silicon

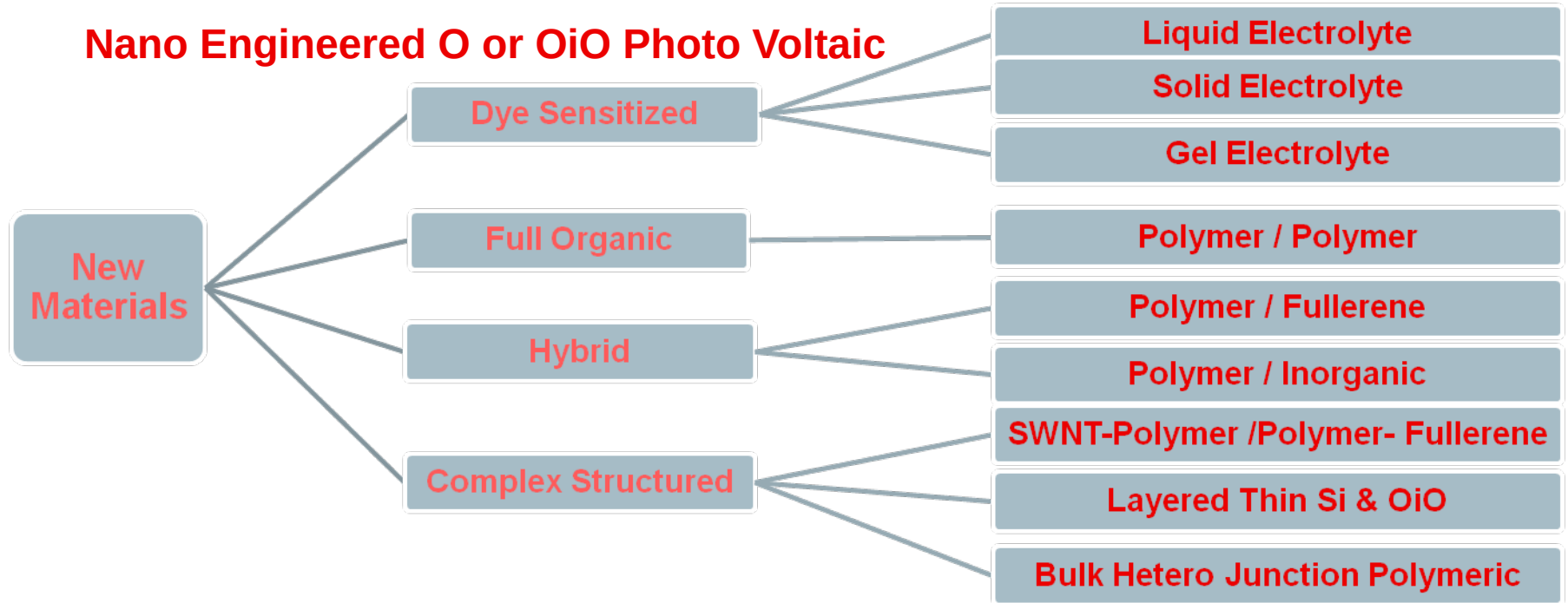
The reflector of small size and with non optic character come into use here also.

To reduce costs and to have economy of scale of manufacture. Opportunity to develop similar systems as a supplier

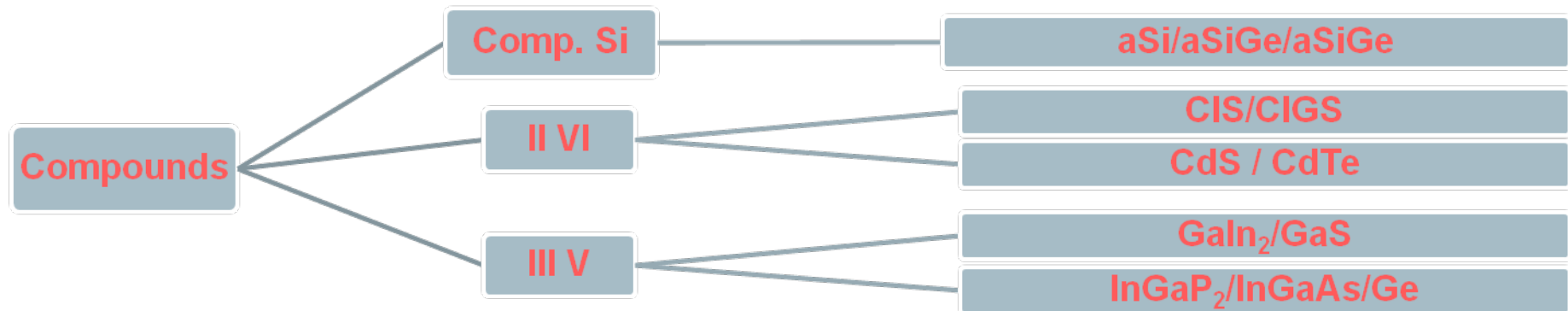


Future Photo Voltaic - Facing & Exceeding Limits

Nano Engineered O or OiO Photo Voltaic



Nano Engineered i – Compound Photo Voltaic



It is based on four assumptions: 1- single p-n junction .

2- one e-h pair excited for incoming photon ie. one e-h pair created at energy E_{gap} for each photon absorbed above threshold.

3- thermal relaxation of the e-h pair energy in excess of the bandgap.

4- illumination with unconcentrated sunlight.

Peaks for gap energy about 2 x blackbody temperature of sun thus Si Mono Crystalline Cells of Single Junction have a 35% Limit.

Compunds to Manage Band Gaps : Roll On Roll CIGS

$$u(x_g) = \frac{h\nu_0 Q_s / P_s}{\left[x_g \int_{x_g}^{\infty} x^2 dx / (e^x - 1) \right] / \int_0^{\infty} x^2 dx / (e^x - 1)} \quad (2.8)$$

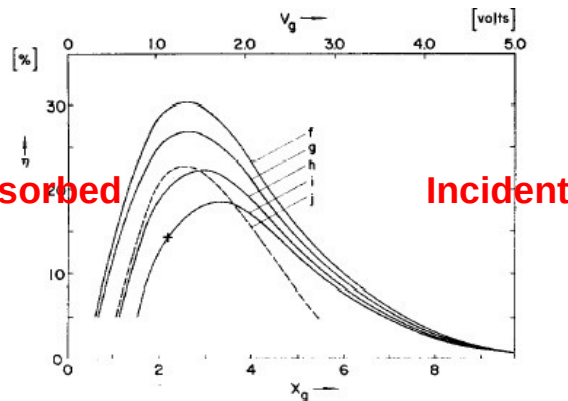


FIG. 6. Efficiency η for a solar cell at temperature $T_c = 300^\circ\text{K}$ exposed to a blackbody sun at temperature $T_s = 6000^\circ\text{K}$. Curve (f) is the detailed balance limit of efficiency, assuming the cell is a blackbody (i.e., $t_s = t_c = 1$). Curve (j) is the semiempirical limit, or limit conversion efficiency of Prince (see footnote 3). + represents the "best experimental efficiency obtained to date" for Si (see footnote 6). Curves (g), (h), and (i) are modified to correspond to 90% absorption of radiation (i.e., $t_s = t_c = 0.9$) and 100 mw incident solar energy. The values for the f quantities discussed in Sec. 6 are: (f) $f = 1.09 \times 10^{-8}$ ($f_s = 2.18 \times 10^{-8}$, $f_c = 1$) $t_s = t_c = 1$; (g) $f = 0.68 \times 10^{-8}$ ($f_s = 1.36 \times 10^{-8}$, $f_c = 1$) $t_s = t_c = 0.9$; (h) $f = 0.68 \times 10^{-8}$ ($f_s = 1.36 \times 10^{-8}$, $f_c = 10^{-3}$) $t_s = t_c = 0.9$; (i) $f = 0.68 \times 10^{-11}$ ($f_s = 1.36 \times 10^{-8}$, $f_c = 10^{-3}$) $t_s = t_c = 0.9$.

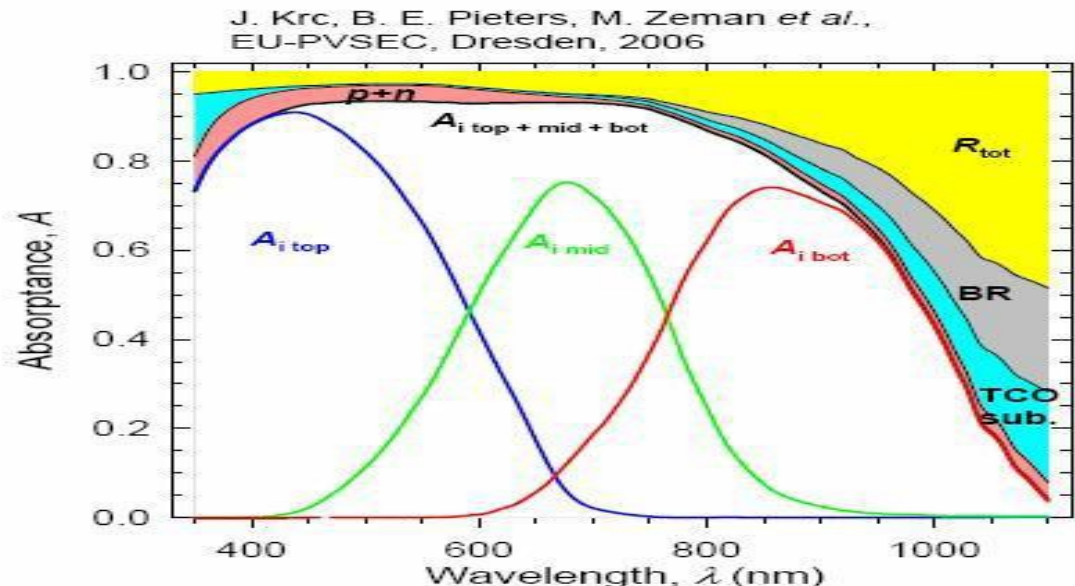
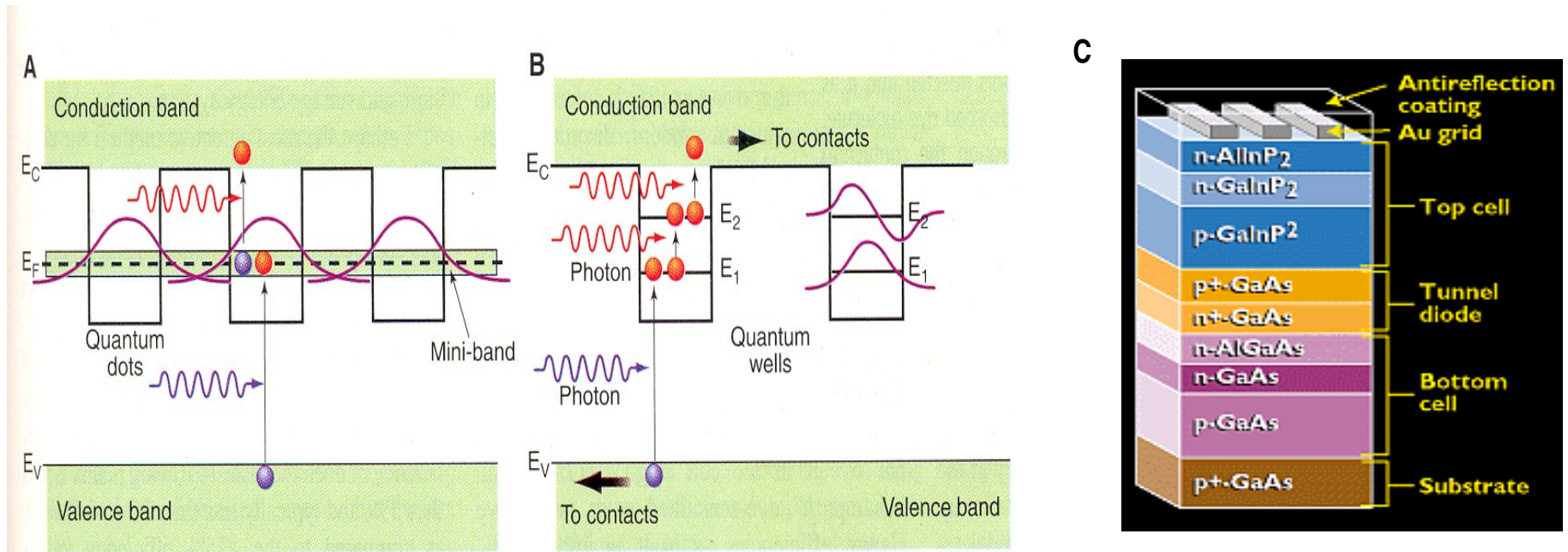


Fig. 1(b): Absorption losses and absorptances in the absorber layers for the optically improved a-Si:H/a-SiGe:H/mc-Si:H solar cell ($d_i \text{ top} = 110 \text{ nm}$, $d_i \text{ mid} = 280 \text{ nm}$, $d_i \text{ bot} = 2.1 \text{ mm}$).

Photovoltaic Efficiency – Shockley and Queisser (J. App. Phys. 1961)



S-Q limit exceeded by violating one or more of its premises.

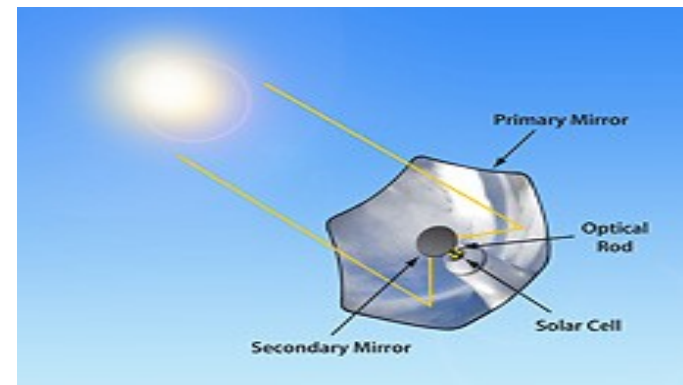
A- Intermediate-band solar cells

B- Quantum-well solar cells

C- Multiple junctions cells

D- Concentration of Solar Energy

D

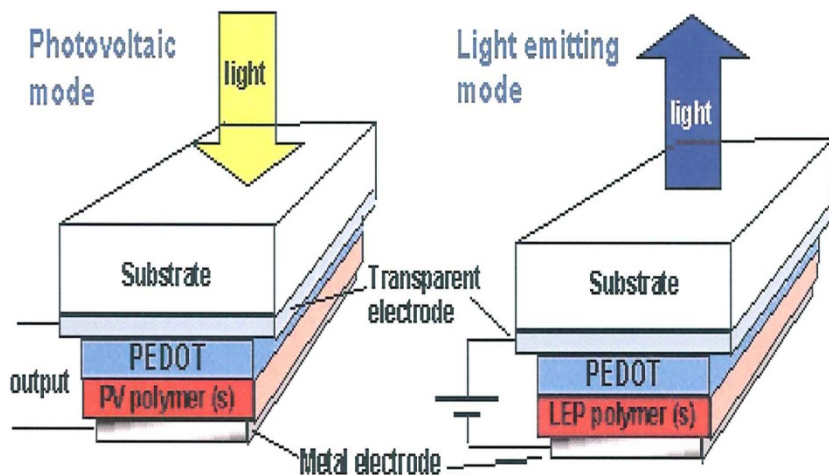


If OLED can be encapsulated for
Weather proofability then O PV can also be
done

O PV
Time to Market
Within 4 Years

Polymer Solar Cells

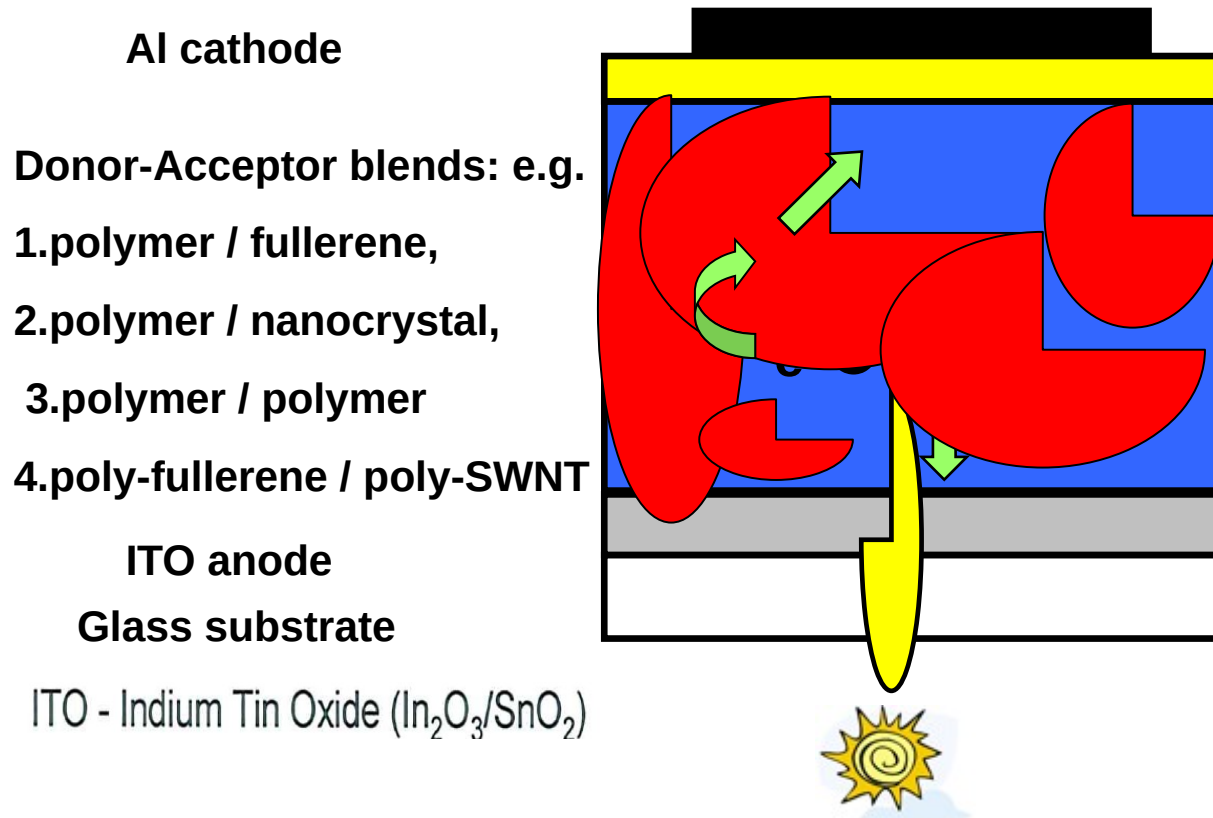
OLED
Time to Market
Took 6 Years
Polymer Light-emitting Diodes



PERIODIC TABLE OF THE ORGANICS

Symbol		picture		Band gap		Name	
B	6 eV					N	5 eV
Benzene						Naphthalene	
A	3.9 eV		T 3.1 eV 	P 2.2 eV 	C 		
Anthracene		Tetracene		Pentacene		Coronene	
Du  Duren e		P 	Cl 				
		Perylen		Corannulene			

- Donor-acceptor bulk heterojunction devices

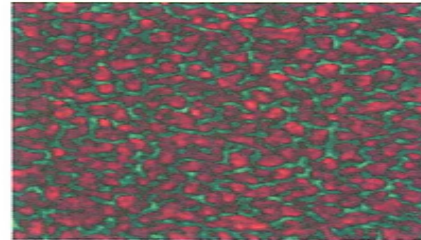


- Both components deposited from same solution

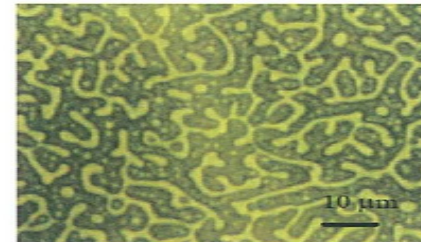
In Industrial System Efficient Blending in Continous production may be a key Issue. Oerlikon Barmag has proprietry Polymer Blending systems

Different Schemes of Polymeric Solar Cells

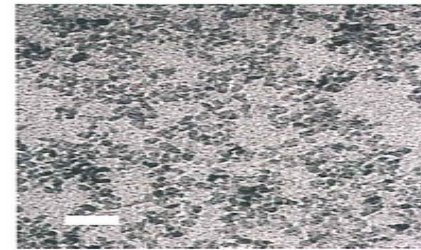
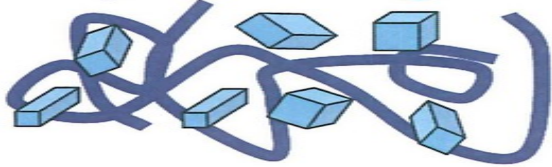
Polymer – fullerene



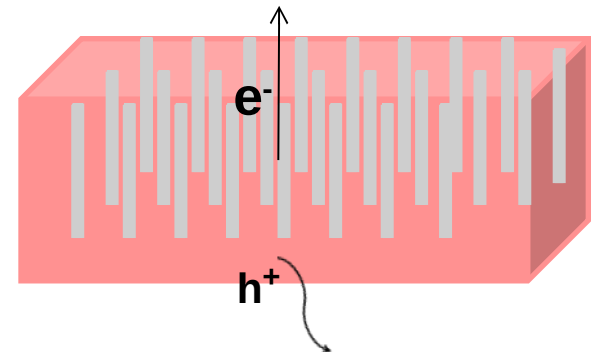
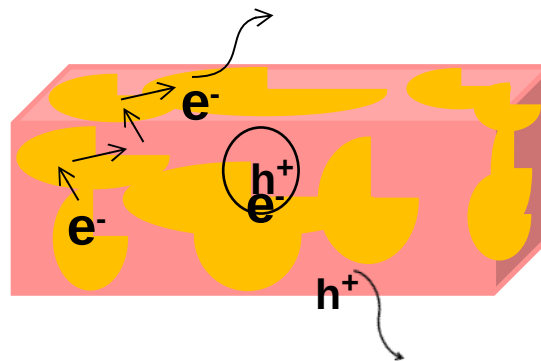
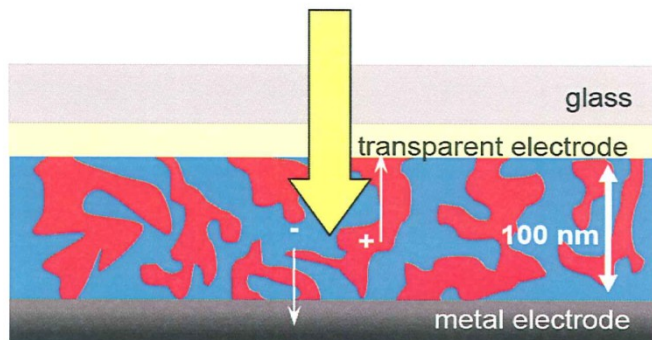
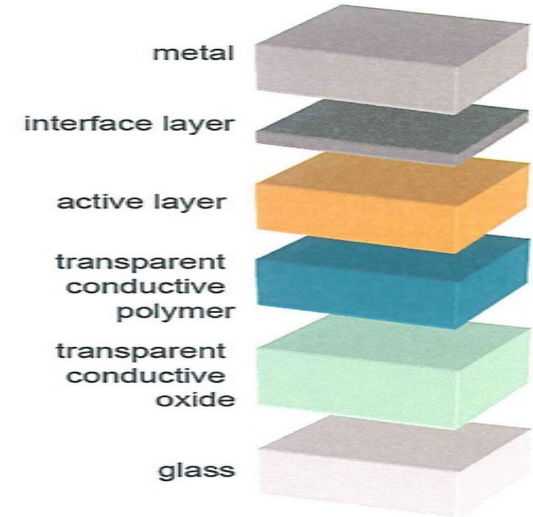
Polymer – polymer



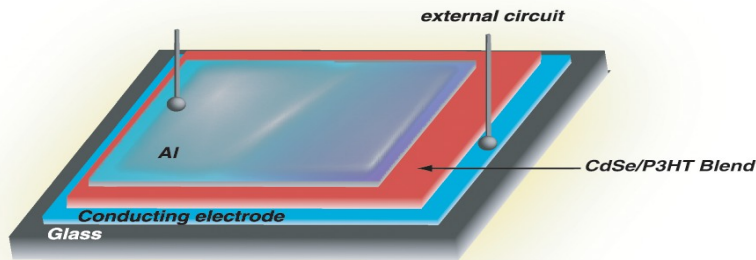
Polymer – inorganic



Blending & Alignment Technologies would be the Key to Benefits

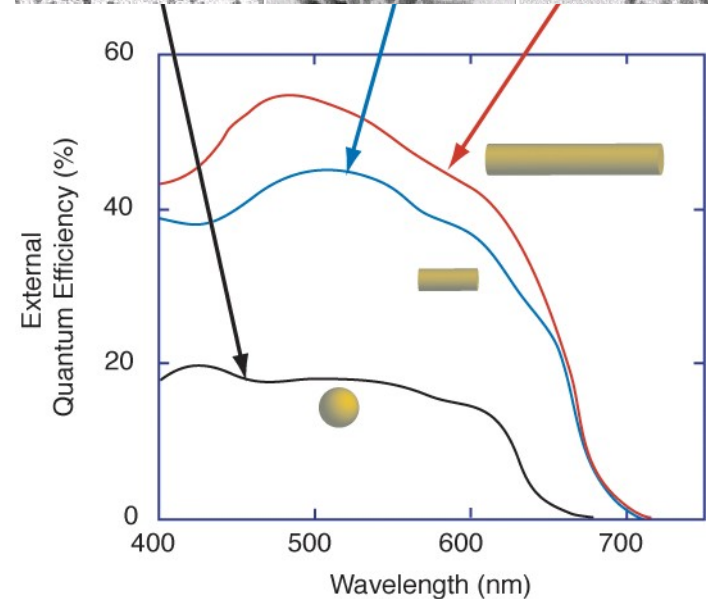
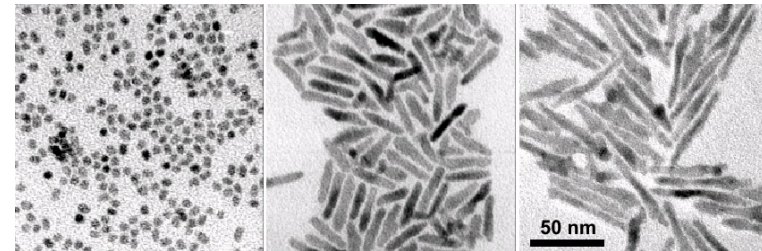


Shape Control and Alingment in Hybrid Cells



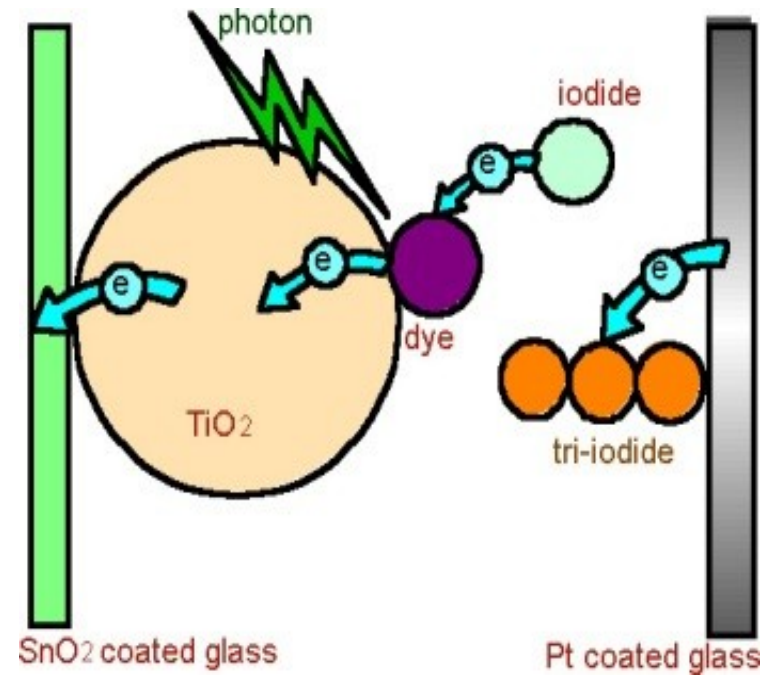
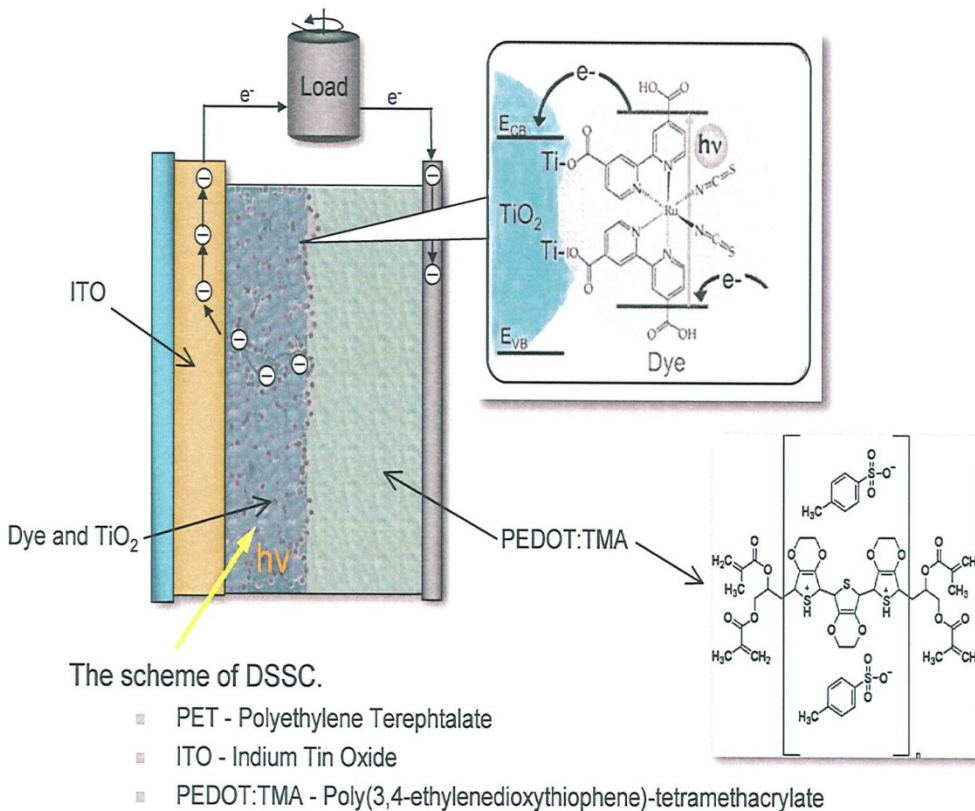
Hybrid nanocrystal-polymer solar cell is made by blending CdSe nanocrystals with P3HT, a conducting polymer, to form a 200 nm thick film sandwiched between an aluminum top contact (orange) and a transparent bottom contact (blue).

Probably Oerlikon Barmag ideas on this as developed can do this in Polymers for Nano Particulates. Are these ideas of Valuable , should be work further and develop systems for the same is question



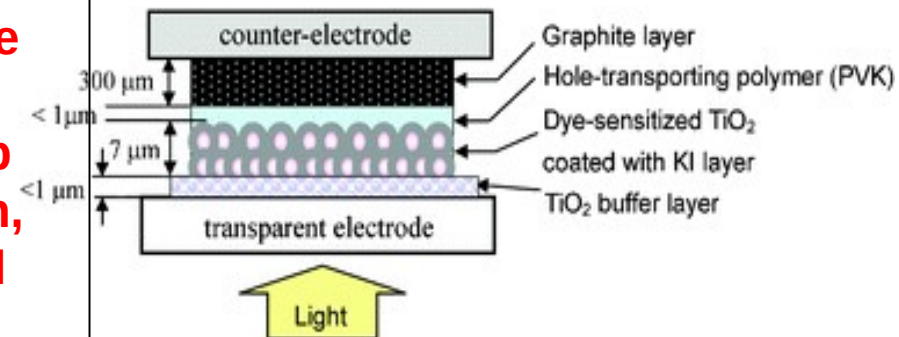
Nanocrystal shape affects the cell efficiency. Monochromatic quantum efficiencies of over 50% are achieved by using rod-like nanocrystals that are partially aligned with the path of current flow in the device.

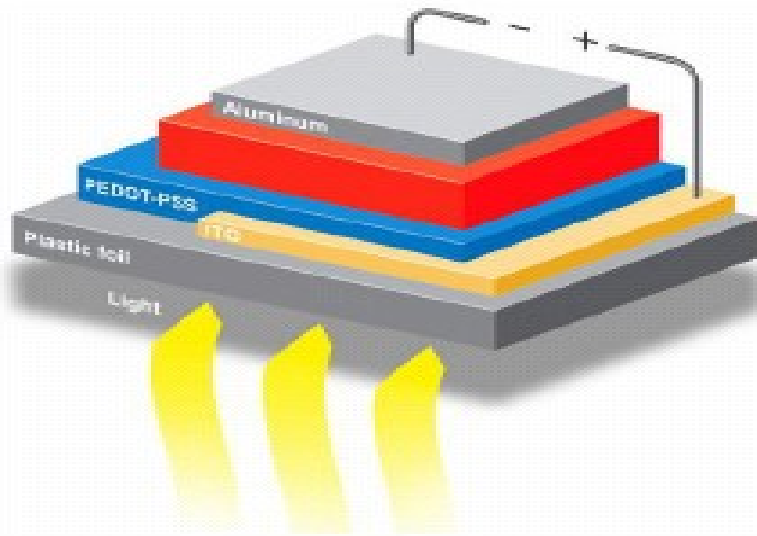
Dye Sensitized Solar Cell : DSSC



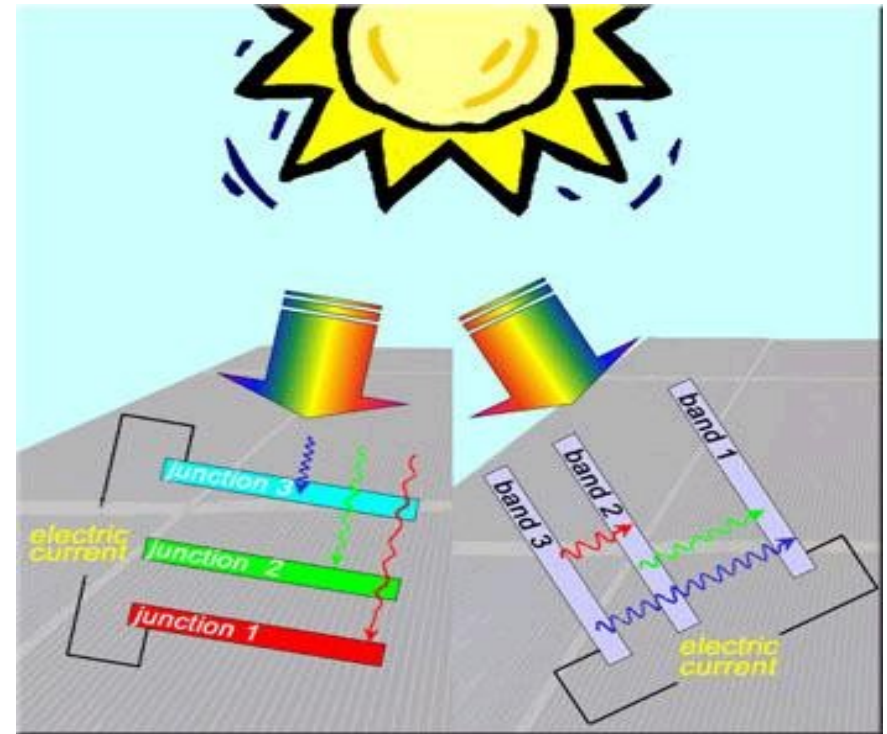
Gratzel Cell: Mimic Photosynthesis

Special Organic Cell : Enclosing Electrolyte for a Practical Cell is Challenge !!
May be possible by special Conjugate Strip spinning with Barmag Technology in which, Electrolyte is Liquid spun through Channel Holes with Bi-Co Extrusion Spinnerettes.



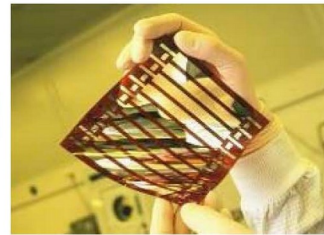
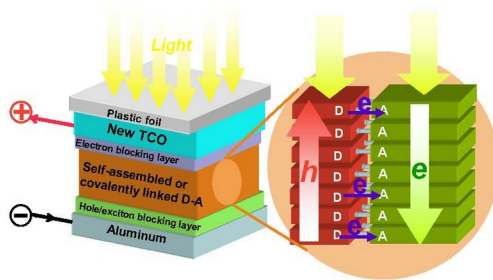


Construction of a typical organic photovoltaic device. The active layer (red) can be a bilayer of vapor-deposited molecules, or a bulk heterojunction containing a polymer and C_{60} or an inorganic quantum structure.

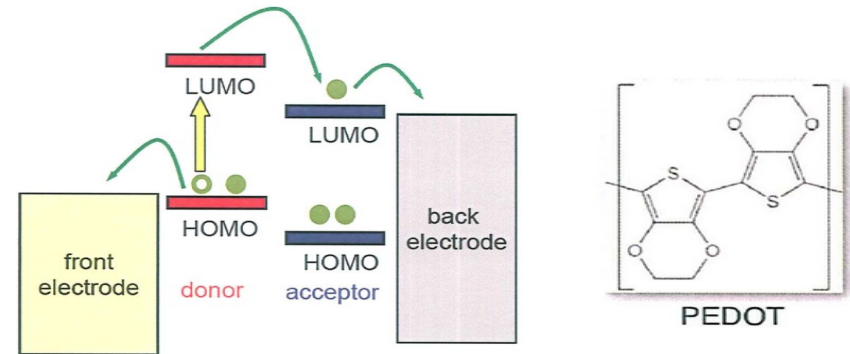
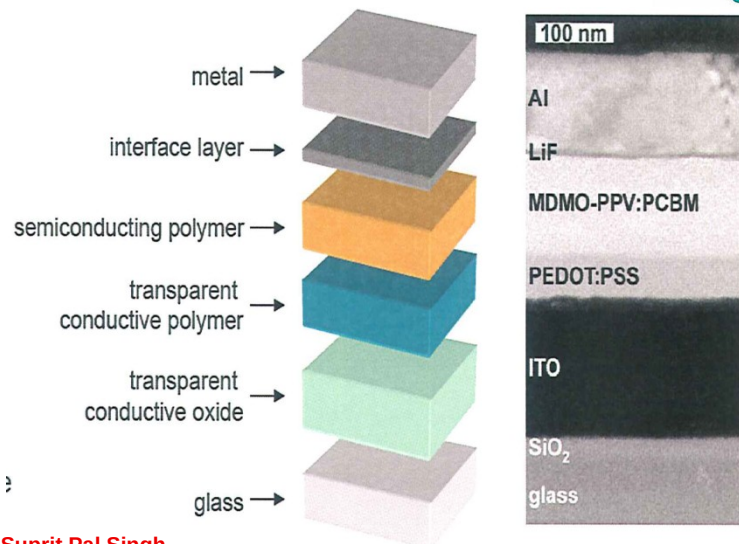
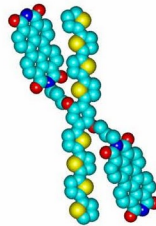


- *Materials issues similar to OLEDs : injection efficiency, transport efficiency, emission efficiency, time latency calculation and tuning*
- *Need new molecules that are : strong, light-absorbing, band-gap and exciton level tunable*
- *C_{60} : undergoes little structural distortion upon electron transfer*
- *Multiple Junction Organic Solar Cells are already Tried out*

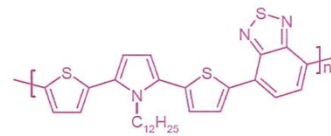
Novel nanoscale organic photovoltaic materials



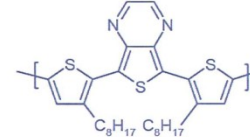
- Light absorption by D and A;
- Charge separation within covalently linked D-A;
- Charge carrier hopping through the π - π stacked pile formed by SA;
- Charge collection through TCO electrodes;
- Prototype devices.



Recent low band gap polymers for photovoltaics



PTBTB $E_g = 1.6$ eV (1.45 eV)
 $M_w = 2440$



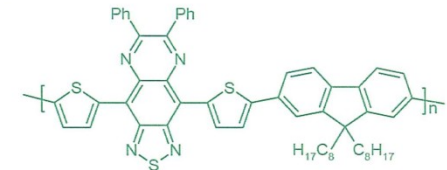
PB3OTP $E_g = 1.30$ eV
 $M_w = 1630$

PTPTB:

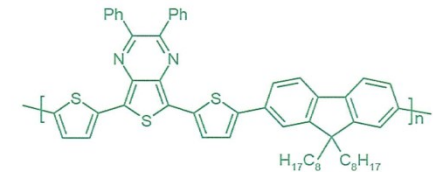
A. Dhanabalan et al., *Adv. Funct. Mater.* 2001, **11**, 255.
C. Brabec et al., *Adv. Funct. Mater.* 2002, **12**, 709.

PB3OTP:

L.M. Campos et al., *Chem. Mater.* 2005, **17**, 4031.



APFO Green 1 $E_g = 1.24$ eV
 $M_w = 6200$

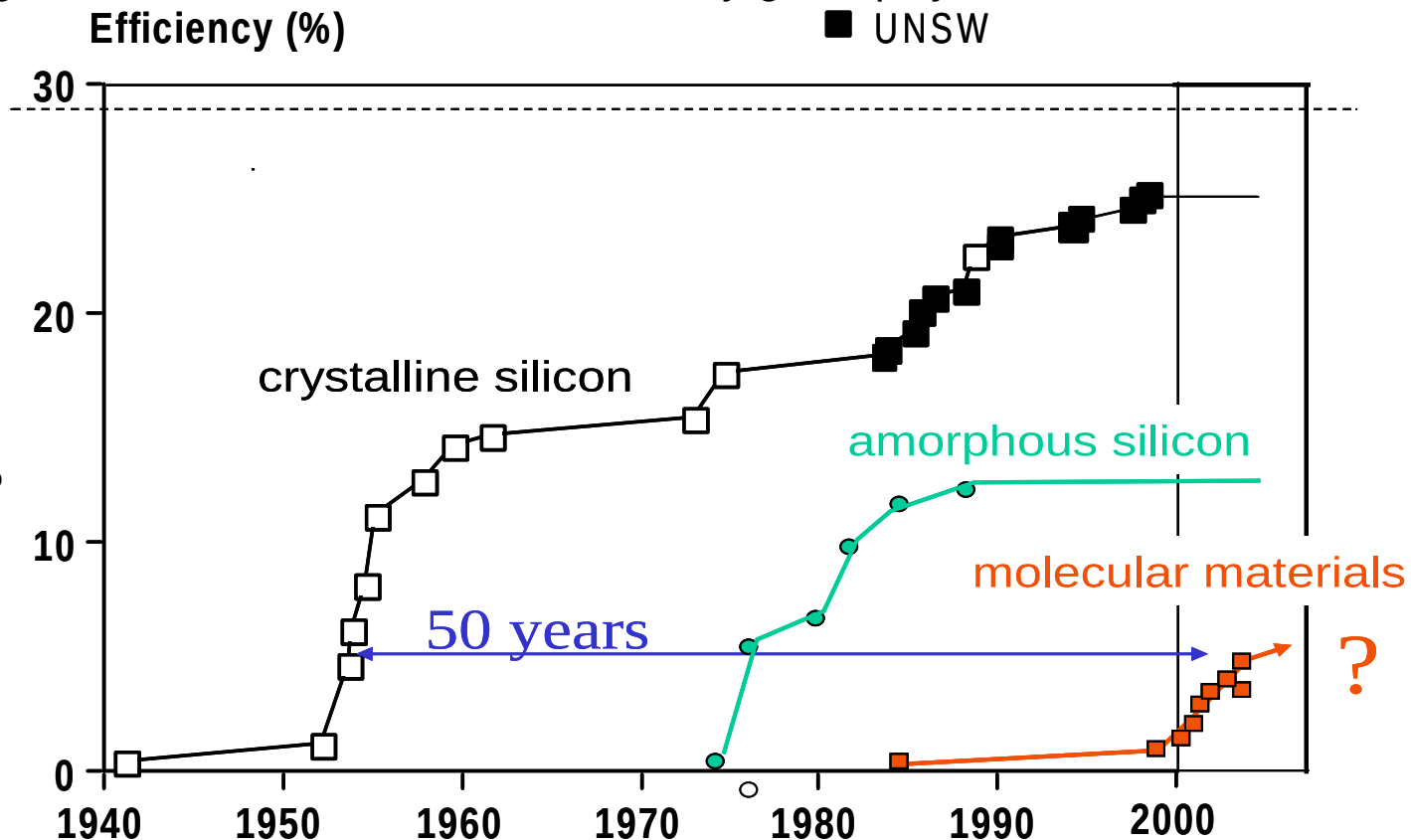
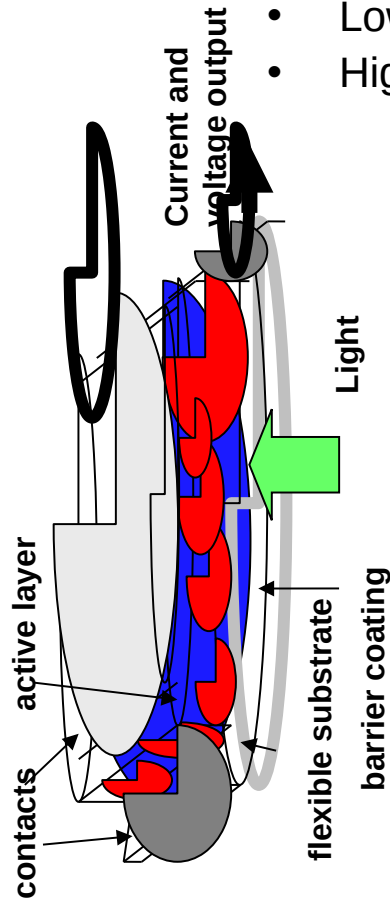


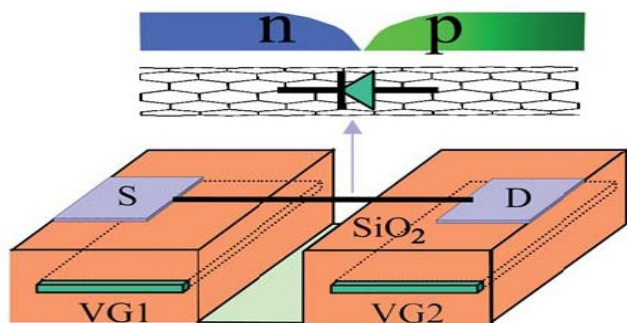
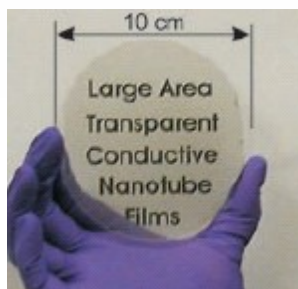
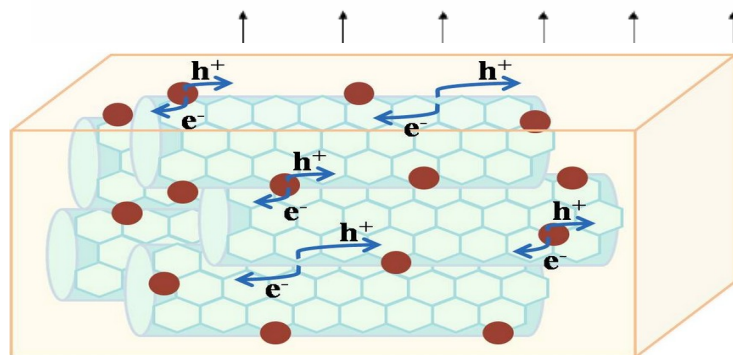
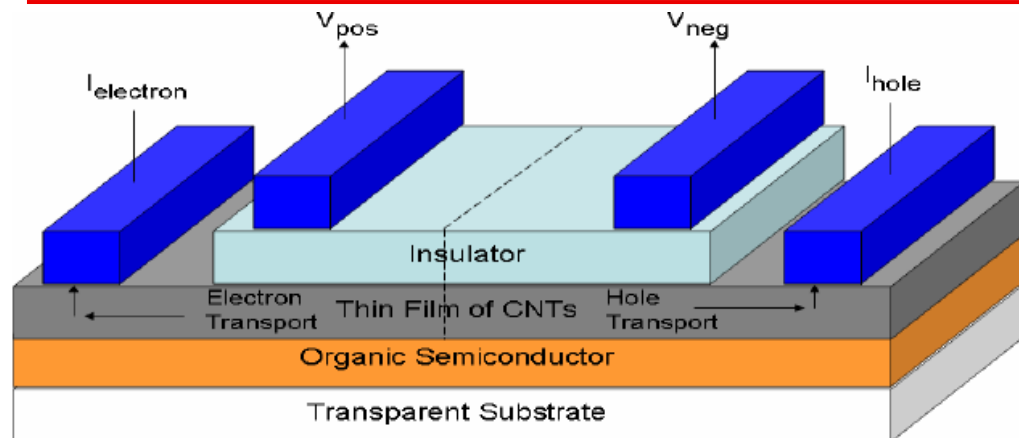
APFO Green 2 $E_g = 1.55$ eV
 $M_w = -$

APFO-Green:

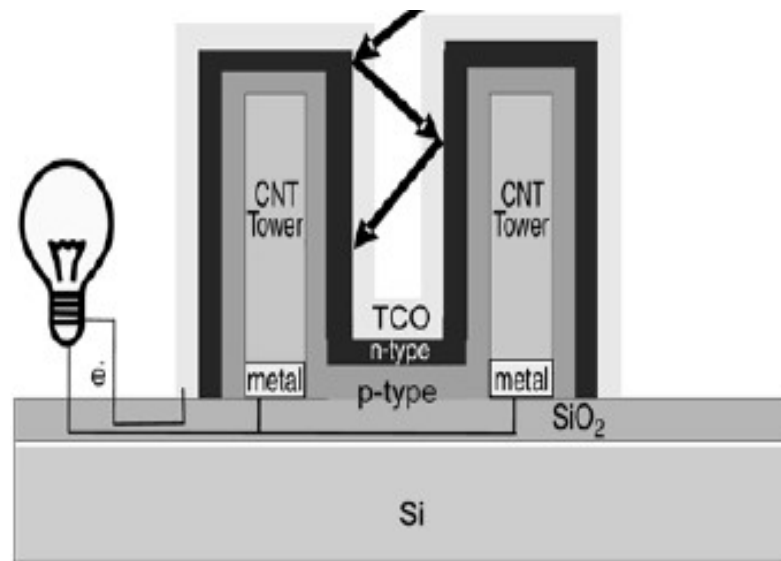
X. Wang et al., *Appl. Phys. Lett.* 2004, **85**, 5081.
F. Zhang et al., *Adv. Funct. Mater.* 2005, **15**, 745.
X. Wang et al., *Adv. Funct. Mater.* 2005, **15**, 1665.
E. Perzon et al., *Synth. Met.* 2005, **154**, 53.

- **Molecular photovoltaic materials** enable low cost device fabrication
- Active layer ~100 nm thick
- Low temperature processing enables use of flexible substrates
- Highest efficiencies 5% from blend of conjugated polymer with fullerenes

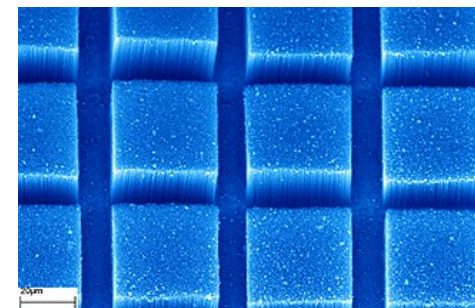
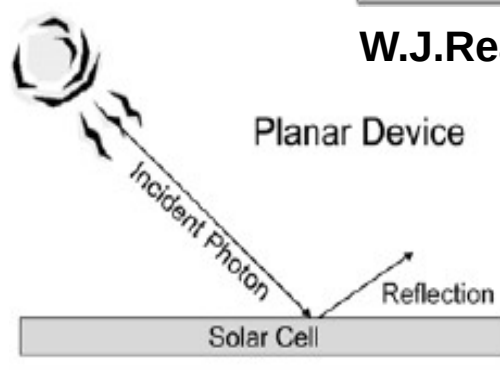




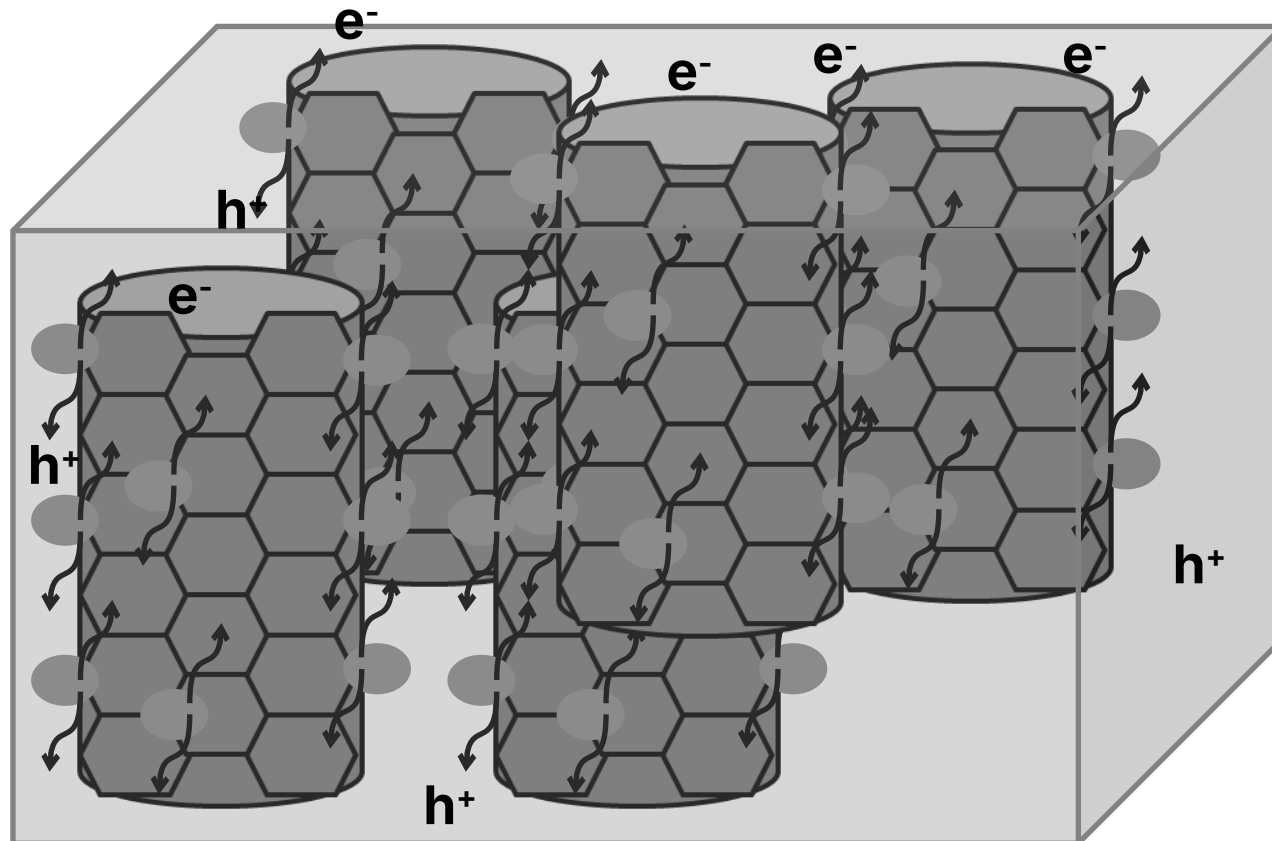
“A Solar Cell with Improved Light Absorption Capacity”
S. Sundar Kumar Iyer and Arun Tej M.
Patent Appln. No. 933/DEL/2006
Dt: 31st March, 2006



W.J.Ready, Georgia Tech, JOM, 2007



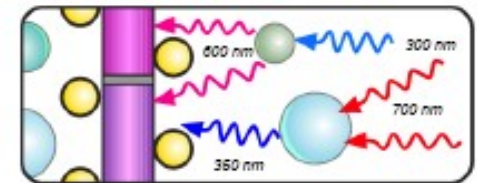
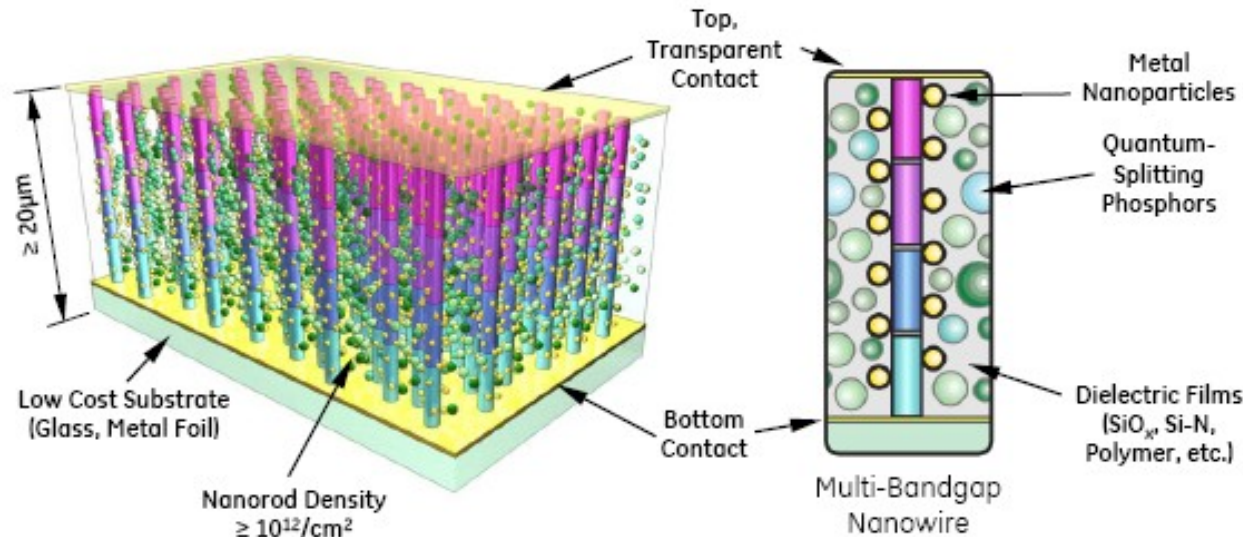
- Synthesis of stable organic compounds
- Separate semiconducting and metallic SWCNTs
- Aligned CNTs in the semiconducting polymers to improved charge transport
- Add nanoparticles, quantum dots, fullerenes etc to the side walls of SWNTs



Nano Structured iO or O or OiO Films

Opportunity for breakthrough technology

Nanorod Array Architecture

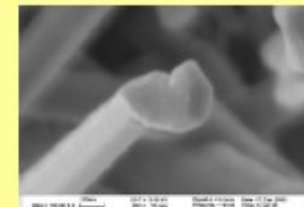
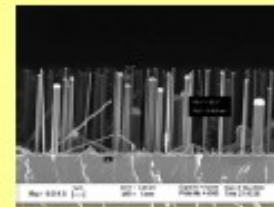


Quantum-Splitting Phosphor Detail

Advantages

- Low (insignificant) material cost
- Multiple bandgaps for UV/IR absorption
- High mobility and lifetime
- Multiple absorption mechanisms
- Low defect density interfaces (heteroj)
- Integration with low cost substrates
- Roll-to-roll manufacturing

Silicon Nanowire Project



Si nanowires grown at GRC by low cost CVD techniques

Goal is 20% efficiency at thin film material cost

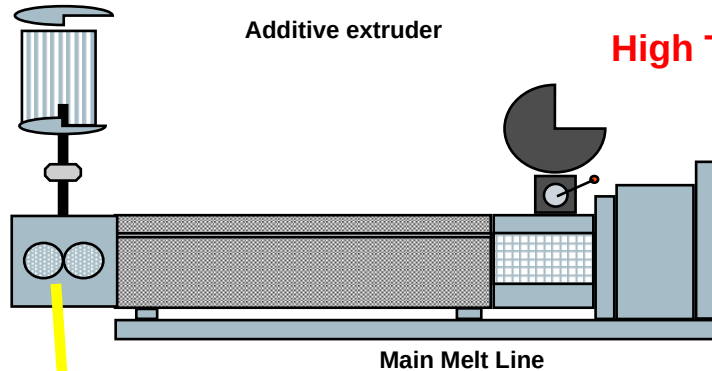
Oerlikon Barmag Possible Bi-Co Strip Spinning Polymers

Pump drive

Additive extruder

Tri- Co ie Three Component Spinning or Extruding !
Also Possible !

High Temperature or Low Depending on Polymer Character



Molecular Engineering Cells would require
Conducting Polymer Matrixes in Many Cases

Possible Shapes : Many More Feasible



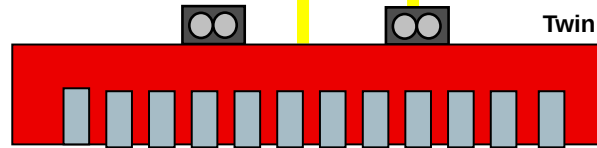
Pump drive

Dosing
pump

Additive extruder

Metering pump

Twin Metering of Conjugate Polymers



DIO STRIP SPIN BEAM

Multiple Strips on One Position Possible !!

Barmag Scale up Possible from 100mm Strips to 2000mm Wide Thin Film

Novel Designs are Possible with this Technique

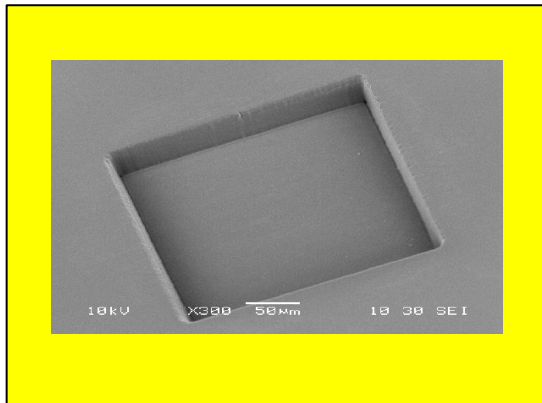
Dissolution of Ex. Ethyl Vinyl Alcohol
Water Dissolvable Polymer at LowTemperature



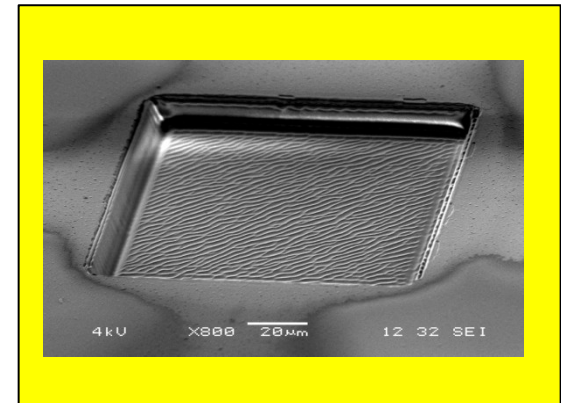
Dissolution of Ex. Ethyl Vinyl Alcohol
Water Dissolvable Polymer at LowTemperature



Laser Ablative Lithography of Hard Polymers is Established



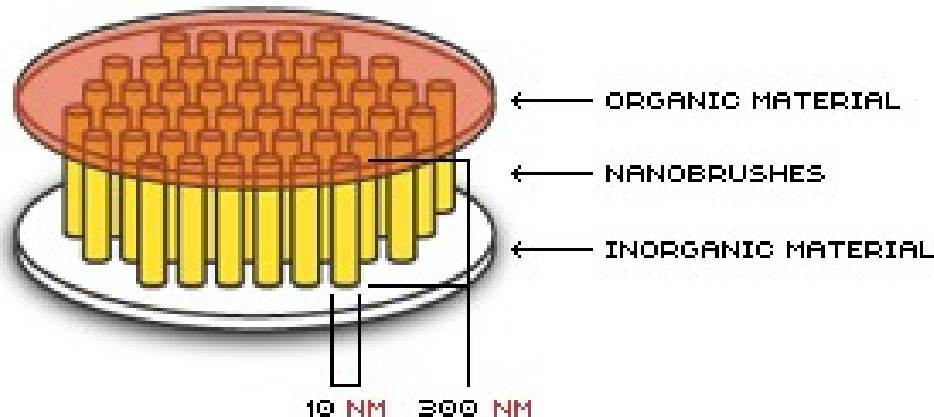
PC, 250x250 μm and 28 μm deep
100 pulses at Excismor (440 mJ/cm^2) static ablation



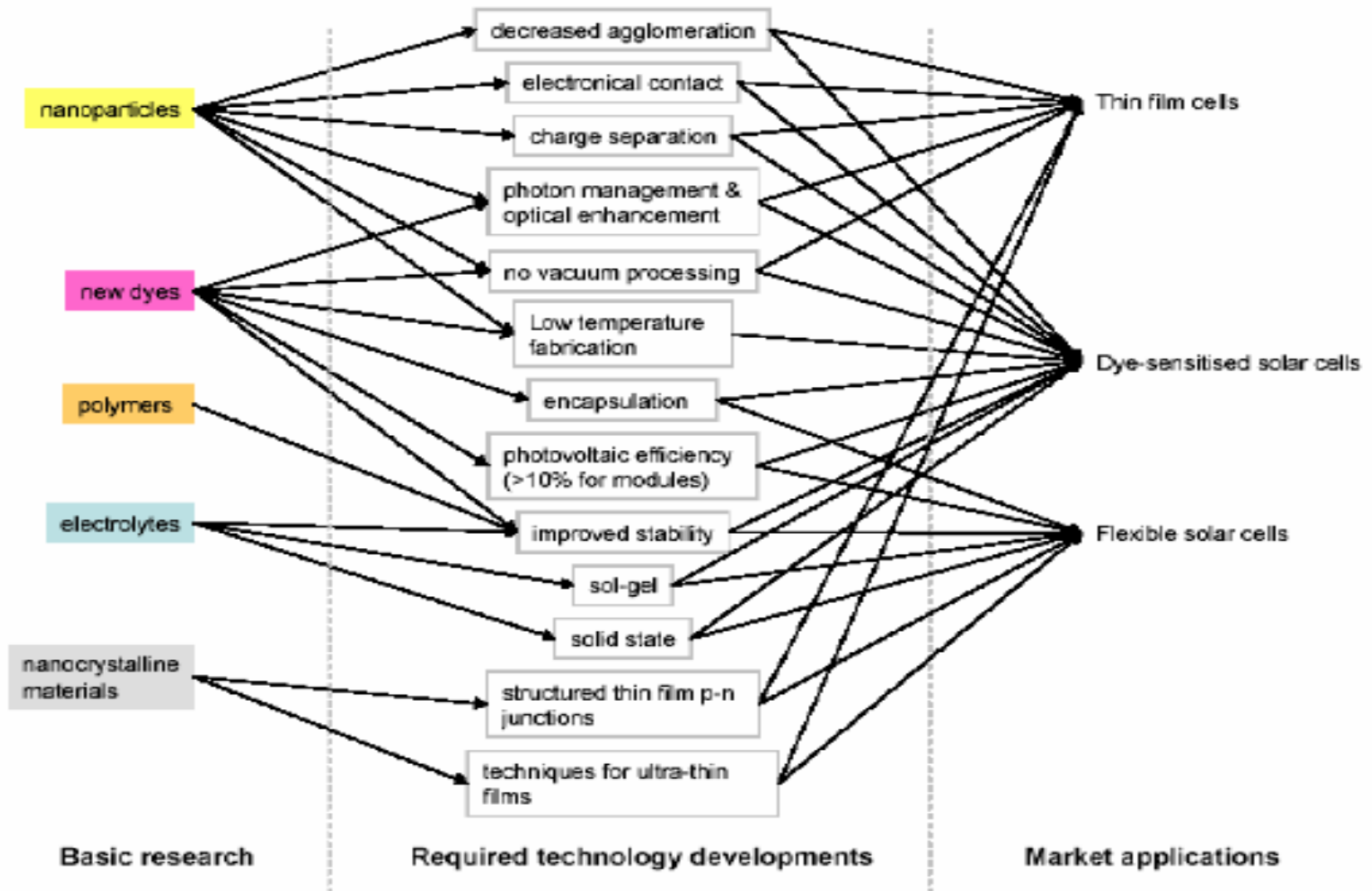
Cavity ablated in PET using
Excismor Laser

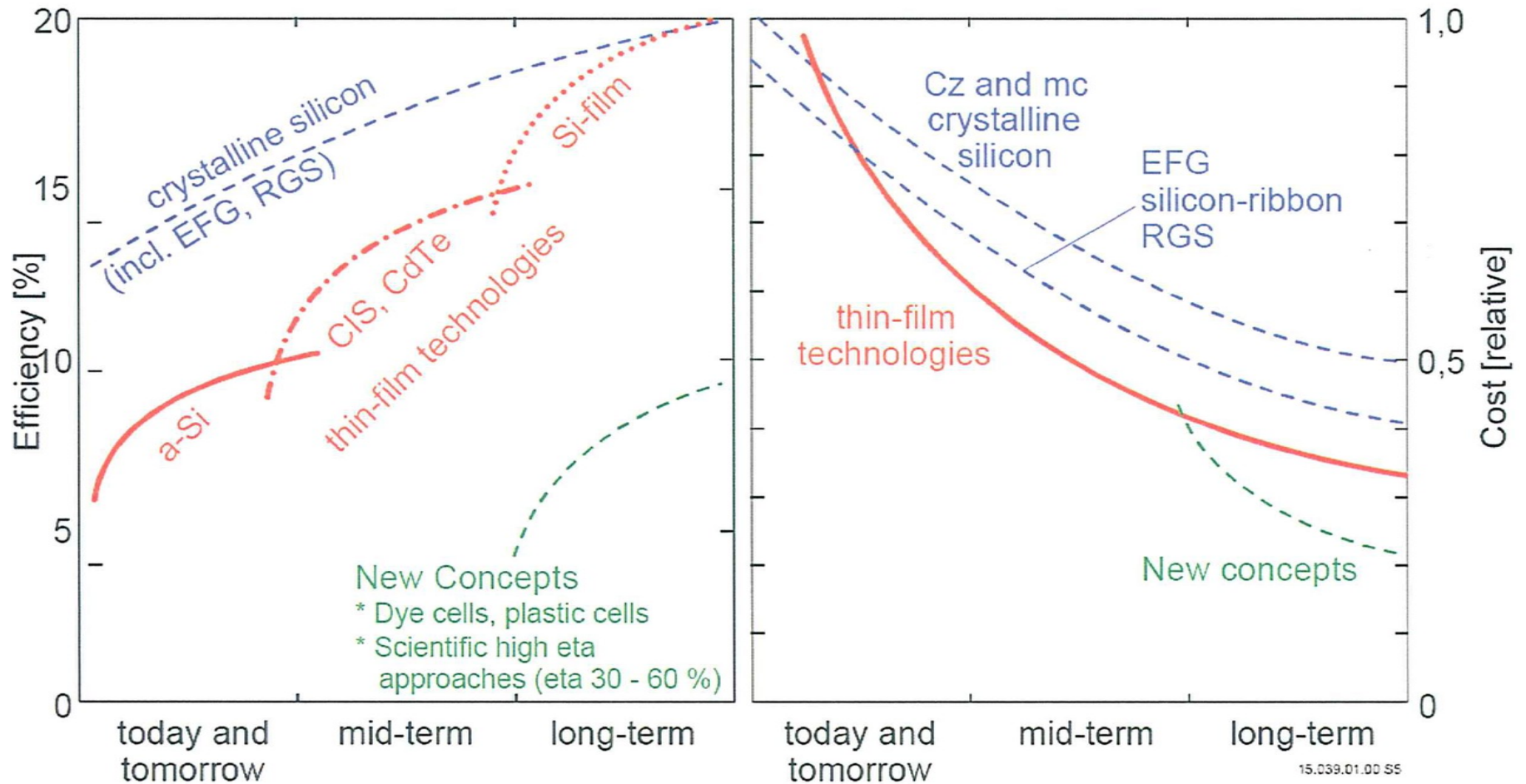
- 1) High cost of Photovoltaics is driven by (a) low photo-conversion efficiency, (b) expensive processing, and (c) extensive use of materials
- 2) Only photons that match the band-gap of the semiconductor can be harvested for electrical energy generation
- 3) The excess energy in higher frequency photons (that in blue and violet)end of the spectrum is wasted as heat
- 4) In Gratzel cells, exciton generation in organic dye is very efficient for visible wavelengths (>1.5 eV) but its poor for long and short wavelengths also requires liquid electrolyte Encapsulation.
- 5) The stability of organics, photo-bleaching, thermal degradation, etc. are major concerns with DSSCs & Polymeric PV
- 6) Research Moving on to Hybrid and Bulk Heterojunction Investigations. With Molecular Scale manipulations.

THE IDEAL SOLAR CELL:

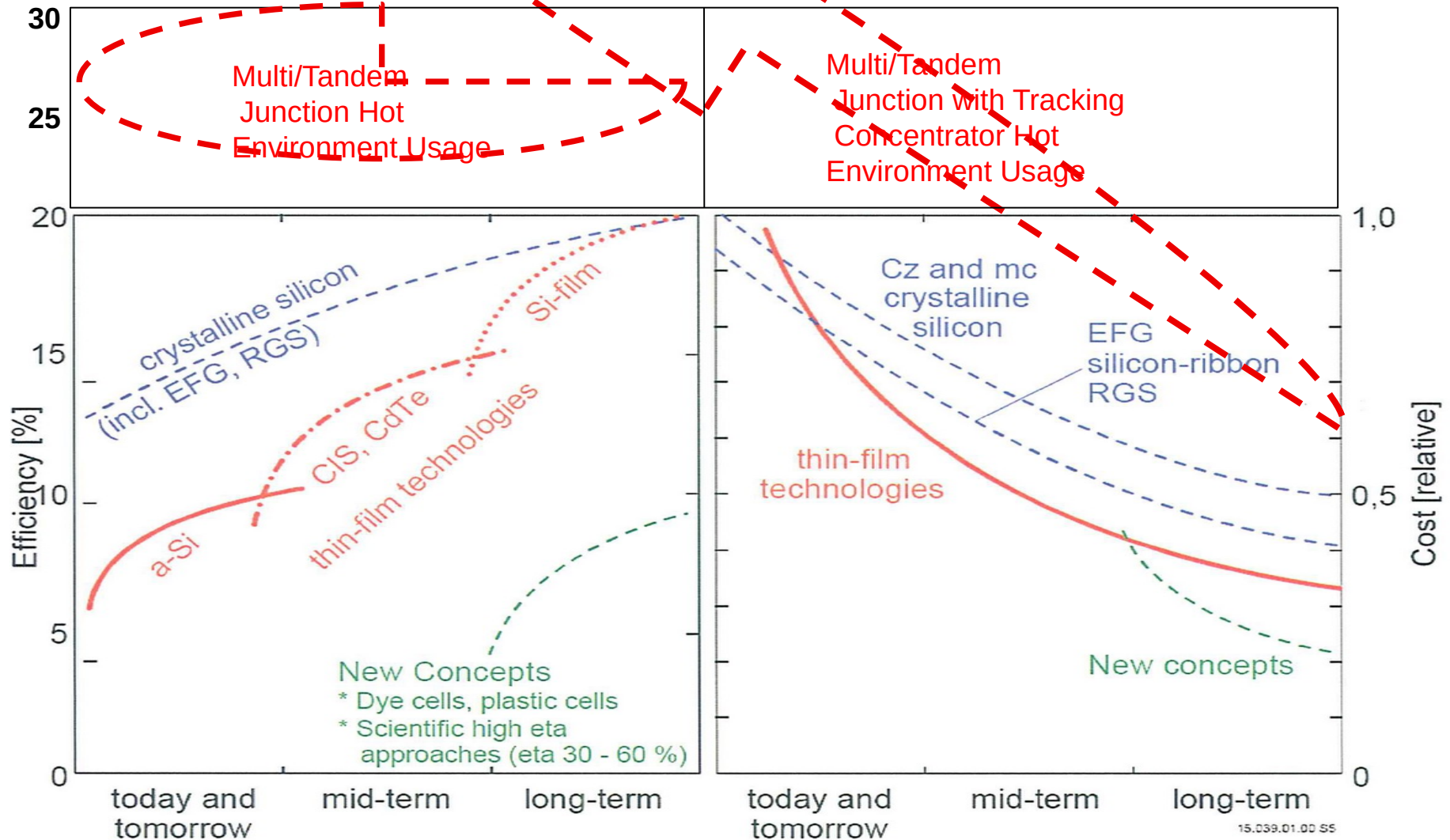


Basic research underway with the technology developments required to achieve the desired applications

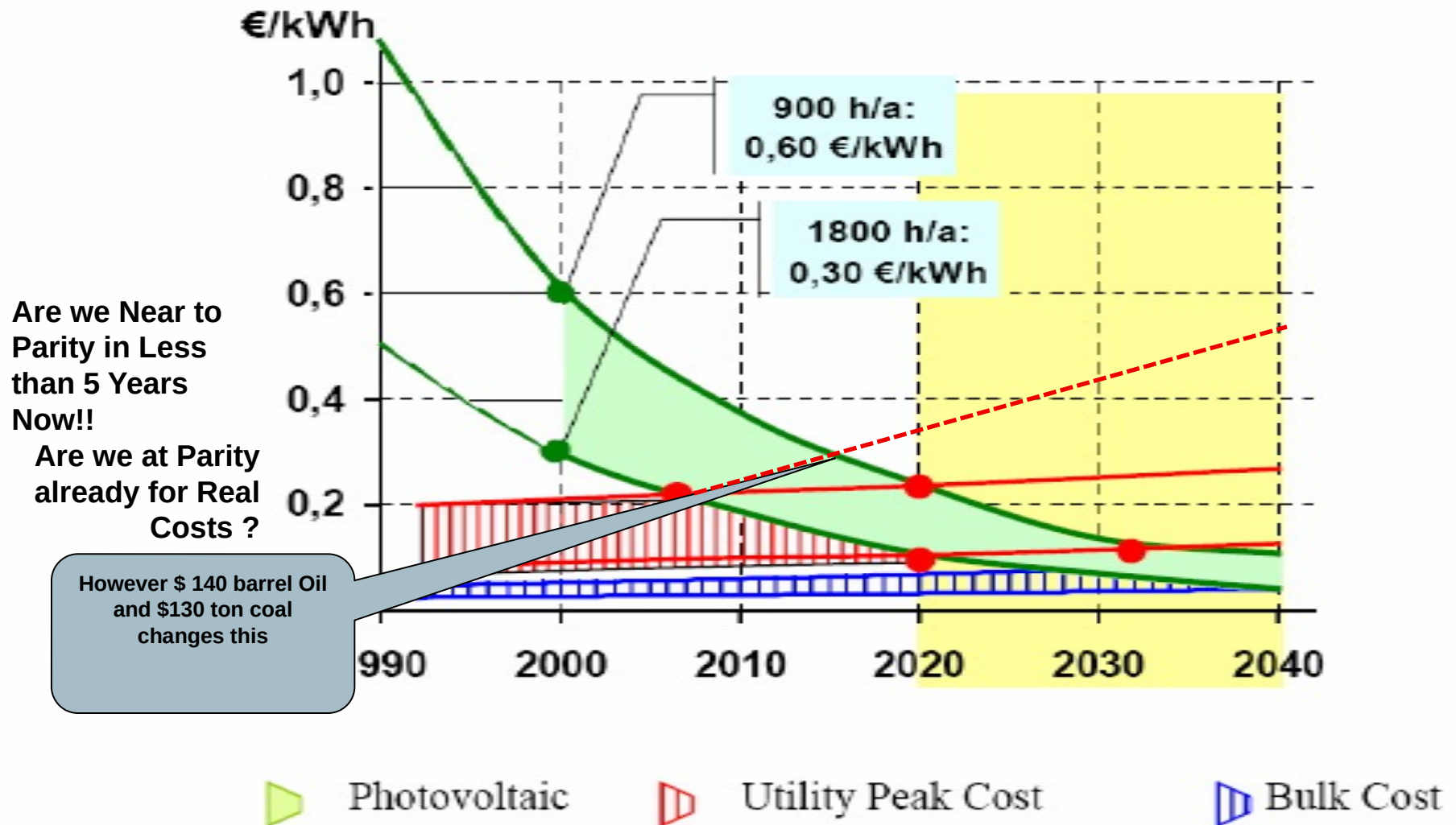




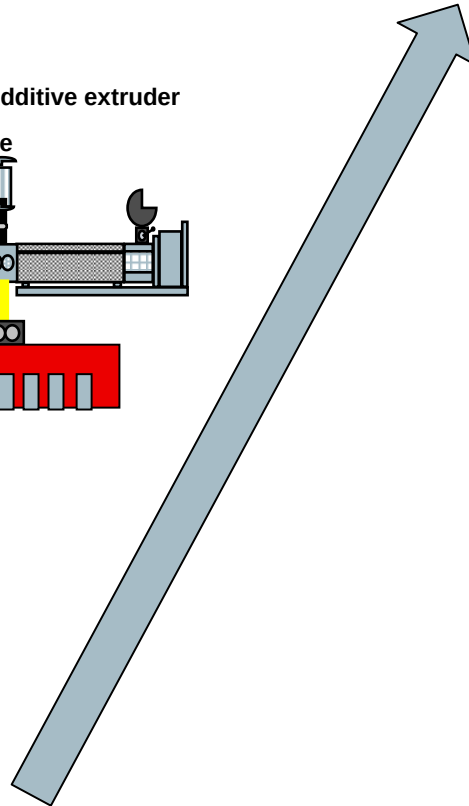
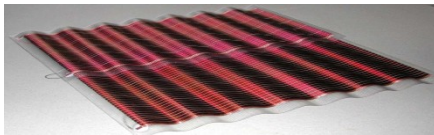
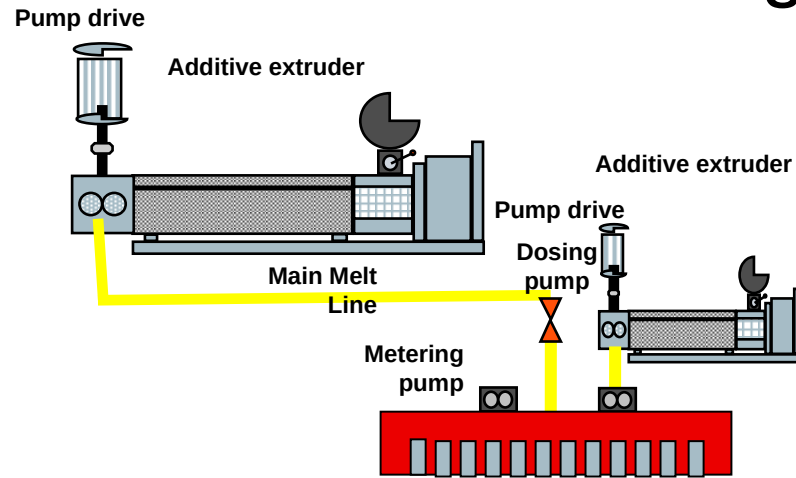
source: W. Hoffmann, RWE Schott Solar, PV Solar Electricity Industry: Market Growth And Perspectives Bangkok 2004



source: Modified by Suprit from base W. Hoffmann , RWE Scott Solar , Market Growth and Perspectives Bangkok 2004



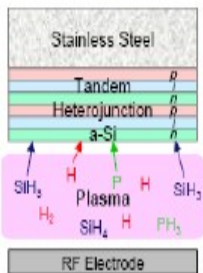
Scale Up Wide Width In Situ Impregnation



Start From Small Strip Extrusion

a-Si

Uni-Solar



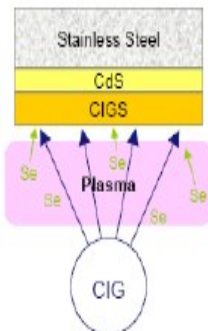
(Micromorph is emerging subset of a-Si)

Plasma Enhanced
CVD

Suprit Pal Singh

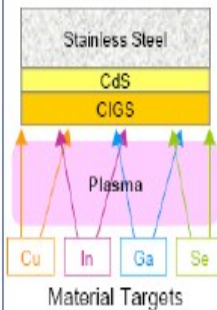
CIGS

Miasole



Rotating Magnetron
Reactive Sputtering

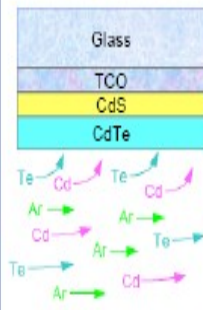
Daystar



Magnetron
Sputtering

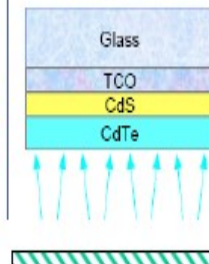
CdTe*

First Solar



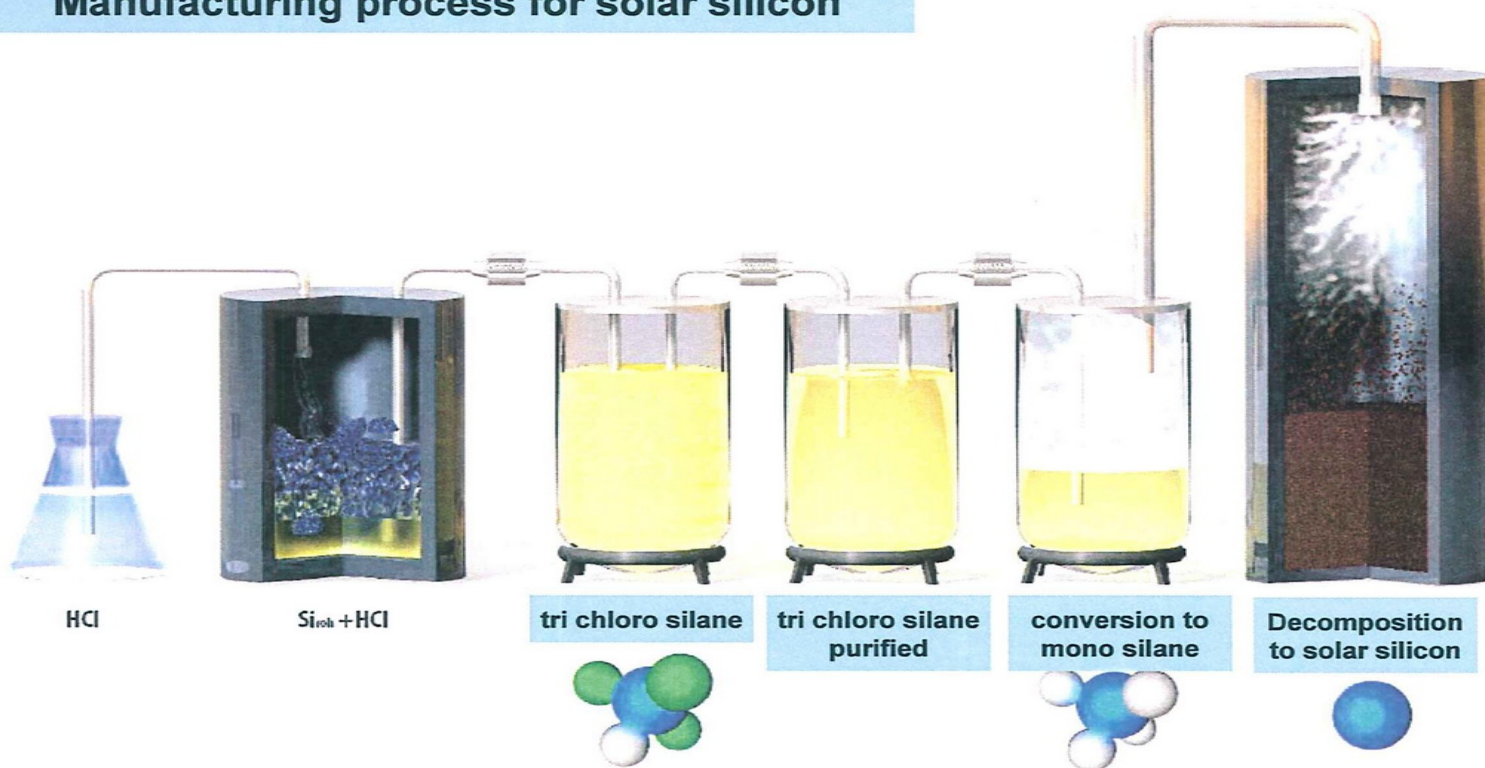
Vapor Transport
Deposition

CSU/AVA



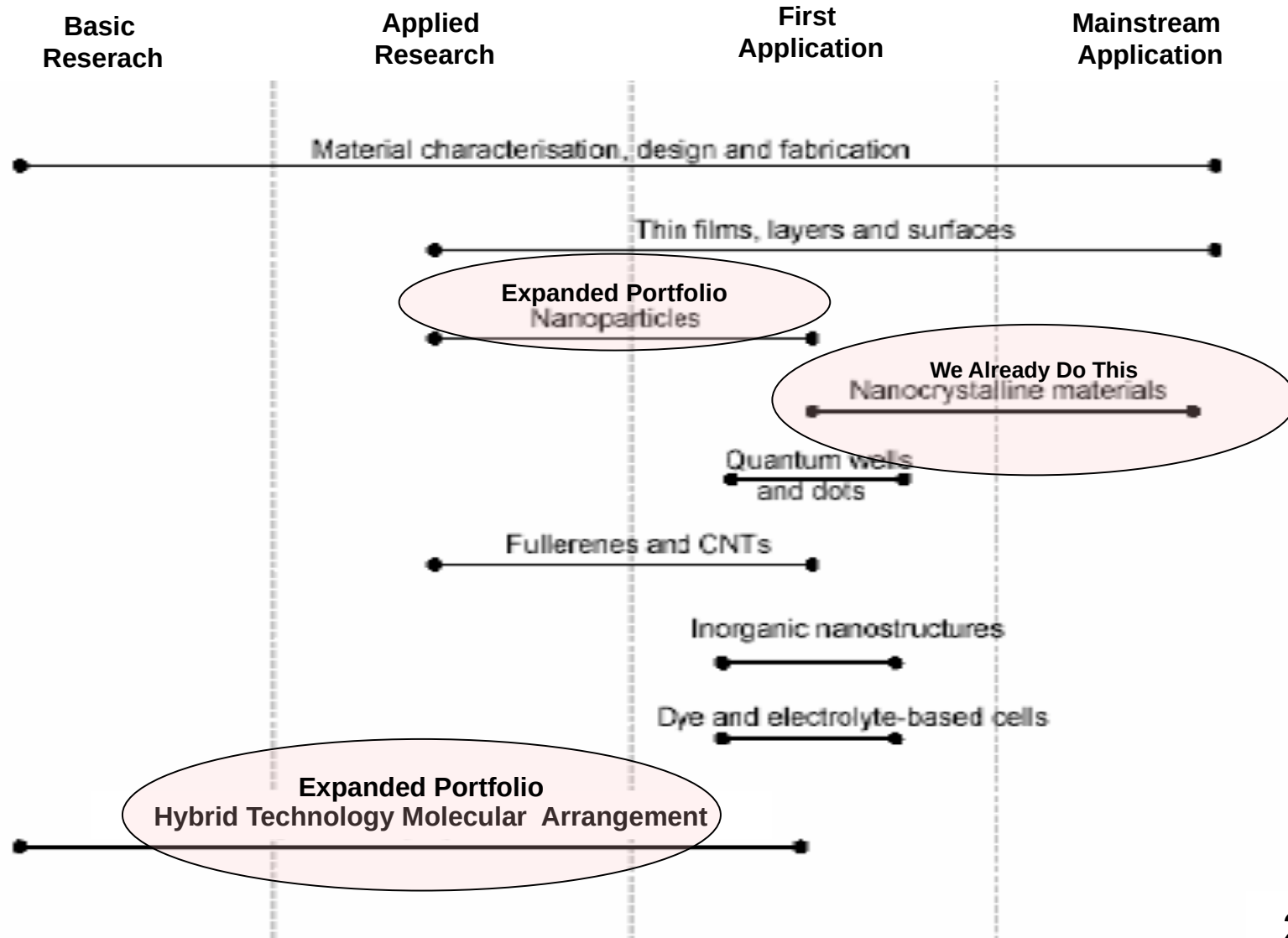
Hot Pocket
Deposition

Manufacturing process for solar silicon



Source Degussa

**MWCNT , FULLERENE , TiO₂ , SiO₂ , Absorbive Dyes , Al , Cu
are all Available in Particulate form. Conjugate Conducting
Polymers are also well Researched. Hence Hetero-Structures
and Hybrid Solutions are not Far**



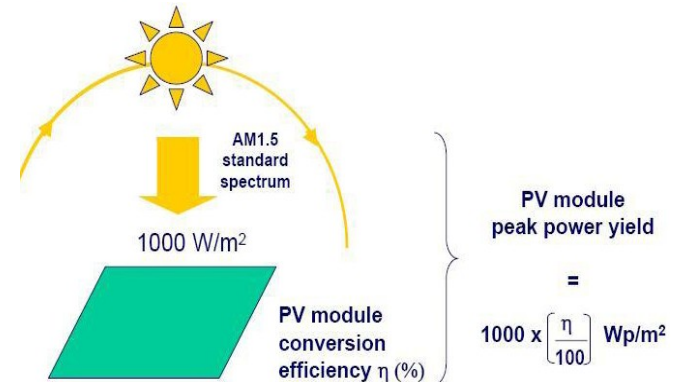
Technology	Com Eff (%)	Champ Eff (%)	Module (\$/W)	Installed (\$/W)	LCOE (cents/kWh)
Wafer Si	15	25	2	8	17
a-Si	6.5	13	1.2	4.5	21.7
c-Si	5	10	1.3	4.8	18.3
CdTe	9	16.5	1.21	4.5	19.9
CIGS	9.5	19.5	1.8	6.3	22.2
Organic PV	-	5.2	0.70	-	-
DSSC	8	11	1.9	-	-
Hybrid	-	6	-	-	-
Coal					5 to 8

- Polymer Cells
 - Not commercially available yet
 - Much lower cost
 - Shorter payback period (<1 yr)
- DSSC
 - 1st commercial plant Oct 07 - *G24 Innovations*
 - Build your own lab kits - 5 cells/\$66 (www.solideas.com)
- Hybrid
 - Not commercially available yet
 - Similar costs to polymer cell
 - Potentially much greater efficiency

Efficiency (η) is calculated:

$$\eta = \frac{P_m}{E \times A_c}$$

- AM 1.5
- $P_m = 1000 \text{ W/m}^2$
- $A_c = 1 \text{ m}^2$
- E = energy output (W)



Bets are being made on solar cell technologies that can achieve the highest level of ix performance while using the least amount of silicon

Generation 1

Silicon wafers
- monocrystalline
- multicrystalline
- ribbon

** Molded Silicon Wafer*

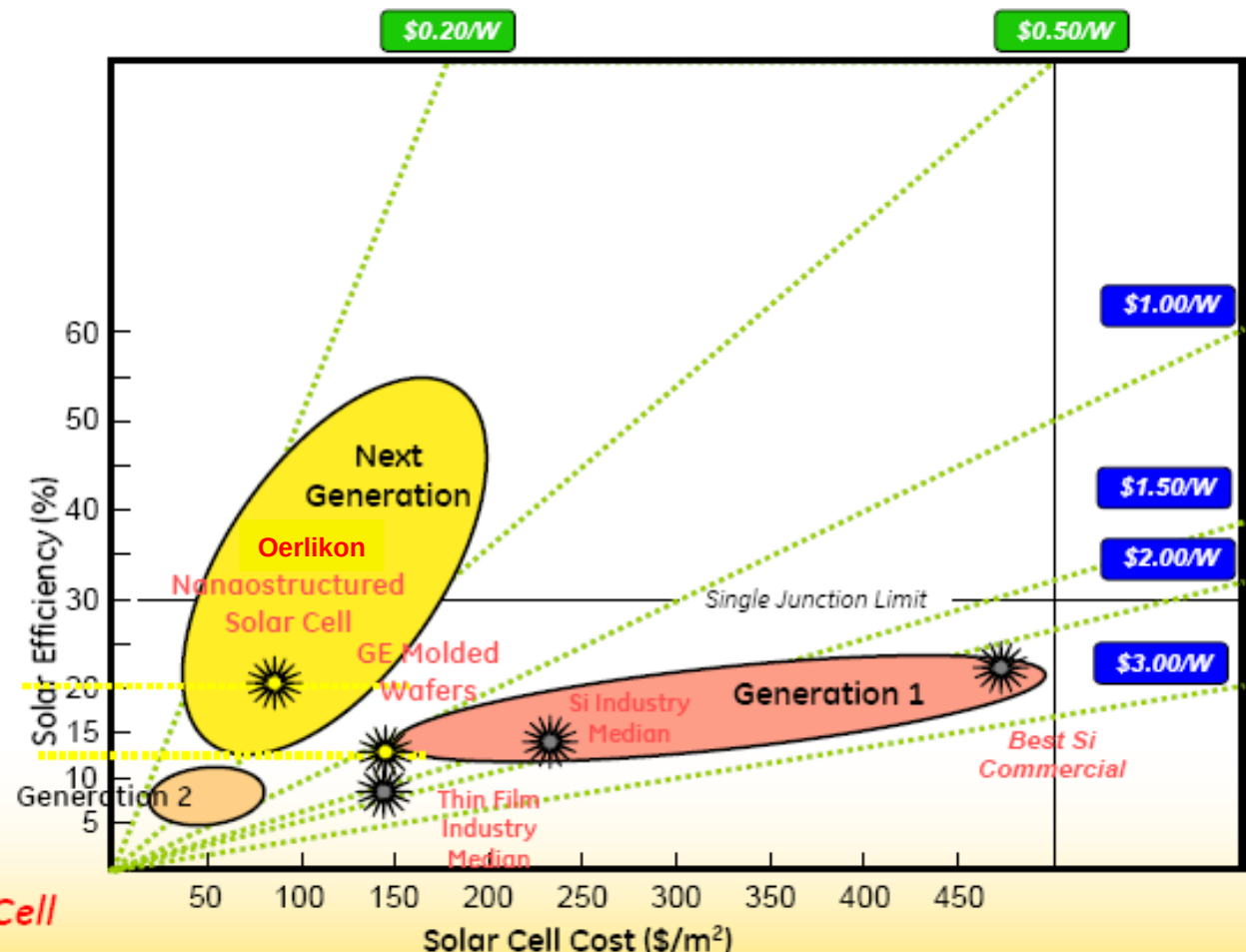
Generation 2

Thin Films
- amorphous silicon
- cadmium telluride
- CIS, CIGS
- crystal Silicon Film
- organic

Generation 3

Tandem ideas, hot elect.
hot electron

** Nanostructured Solar Cell*



Solar Cell Technology Metrics based on Martin Green, UNSW , Australia

It is not the Solar Cell Alone ?

- Photo Voltaics
- Solar Thermal Energy for Heat
- Solar Thermal Energy for Cooling
- Thermo Voltaic
- Solar Chemo-Synthesis
- Wind Energy

Research Needs ?

- Fundamental Research
- Application Research

EveryBody Needs REFLECTOR or Lens CONCENTRATOR

parabolic trough (PSA)



solar tower (SNL)



linear Fresnel (Solarmundo)



parabolic dish (SBP)



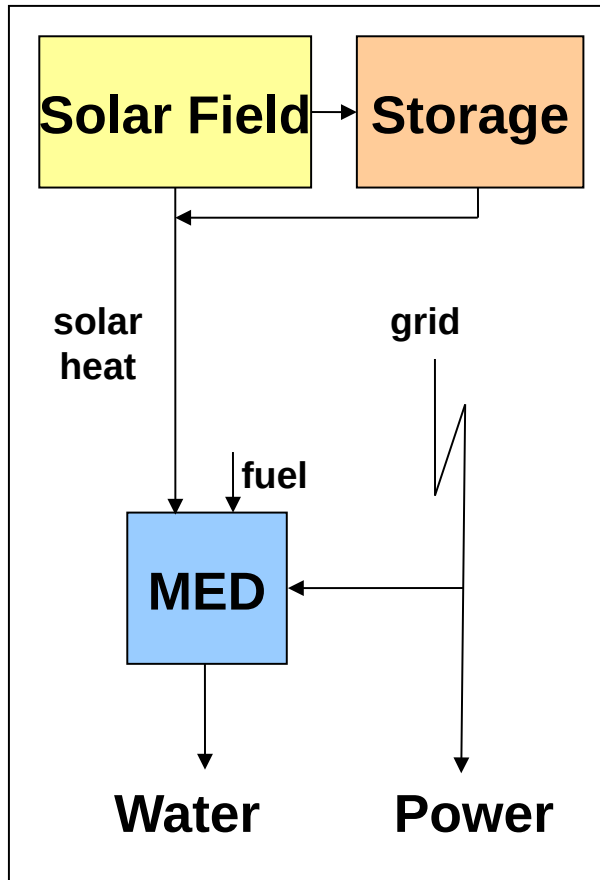
Concentration Method	line concentrating system		point concentrating system	
Solar Field Type	Parabolic Trough	Linear Fresnel	Central Receiver	Parabolic Dish
State of the Art	commercial	pre-commercial	demonstrated	demonstrated
Cost of Solar Field (€/m²)	200 - 250	150 - 200	250 - 300	> 350
Typical Unit Size (MW)	5 - 200	1 - 200	10 - 100	0.010
Construction Requirements	demanding	simple	demanding	moderate
Operating Temperature	390 - 550	270 - 550	550 - 1000	800 - 900
Heat Transfer Fluid	synthetic oil, water/steam	synthetic oil, water/steam	air, molten salt, water/steam	air
Thermodynamic Power Cycle	Rankine	Rankine	Brayton, Rankine	Stirling, Brayton
Power Unit	steam turbine	steam turbine	gas turbine, steam turbine	Stirling engine
Experience	high	low	moderate	moderate
Reliability	high	unknown	moderate	high
Thermal Storage Media	molten salt, concrete, PCM	molten salt, concrete, PCM	molten salt, ceramics, PCM	molten salt, ceramics, PCM
Combination with Desalination	simple	simple	simple	Simple
Integration to the Environment	difficult	simple	moderate	Moderate
Operation requirements	demanding	simple	demanding	Simple
Land Requirement	high	low	high	Moderate

1) PET Encapsulated in Weater Proof Thin Layer of PMMA with Al or Ag Particulate deposition ?? Moldable , Cheap , Effective , Recyclable !!

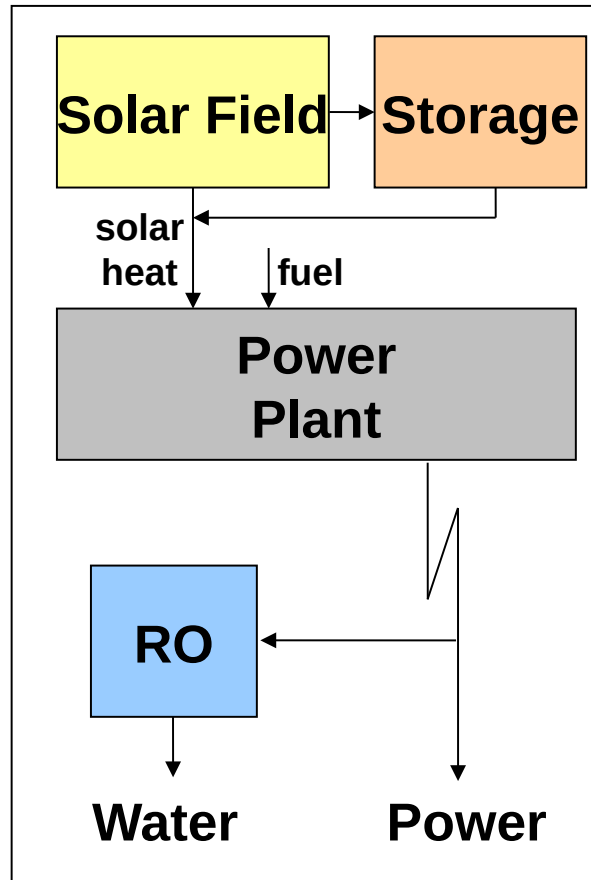
2) Manifolds for Heat Recycling whcih carry the Salt for the Plants from Barmag ???

3) Hard Polymeric Fresnel Lenses ??

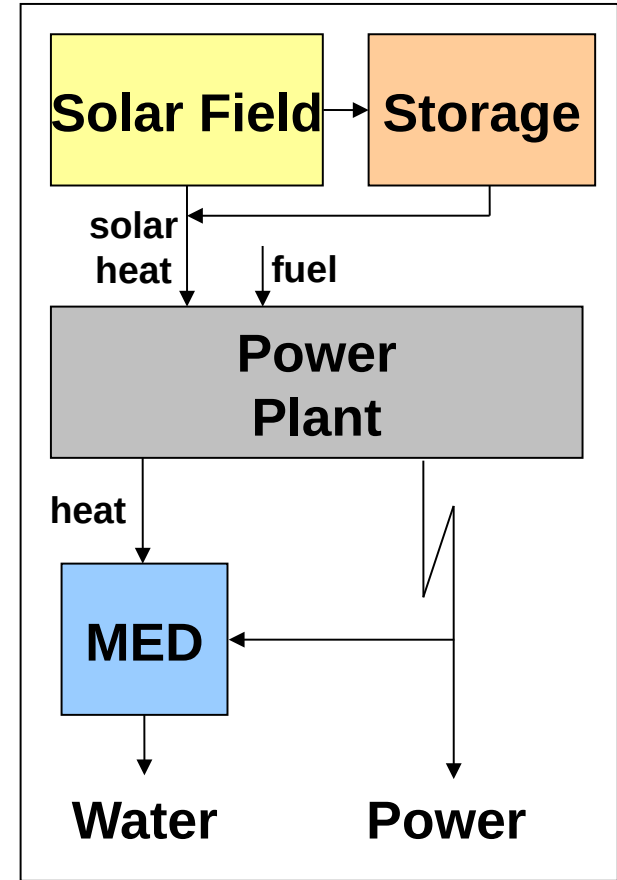
Heat Only



Power Only

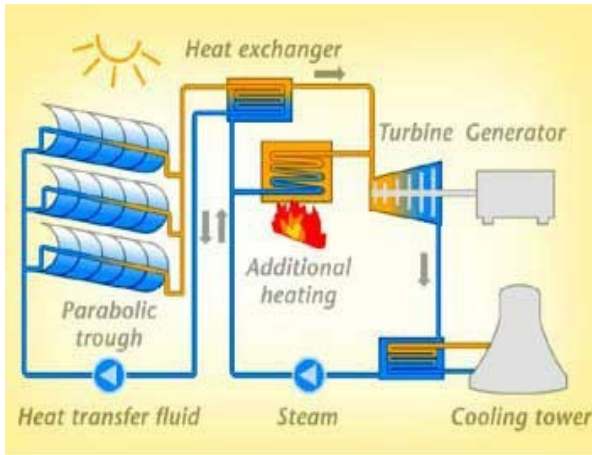


Combined Heat & Power

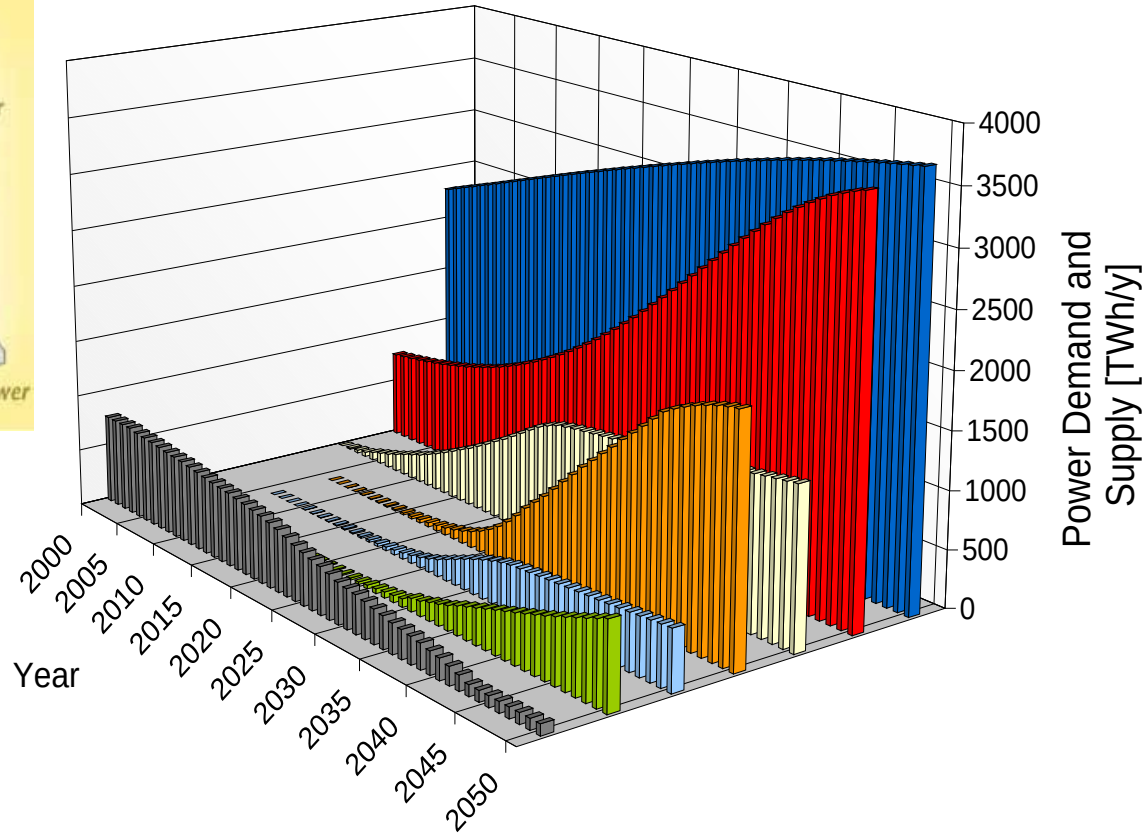


MED: Multi-Effect-Distillation

RO: Reverse Osmosis Membrane Desalination



All the Potassium Nitrate and Sodium Nitrate Molten salt lines (Heat Transfer Fluid) are a very Hot Piping which are running at 400 Degree and exactly similar to the Barmag spinning Manifolds and this can be an area for consideration and development.



Old Plants MENA	CSP Export	CSP Desalination	CSP MENA
New Plants MENA	Total Demand MENA	Total Demand EU	

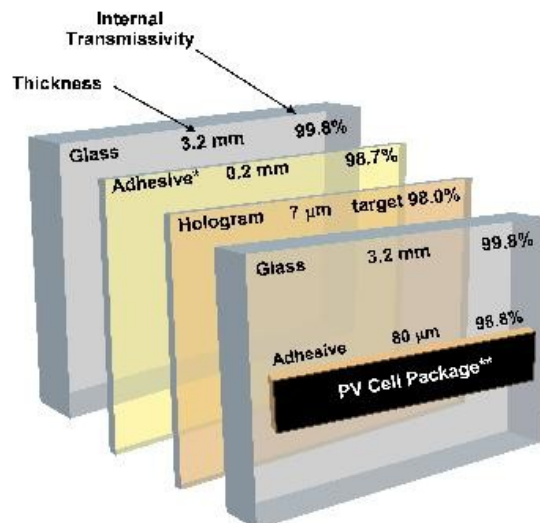
1. **Thin glass (< 1mm)**
Relatively light weight, but more fragile; handling costs increase
Better protective backing needs to be developed
2. **Front Surface Mirrors**
A silver reflective layer on a polymeric substrate with a protective hard coat at the top. Results of accelerated testing are encouraging (Luz). **(Good Area To work on)**
3. **Super Thin Glass**
NREL is working to use an ion beam assisted deposition process to deposit very hard (cleanable) and dense (protective) alumina top coat on polymeric or steel substrate.
4. **All polymeric reflectors**
It employs alternating co-extruded polymers layers of differing refractive indices to create a reflector. UV-stability is the issue.

Solutions Needed?? Research Needed ??

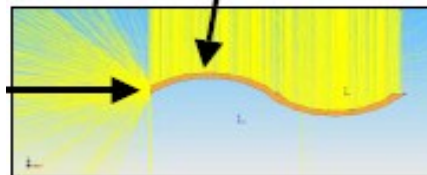
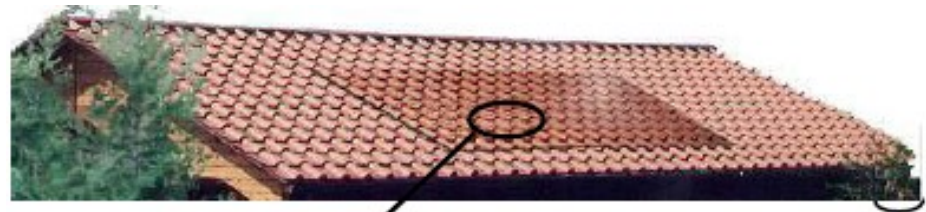
- Have to meet 10 year Life Cycle Assessment. Why ? If Cheap Replace

**Our Idea : Planar Technology Development is very Good for Future Thin Film
Medium efficiency Cells**

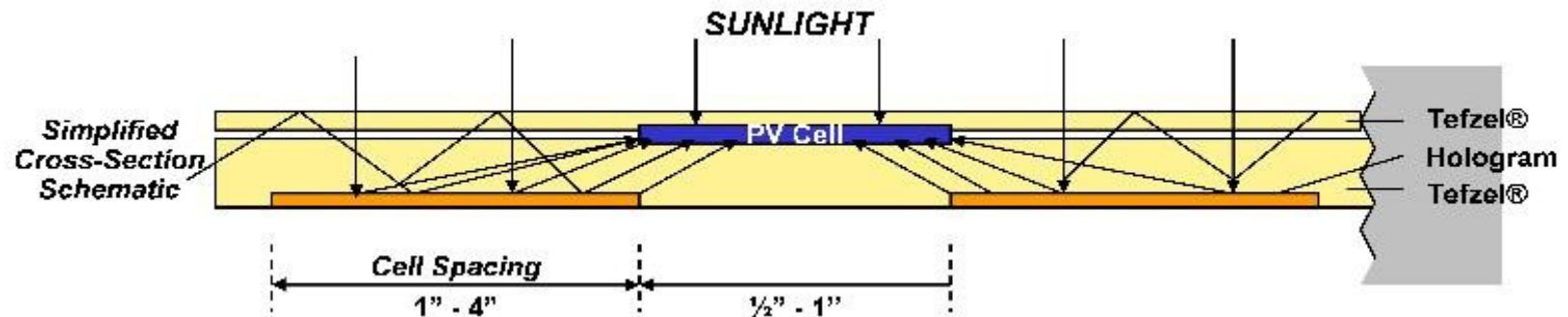
Prism Solar Technologies USA



¹ Polyurethane or ethylene vinyl acetate
² Externally fixed to glass



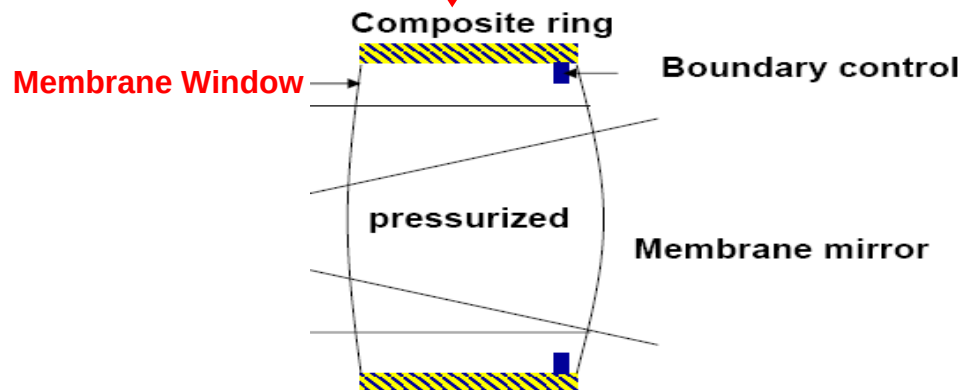
1. Plastic tile shape a match to roofing material
2. Dyes incorporated into plastic shift portion of solar spectrum to better match silicon response
3. 6x concentrated light is transferred to a single edge reducing the area of silicon needed



**LARGE POLYMERIC POLYIMIDE
MEMBRANE MIRRORS FROM CAST FILMS**

Polyimide Cast Sheets

- Weather Proof
- UV Resist
- Last Long
- NASA uses them in Space
- High Precision Thickness if Cast on Liquids like Float glass

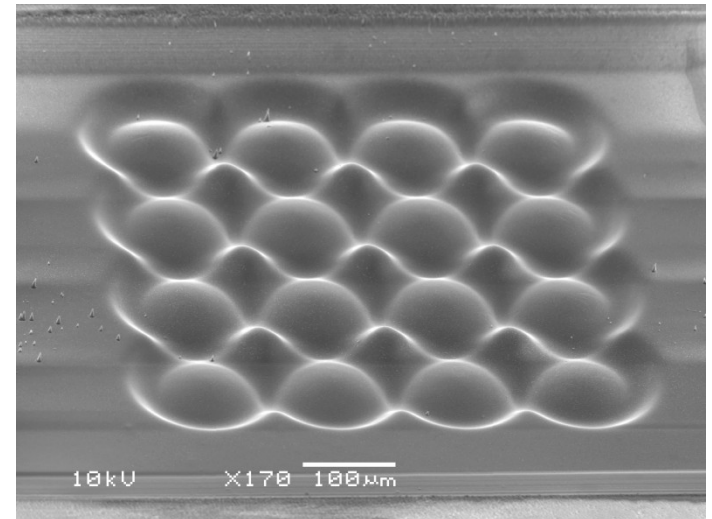
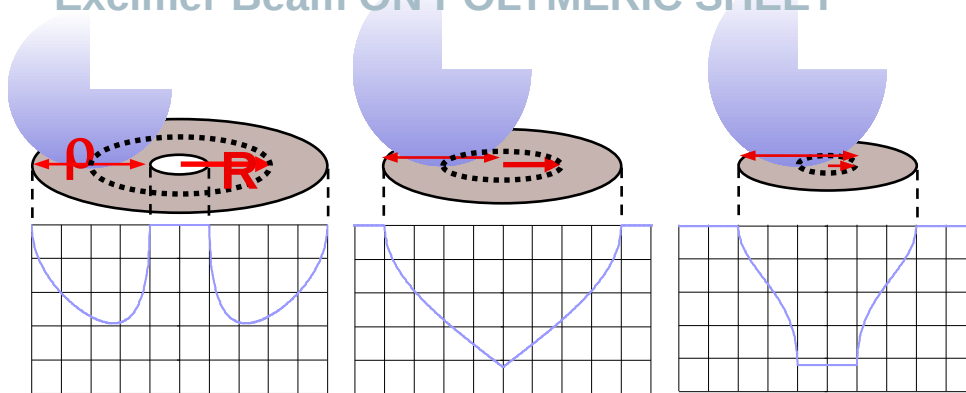


REFLECTOR TECHNOLOGY CAN GO FAR
- LASER ON PMMA FOR ABLATIVE CONTOURS

LASER MADE POLYMERIC MICRO LENS

**ARRAY OF LENSES ON ARRAY OF SOLAR
POLYMERIC MICRO CELLS-
SHEET ON SHEET CONSTRUCTION!!!
New Idea . Any Takers ?**

Excimer Beam ON POLYMERIC SHEET

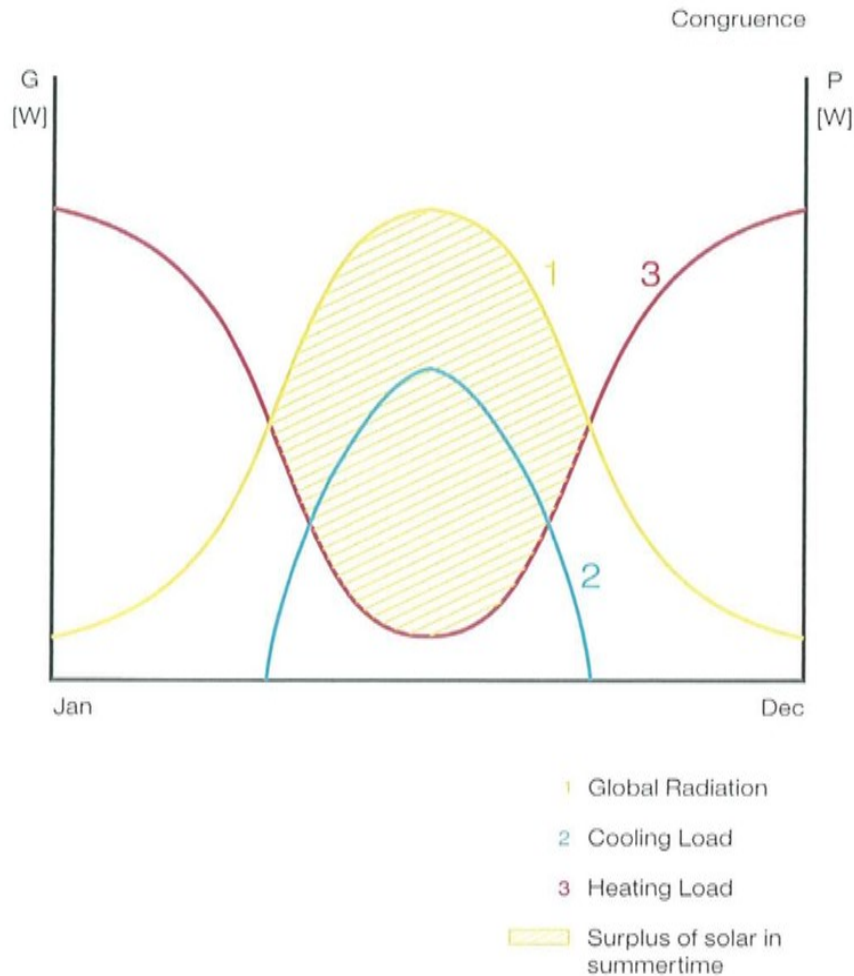


It is not the Solar Cell Alone ?

- Photo Voltaics
- Solar Thermal Energy for Heat
- Solar Thermal Energy for Cooling
- Thermo Voltaic
- Solar Chemo-Synthesis
- Wind Energy

Research Needs ?

- Fundamental Research
- Application Research



Why solar cooling ?

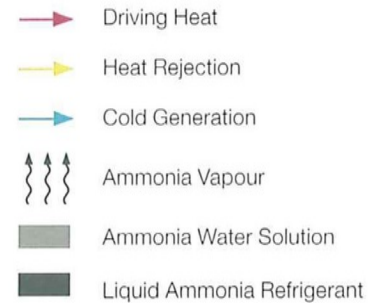
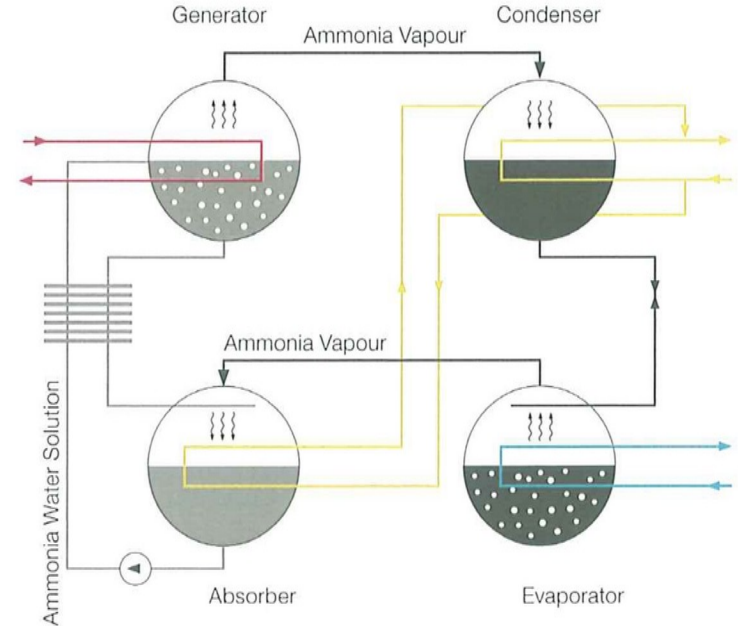
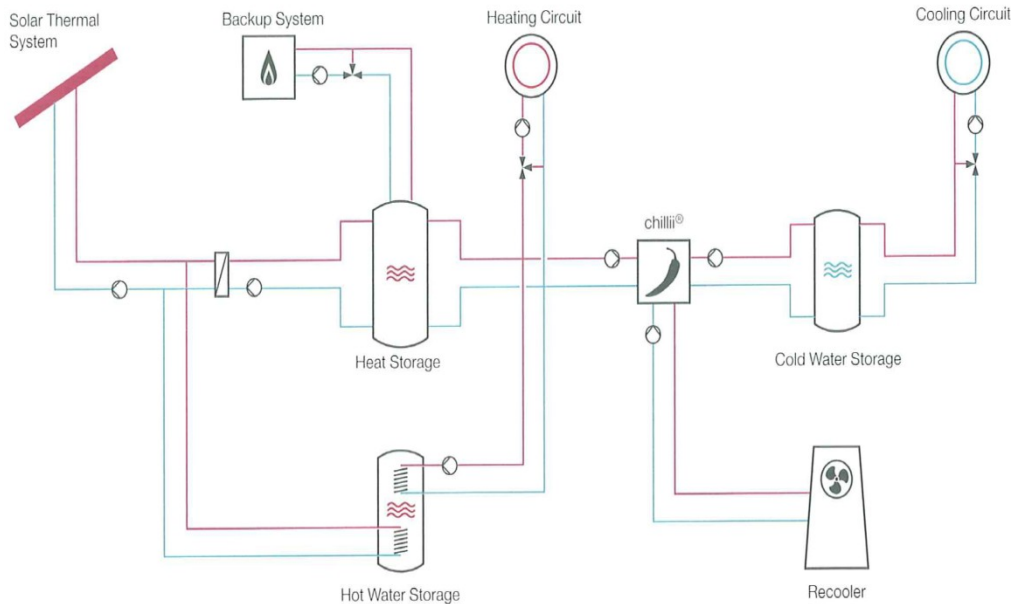
- Enables the usage of the surplus solar heat during the summer
- No overheating of the solar system during summer time
- Simultaneity of solar heat supply and cooling demand
- Minimal operating costs for cooling / air-conditioning
- Solar heat as a renewable energy source

Advantages compared to electrically driven compression cooling technology:

- Increased independence from public energy suppliers
- Decrease in electricity and operating costs
- Saving of expensive electricity costs
- Reduction of CO₂ – emission by reducing the use of primary energy
- Reduction of global warming potential (GWP) by using environmentally friendly, natural refrigerants

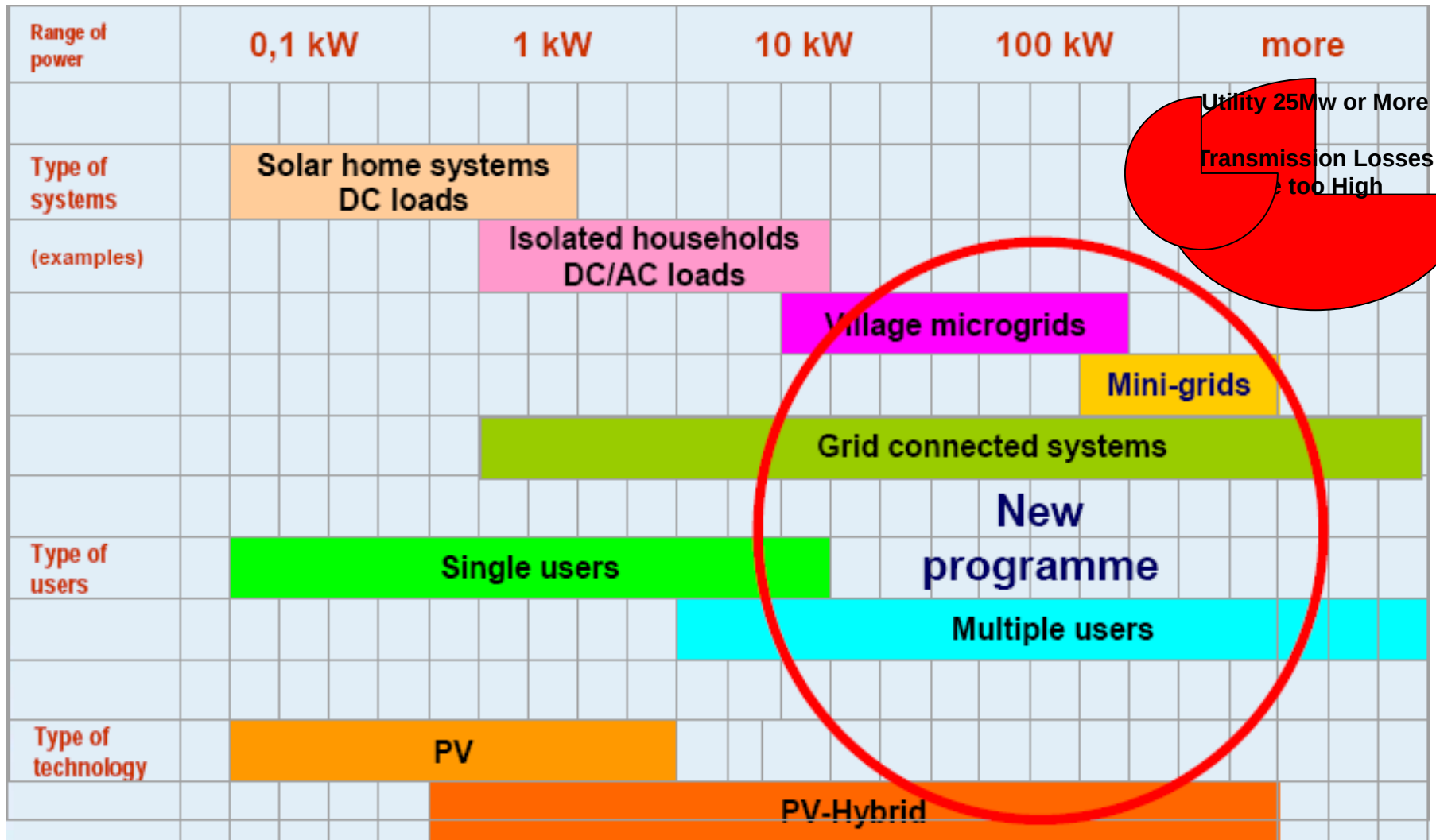
Missing Link is Cheap Absorption Chiller

Example for hydraulic integration:



- 1) If a \$5000 Absorption is Available then Parity with Air Conditioner!!! For 10 Year Pay Back
- 2) However today Economic Business Model Exists for Community (15 to 100 House Holds) For combined HPC systems !!!
- 3) Missing Link is system Integrator.

The Future of Most Efficient Systems



It is not the Solar Cell Alone ?

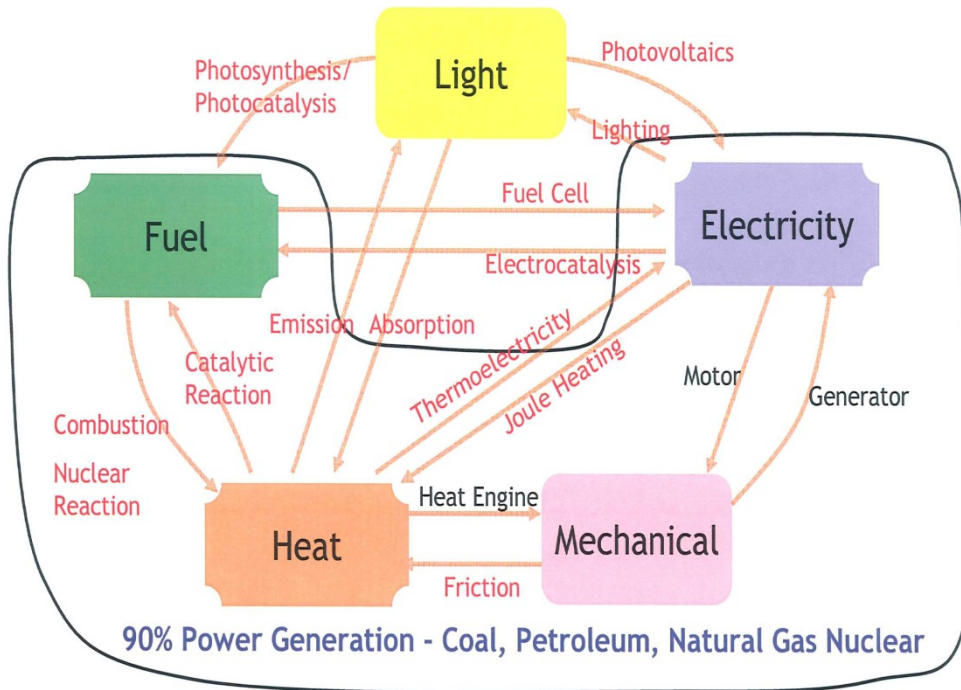
- Photo Voltaics
- Solar Thermal Energy for Heat
- Solar Thermal Energy for Cooling

- Thermo Voltaic

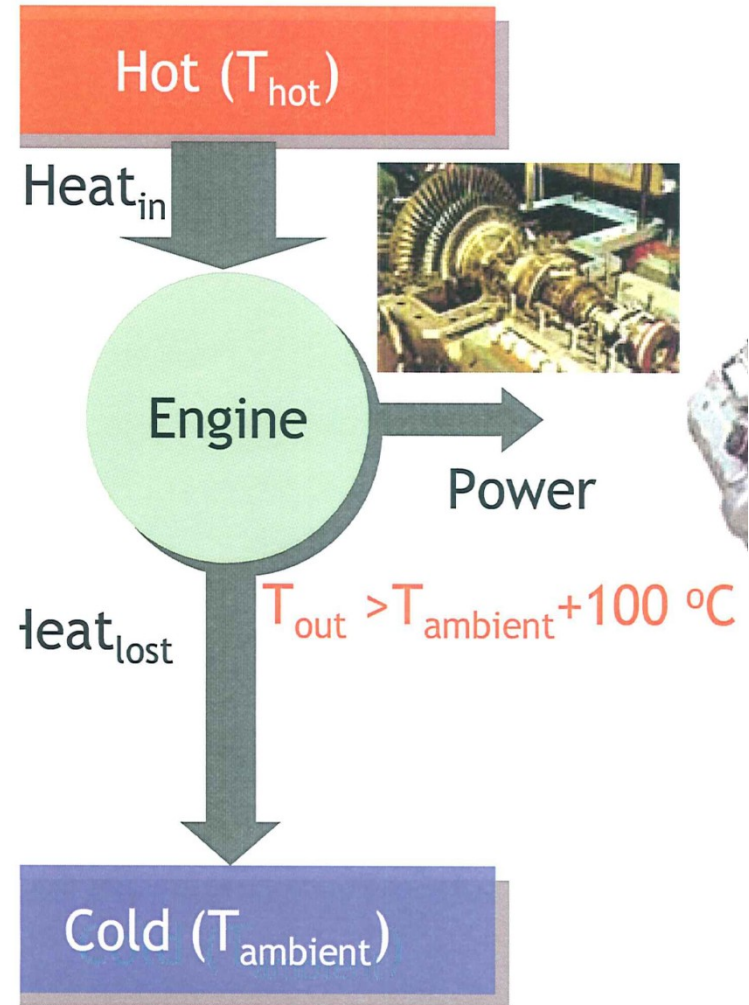
- Solar Chemo-Synthesis
- Wind Energy
- Marine Energy

Research Needs ?

- Fundamental Research
- Application Research

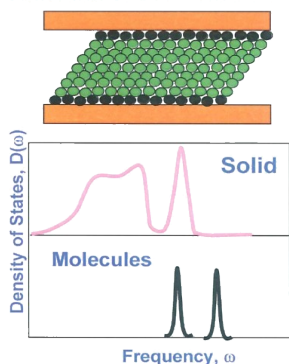


Power = 10 TrillionWatts
 Efficiency = Power/Heat_{in} ~ 40%
 Heat_{in} = 25 TW
 Heat_{lost} = 15 TW

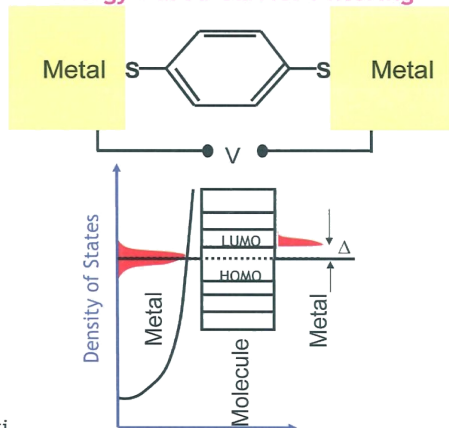


Why Molecular Thermoelectrics?

Large Thermal Impedance
By Phonon Filtering
Molecular Heterostructures



Potentially High Power Factor by
Energy-Based Carrier Filtering



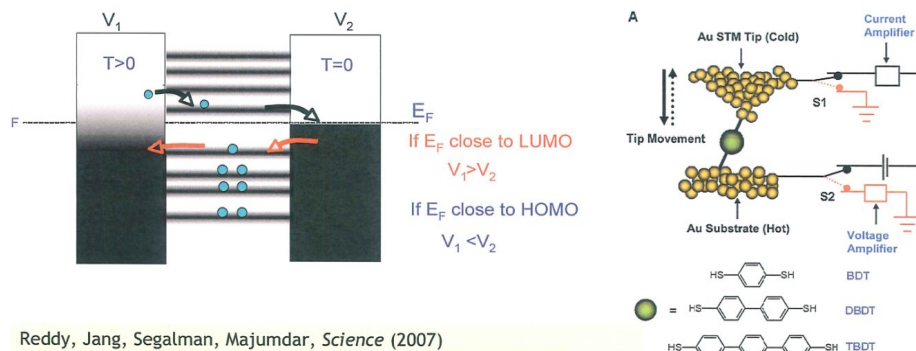
**Combine With Flexible Hybrid
Device ON METALFOIL Stick it on
Surface & Extract Heat for
Electricity.
Combine with All Heat Differential
Sources!!**

Pramod Reddy, Sung-Yeon Jang, Kaal Baheti,
Jon Malen, Peter Doak, Don Tilley, Rachel Segalman

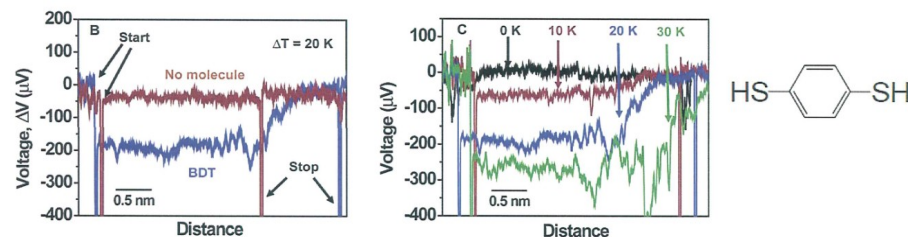
Jeff Neaton, Joel Moore

**Combine With Flexible Hybrid
Device ON Polymeric
Insulator Extract Heat for
Electricity. Have an Active
cooled Insulator for Sticking
on to All Surfaces**

Thermopower of Molecular Junctions



Reddy, Jang, Segalman, Majumdar, *Science* (2007)



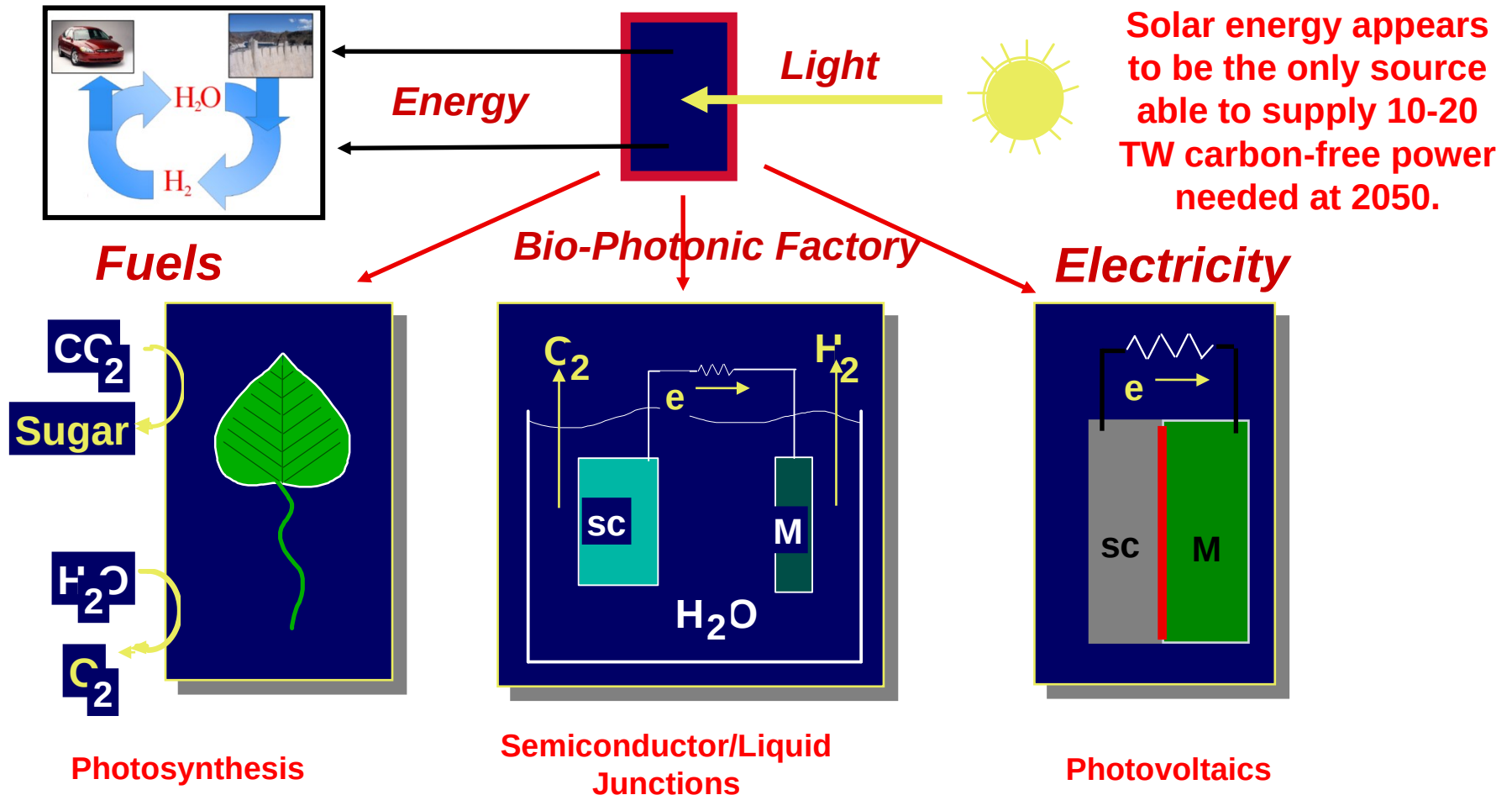
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Research Needs ?

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- Application Research

Photonic Bio Factory for Chemo-Synthesis



Conversion Strategies:

- Water Splitting by Sun Photo Genration of Hydrogen and then Hydrogen being used for energy.
- Conversion of Bio Mas into Methonal by Photonic Energy
- Direct Photonic Concentration for Non Continuous Factories

It is not the Solar Cell Alone ?

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Research Needs ?

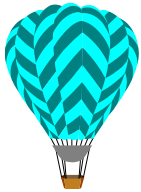
- Fundamental Research
- Application Research

Bigger Rotor is Essential for Wind Power. How Big ?

Power in the Wind (W/m^2)

$$= \frac{1}{2} \times \text{air density} \times \text{swept rotor area} \times (\text{wind speed})^3$$

ρ



$$\text{Density} = P/(R \times T)$$

P - pressure (Pa)

R - specific gas constant (287 J/kgK)

T - air temperature (K)

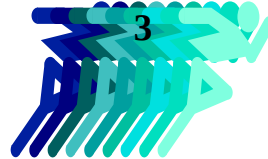
kg/m^3

A

$$\text{Area} = \pi r^2$$

m^2

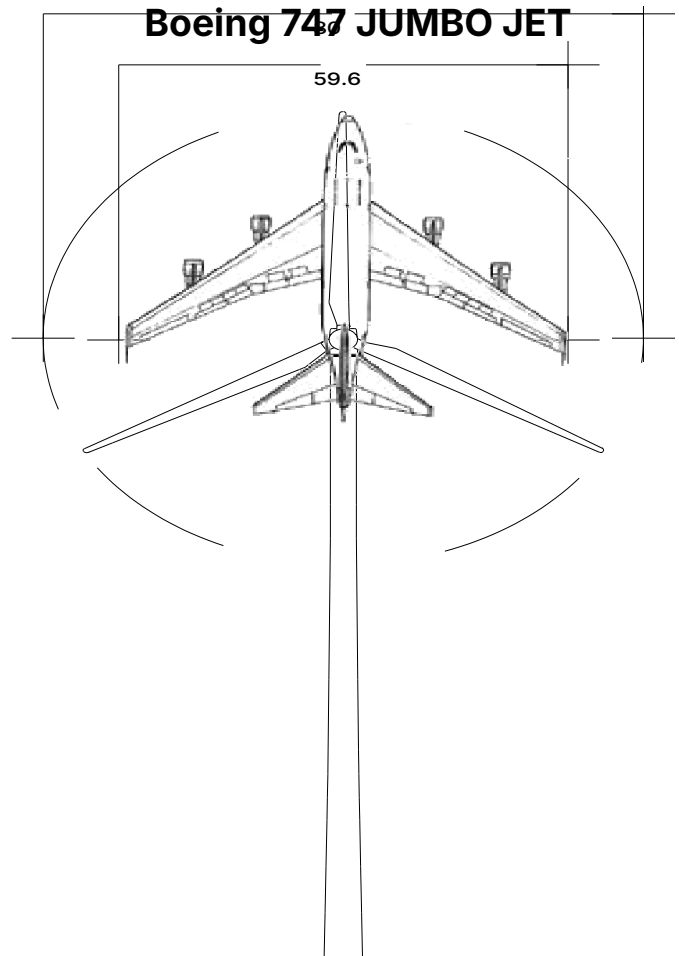
V

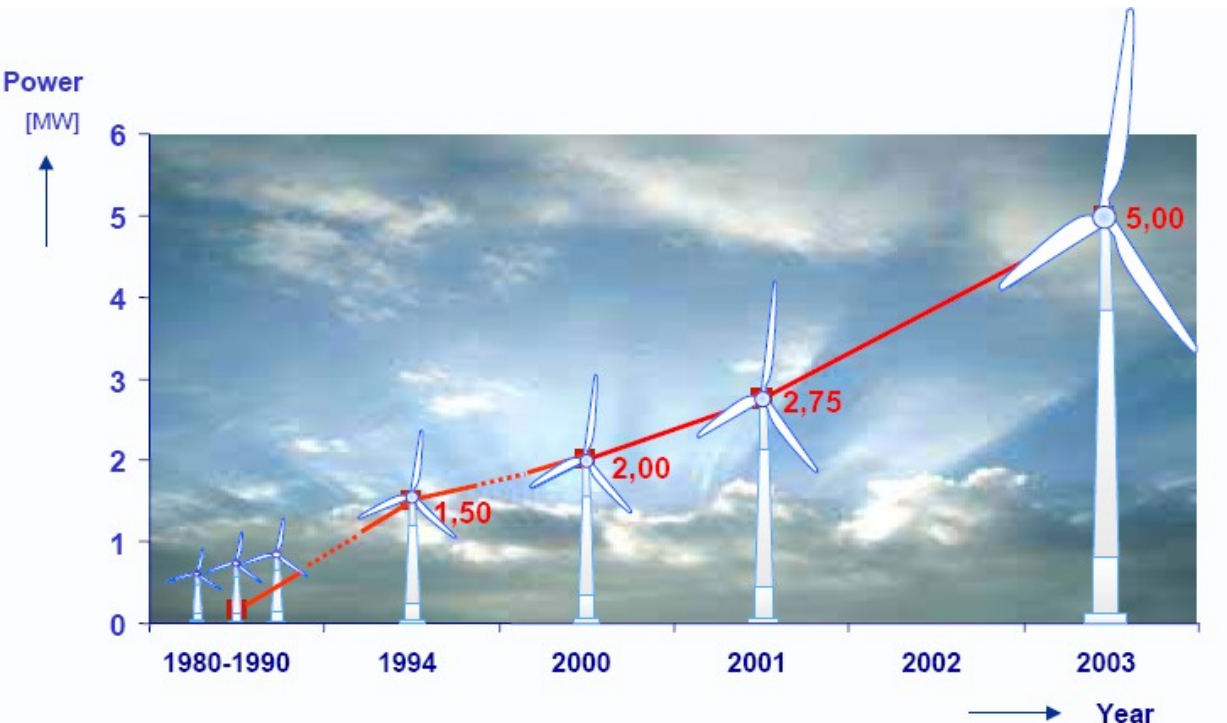


Instantaneous
Speed
(not mean speed)

m/s

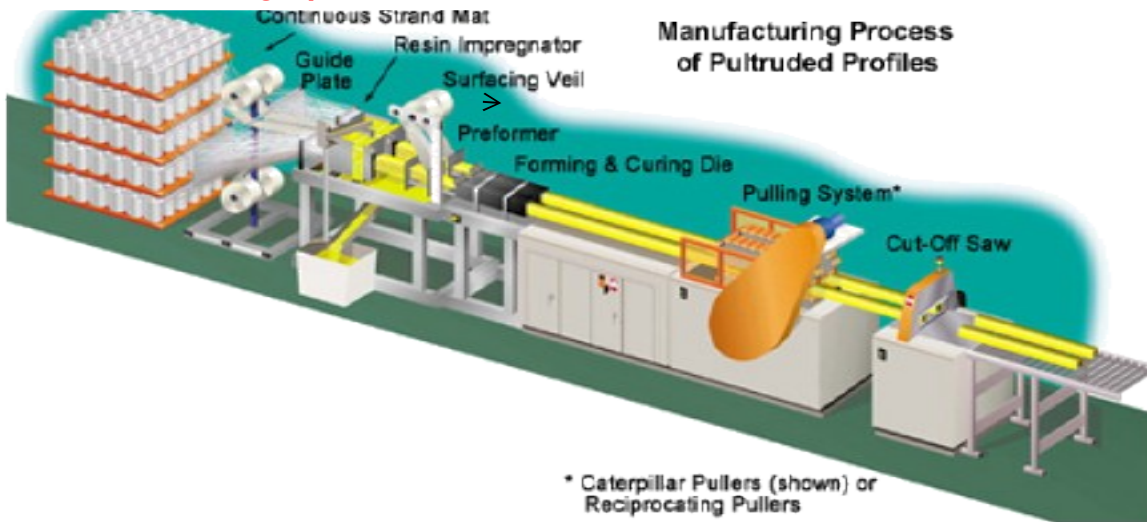
This picture shows a Vestas V-80
2.0-MW wind turbine superimposed
on a





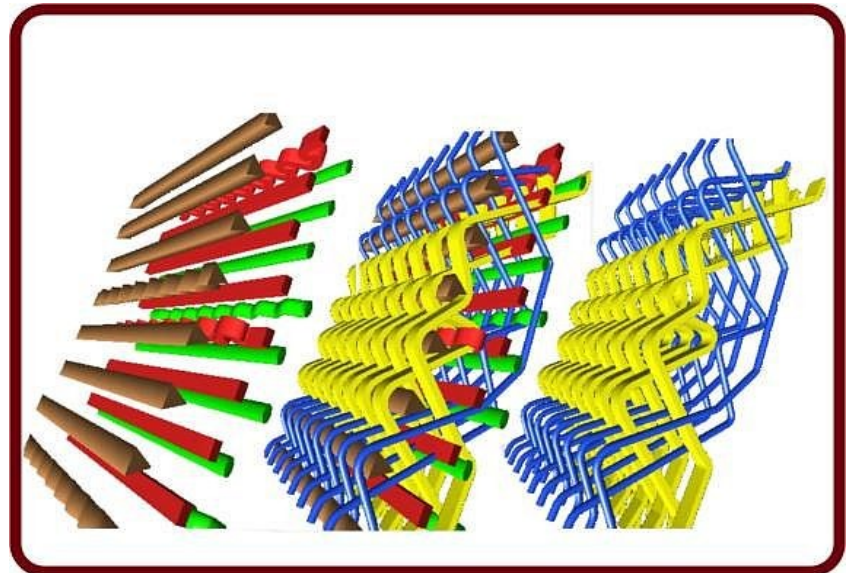
- 1.5 - 6 MW per turbine
- 60-120 m hub height
- 5 km from shore, 30 m deep ideal
- Gravity foundation, pole, or tripod formation
- Shaft can act as artificial reef
- Drawbacks- T&D losses (underground cables lead to shore) and visual eye sore

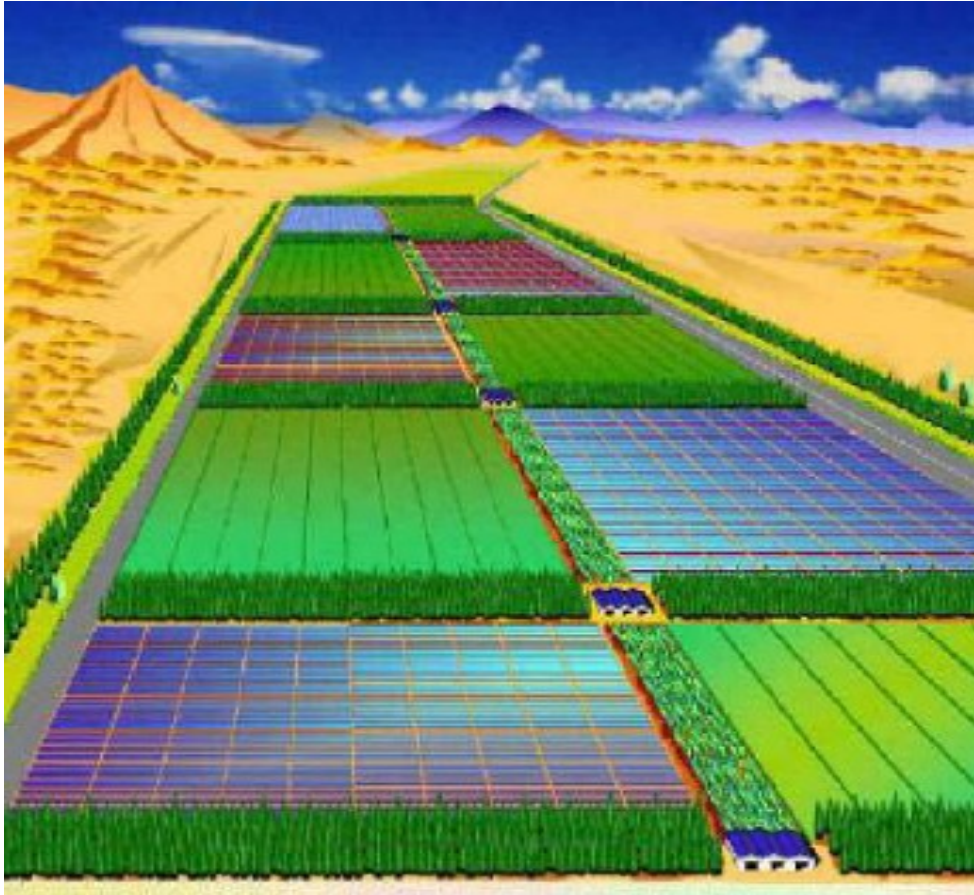
Oerlikon Barmag Special IDY



At High Dynamic of Wind Mill Rotor Only FILAMENT REINFORCED POLYMERIC Matrix STRUCTURES WORK.

High Strength Industrial Yarns Structured on Contours of Blades and then Resin Impregnation is the Technology which has best future for wind Turbine Rotors. It has just started to be used for this application where predominantly Glass Fibre Reinforced Structures are being used. Carbon Fibre Composite are too Expensive to use as this is Static Structure and little Weight Penalty. Filament Structure Composites is Interesting Area to develop as Business Model. Several Applications are available for the same. Oerlikon Barmag Filament Technologies can be leveraged for this Start up.





Thank You

**Desert Solar Farms with Combined Heat , Power ,
Cooling , Desalination , Photo-Chemo Synthesis , Wind.**

Namindo Pty Ltd

Thank you

Suprit Pal Singh, Founder Director

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