CA THE INSTITUTE OF CHARTERED ACCOUNTANTS OF SRI LANKA

CATALYST 2014
RETHINK to REVIVE
35th National Conference of Chartered Accountants

SESSION 2:

Rethink Disruptive Technologies

By:

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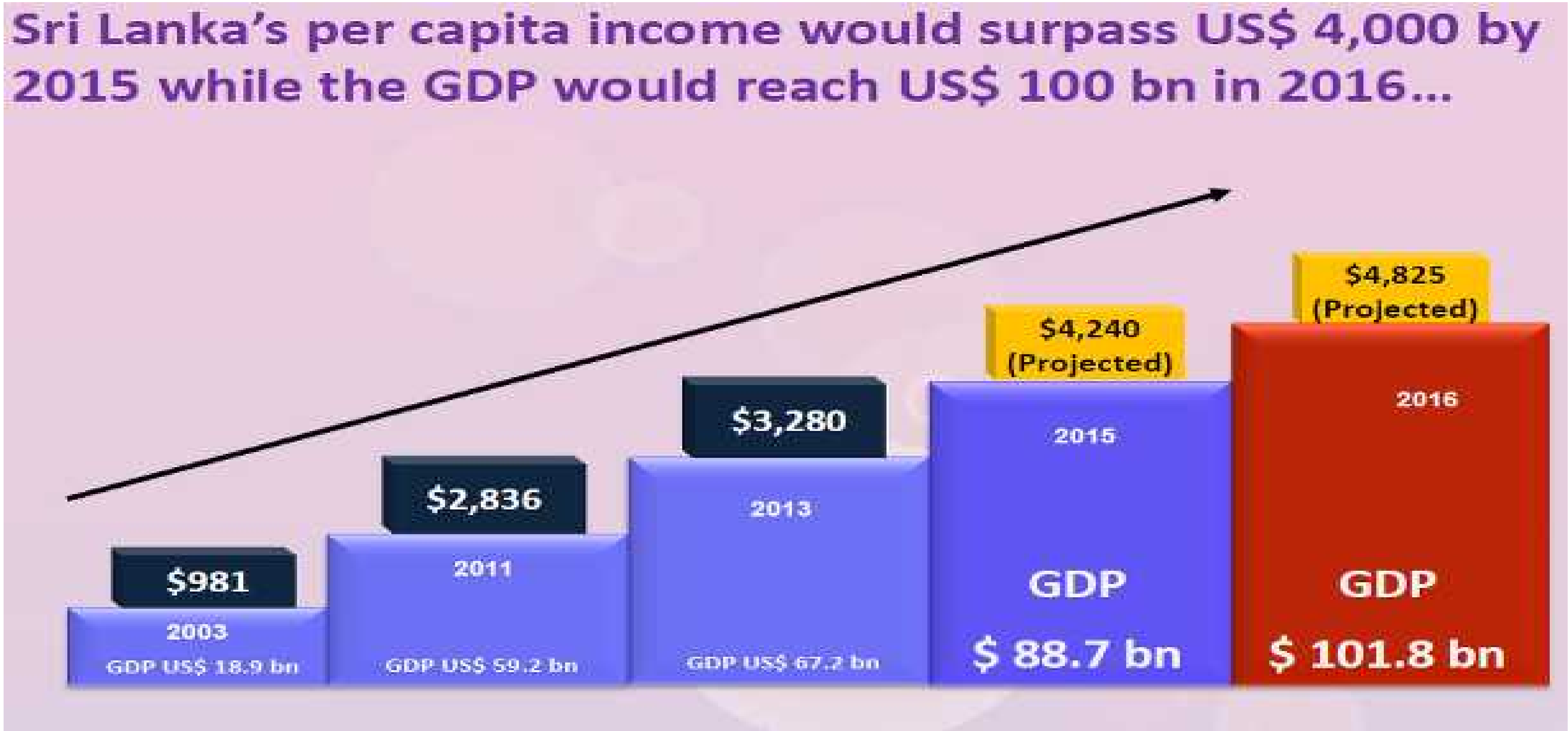
Current development vision – short term



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Medium term development vision

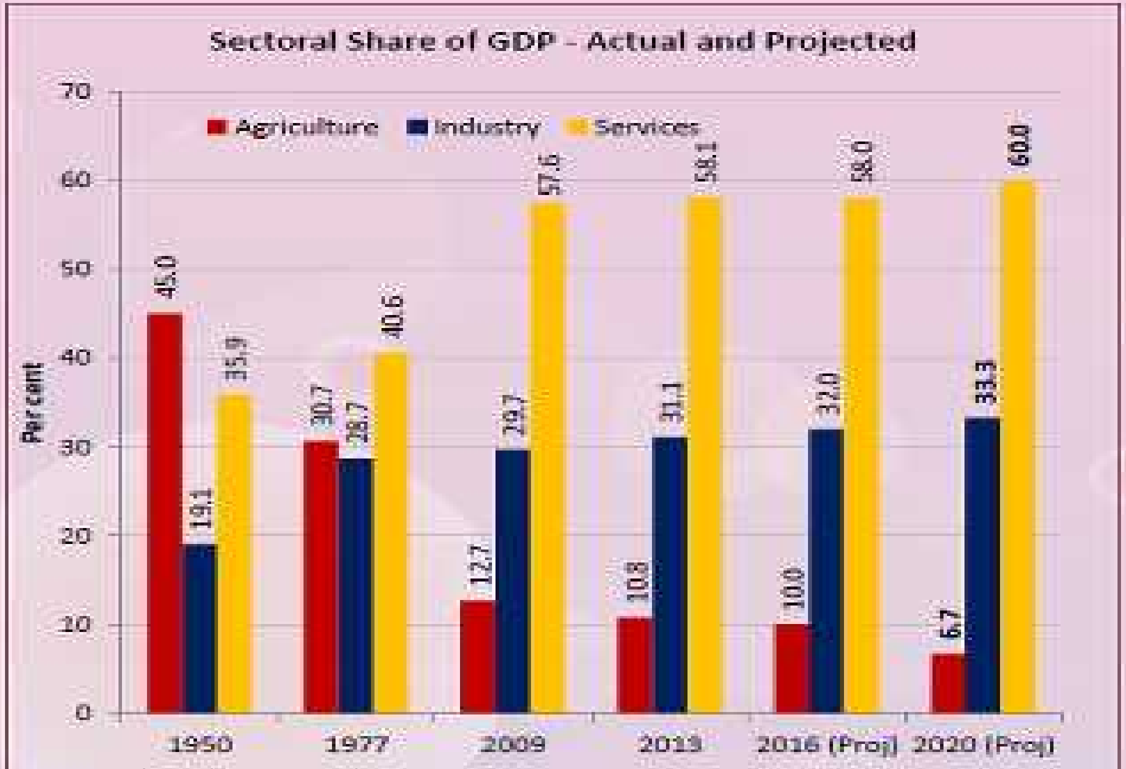
Sri Lanka: 2020 would have a GDP around US$ 150 bn, a US$ 7,000+ per capita income, and sound macroeconomic fundamentals…

How do we get there?

Will Sri Lankan industry look the same just doing more?

Central Bank view:

A more innovative and advanced Industry sector of US$ 50 bn (33.3%)
(2013: US$ 21.8 bn)



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Industrial base?

Opaque as to how it will change

Industry
- Mining and Quarrying
- Apparel
- Other Manufacturing
- Electricity, Gas and Water
- Oil and Gas Exploration
- Marine and Aquatic Resources
- Technology and Innovation
- Construction

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Rethink Disruptive Technologies

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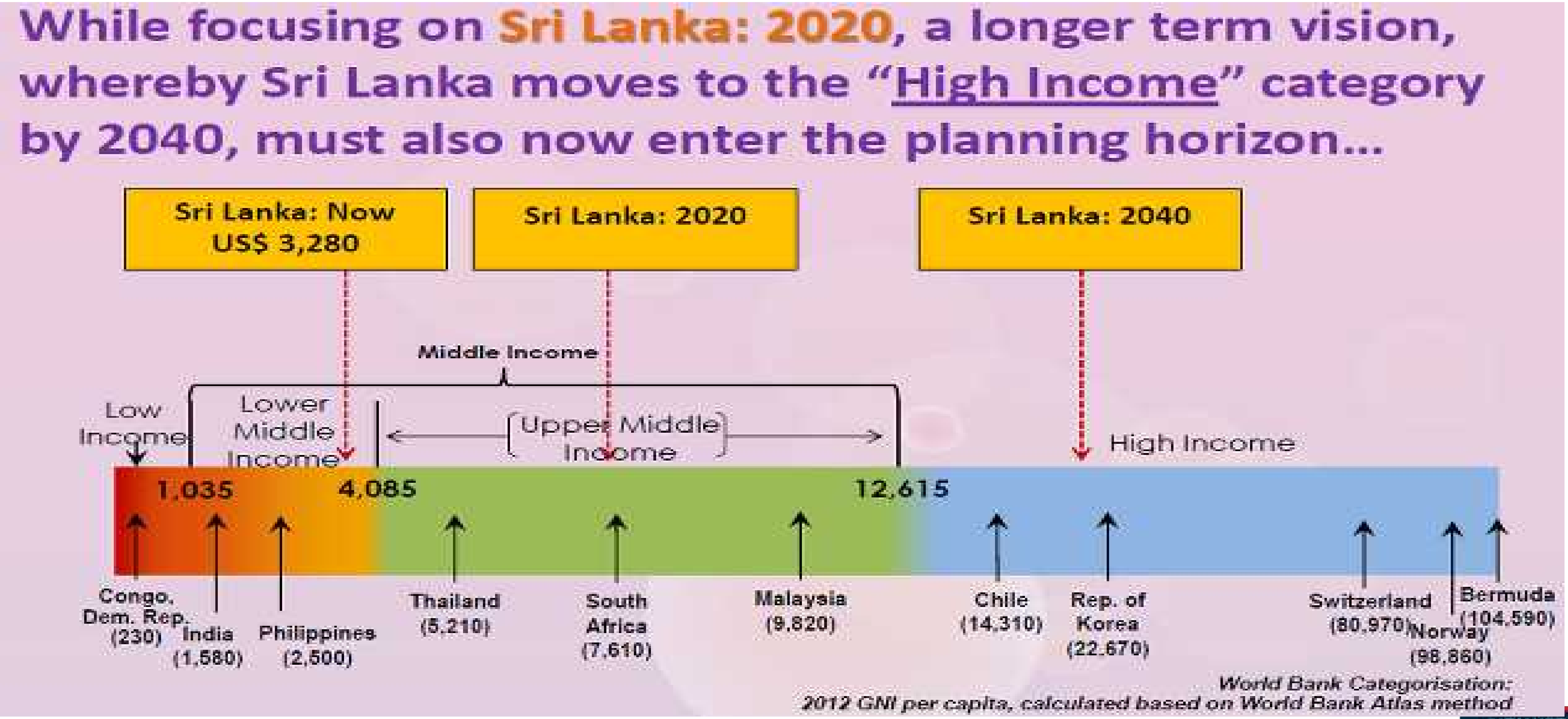
Long term development vision



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Is there any relevant example of a country - a diversified island of 20M+ people- which has made a similar transition from Sri Lanka 2014 ($4000+) to the vision for Sri Lanka 2040 ($20,000+)?

Yes : Taiwan

Area: 36,193 km^2 (half of Sri Lanka)

Population: 23 Million

- ‘The quick industrialization and rapid growth of Taiwan during the latter half of the 20th century has been called the "Taiwan Miracle". Taiwan is one of the "Four Asian Tigers" alongside Hong Kong, South Korea and Singapore’ - Wikipedia

- Per capita GDP in 1962 – US$170 (Sri Lanka ~ US$250)

Headline comparison of Sri Lanka now and Taiwan then (and now)

Metric	Sri Lanka 2013	Taiwan 1981	Taiwan 2011
GDP	$67B	$84B	$465B
Per capita GDP	$3280	$4128	$20,057
Agricul. %	11%	15%	3%
Industry %	**31%**	**41%**	**36%**
Services %	58%	44%	61%

Industry sector comparison

Sector (% GDP)	Sri Lanka 2013	Taiwan 1981	Taiwan 2011
Construct.	10%	7%	2%
Electricity+ Water	2%	2%	2%
Mining	2%	3%	0.3%
Manufact.	17%	29%	31%

Things to note in Taiwan's 5X growth in GDP over 30 years – SL aims this in 25 years from similar base

- Electricity and water supply has also grown 5X

- Industry excluding mining has grown ~ 5X

  (38% GDP in '81 – 36% GDP in'11)

- Manufacturing has grown ~ 5X

  (29% GDP in 81- 31% GDP in 11)

In manufacturing however %GDP is not the whole storey

- **Although %GDP remained the same the manufacturing base was completely transformed – Not 5X of the same activity as in ‘81**

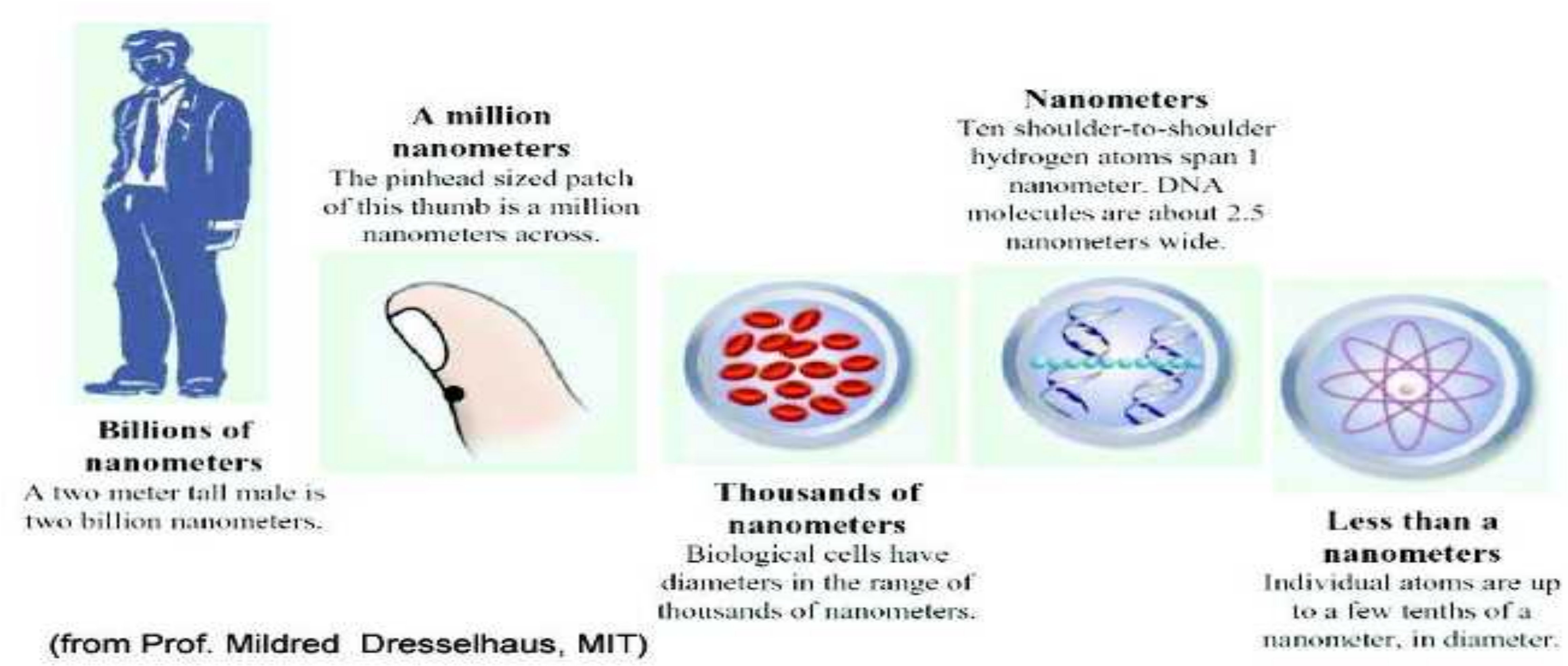
Sector % of Manu.	Taiwan 1981	Taiwan 2011
Apparel+ Textiles	23%	2%
Electronic process.+ products	5%	59%
Chemicals+Petroleu.	6%	8%
Plastics	9%	1%

Which are the emerging areas which can give SL manufacturing the opportunity to transform, expand and be globally leading – akin to integrated circuit electronics and displays in '81 focused on by Taiwan (and South Korea)?

- Nanotechnology
- Biotechnology/Natural medicines
- Information Technology – Software
- Marine Technology

are possibilities

The scale of the physical world



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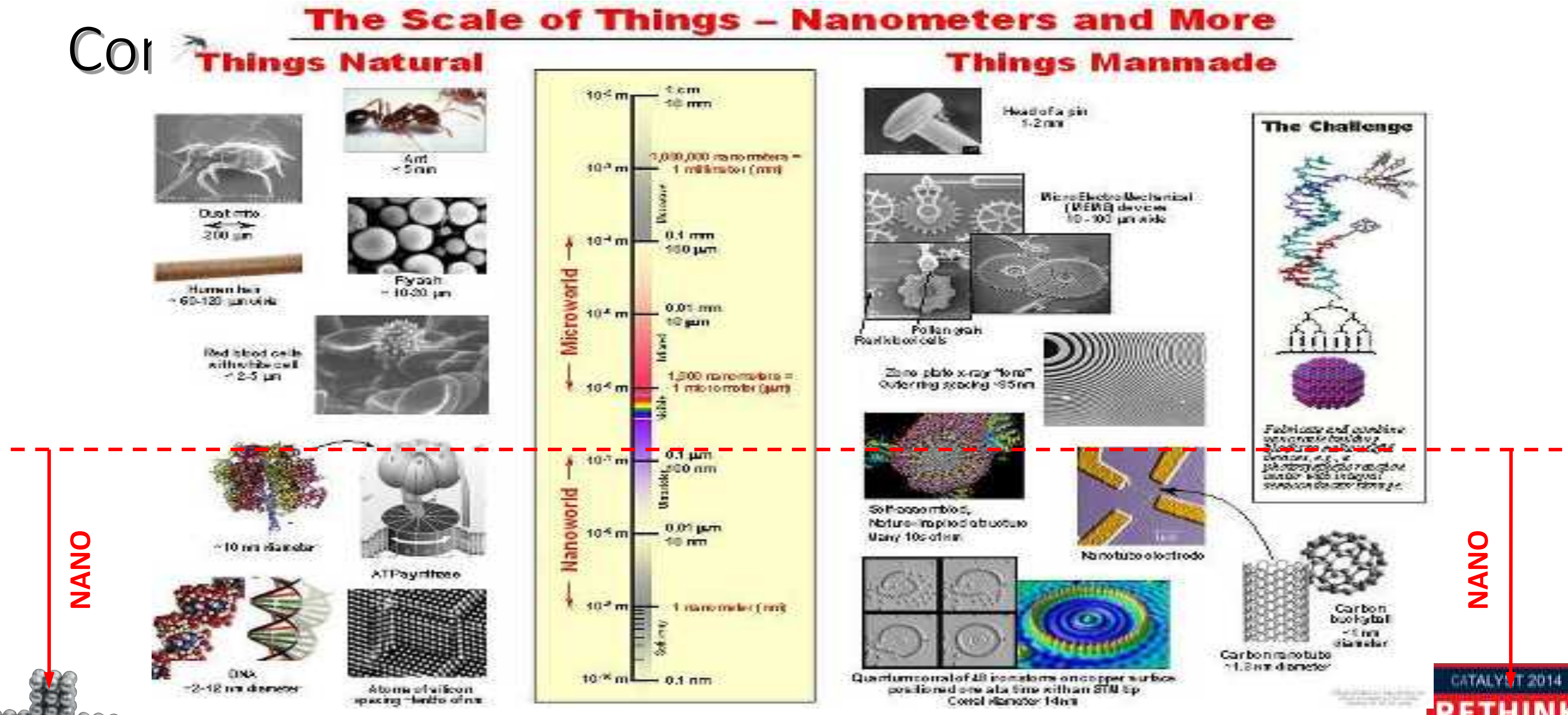
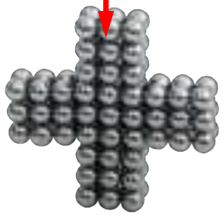




Rethink Disruptive Technologies

Materials when taken down to the < 50nm scale can exhibit physical and chemical properties not seen in bulk phases

The Carbon Nanotube is a good example of this

Technologies Driven by Economics

Example: Drive to lower costs of solar cells has led to the development of several new technologies. Some of the directions being pursued are:

- **Reduction in the use of materials – i.e. thinner solar cells**
- **Reduction in the electronic quality of materials – use of lower cost, lower purity materials**
- **Use of solution processable (e.g. printable) materials which enable high volume, low cost roll-to-roll processing**
- **Improved structural and optical design to allow the above developments to maintain sufficient efficiencies**

Why Nanomaterials?

Surface area

Flexibility

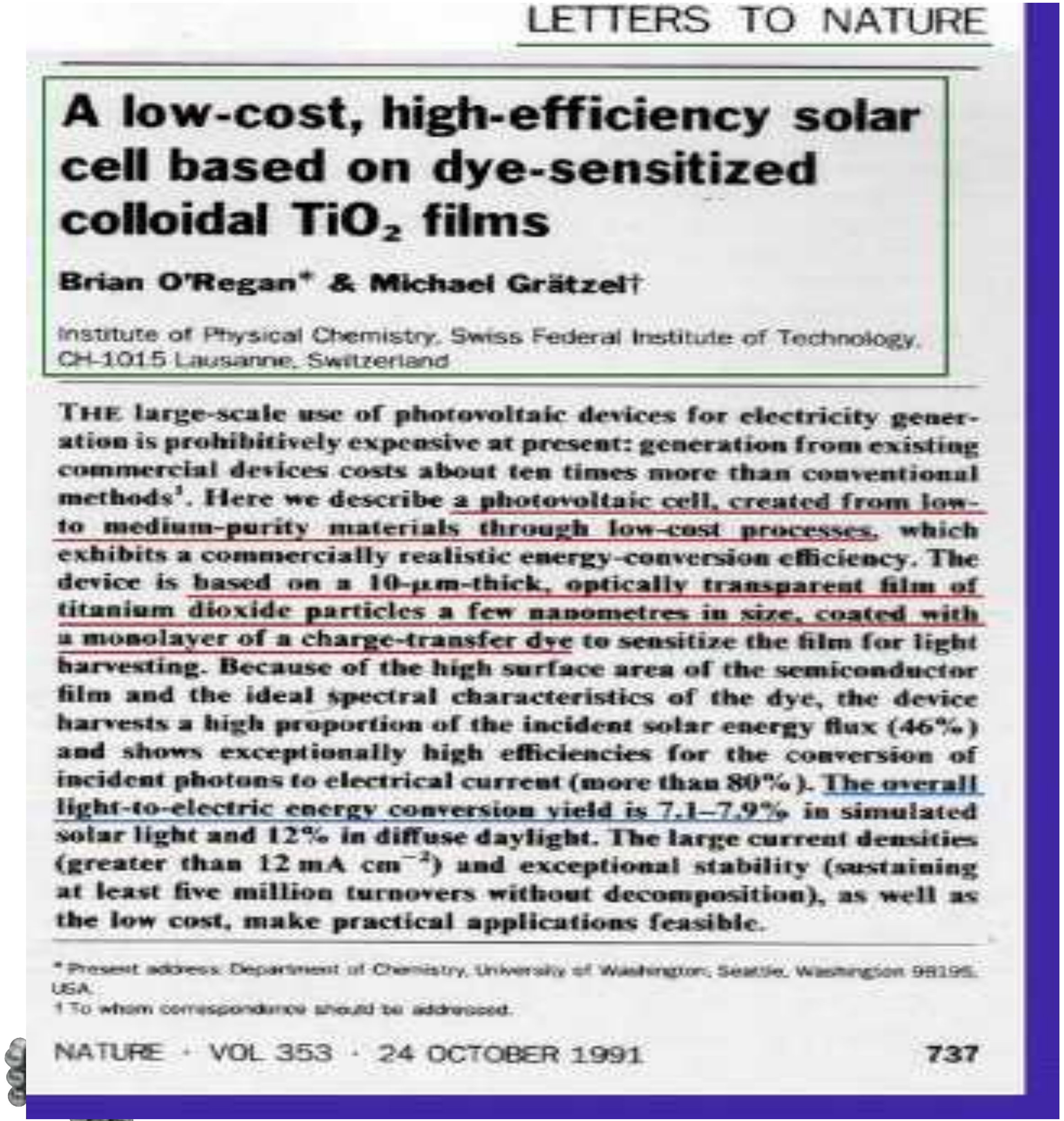
Heterostructures

Optical Effects

Printability

Quantum Effects

Example:Dye Sensitized Solar Cells (DSSCs)



LETTERS TO NATURE

A low-cost, high-efficiency solar cell based on dye-sensitized colloidal TiO_2 films

Brian O'Regan* & Michael Grätzel†

Institute of Physical Chemistry, Swiss Federal Institute of Technology, CH-1015 Lausanne, Switzerland

THE large-scale use of photovoltaic devices for electricity generation is prohibitively expensive at present: generation from existing commercial devices costs about ten times more than conventional methods[1]. Here we describe a photovoltaic cell, created from low- to medium-purity materials through low-cost processes, which exhibits a commercially realistic energy-conversion efficiency. The device is based on a 10-μm-thick, optically transparent film of titanium dioxide particles a few nanometres in size, coated with a monolayer of a charge-transfer dye to sensitize the film for light harvesting. Because of the high surface area of the semiconductor film and the ideal spectral characteristics of the dye, the device harvests a high proportion of the incident solar energy flux (46%) and shows exceptionally high efficiencies for the conversion of incident photons to electrical current (more than 80%). The overall light-to-electric energy conversion yield is 7.1–7.9% in simulated solar light and 12% in diffuse daylight. The large current densities (greater than 12 mA cm^{-2}) and exceptional stability (sustaining at least five million turnovers without decomposition), as well as the low cost, make practical applications feasible.

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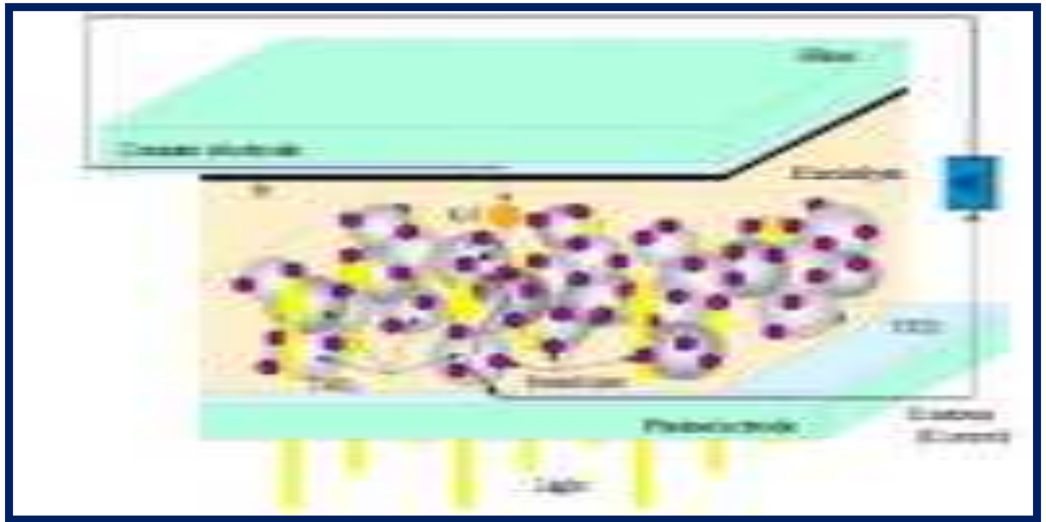
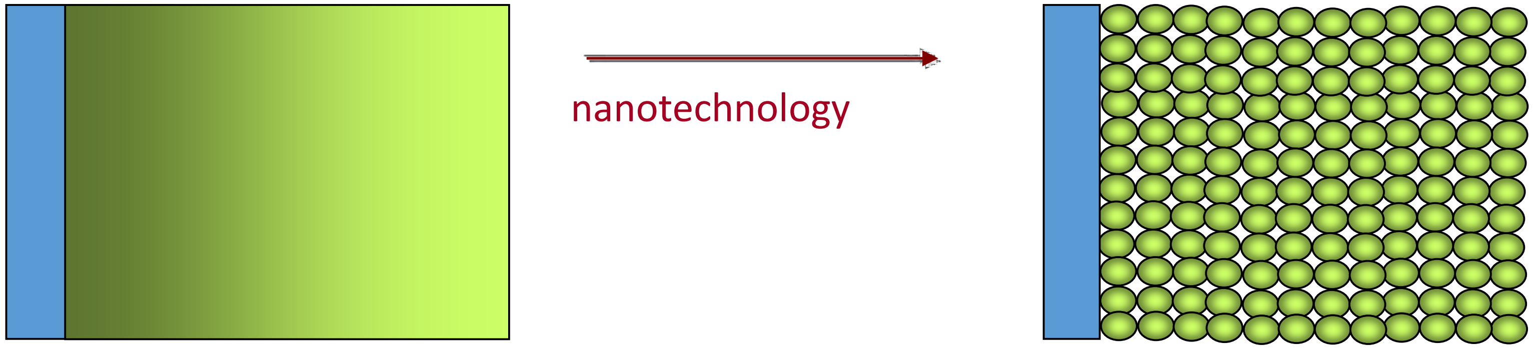


- TiO_2 : mesoporous for greater surface area to attach dye
  - porosity > 50%
  - nanoparticles ~20 nm
  - other semiconductors
  - TiO_2 easy to synthesize, abundant inexpensive
- Electrolyte : usually iodide/tri-iodide couple
  - reduces dye after injection to **TiO_2**
  - new research in gel electrolyte
- Dye: usually ruthenium based
- Electrodes: Sn**O_2** thin film and Pt thin film

Nanocrystalline oxide photoanode



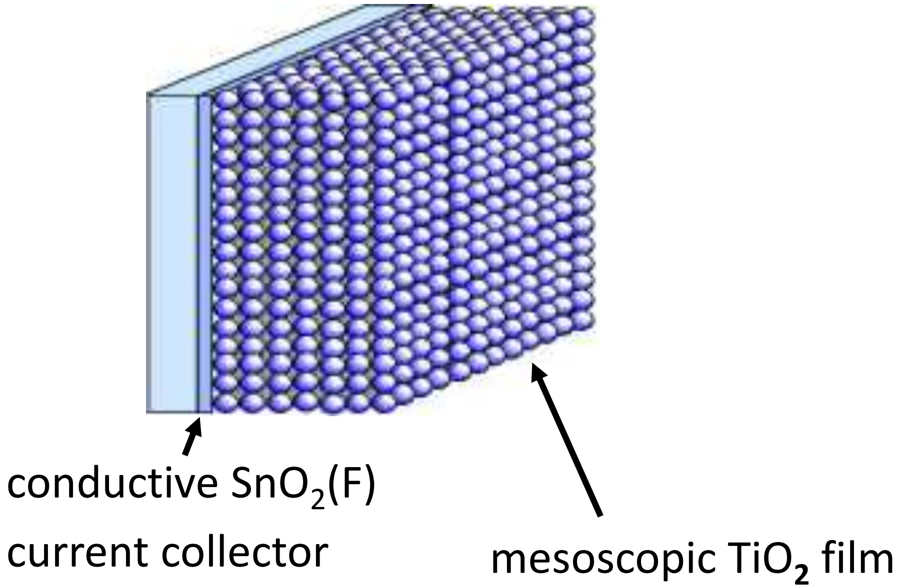
Consider a ***one micron*** (10^{-6}m) layer of particles with a diameter of 20 nm and a porosity of 50% spread on a 1 cm^2 flat electrode

Volume occupied by spheres is 0.5×10^{-4} cm^3

Since $A/V = 3/r$

$A = 3V/r = 3 \times 0.5 \times 10^{-4} / 10^{-6} = 150$ cm^2

The internal area is 150 times higher than the geometric area



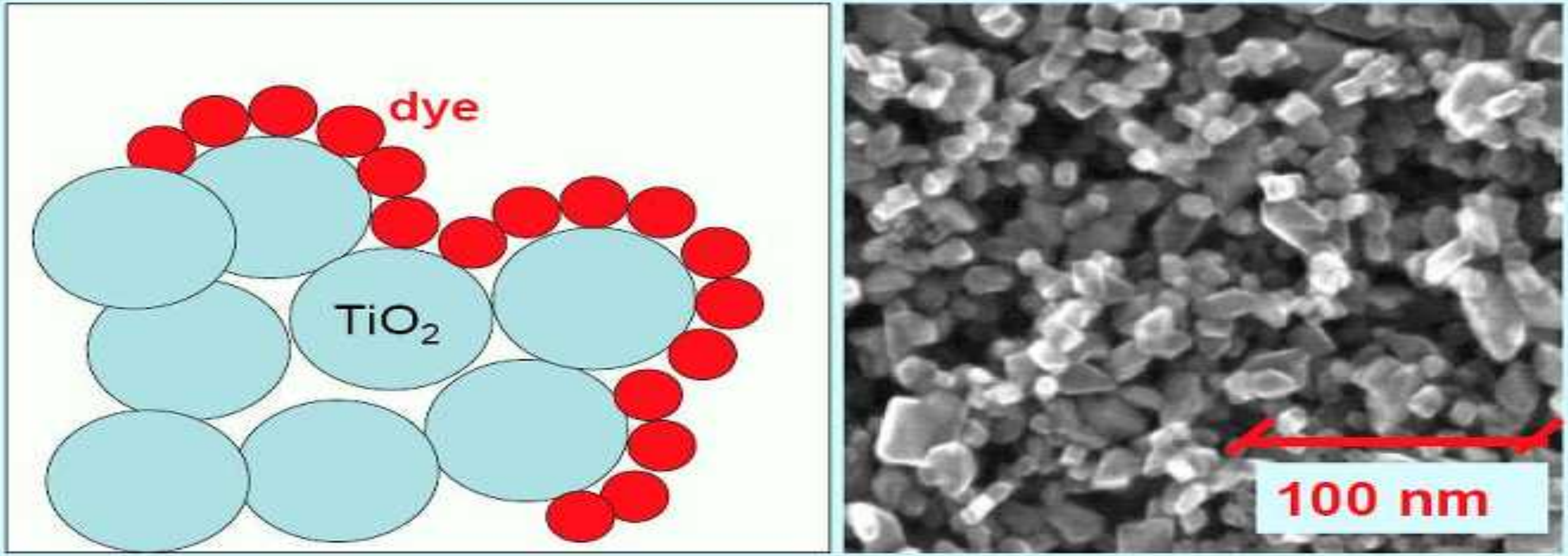
Advantage of nanocrystalline Oxides electrodes:

1) translucent electrode - avoids light scattering losses

2) Small size is within minority carrier diffusion length, the valence band holes reach the surface before they recombine.

The photocurrent is over 1000 times higher than with a flat junction

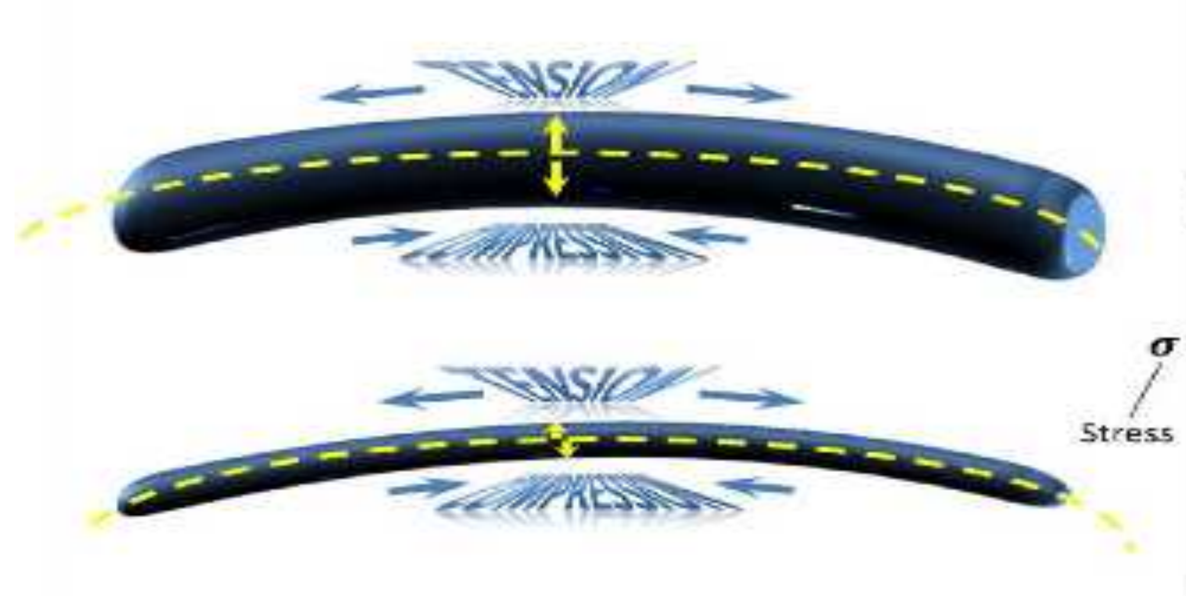
The excited dye injects electrons into the network of TiO2 nanocrystals which conduct them to the current collector

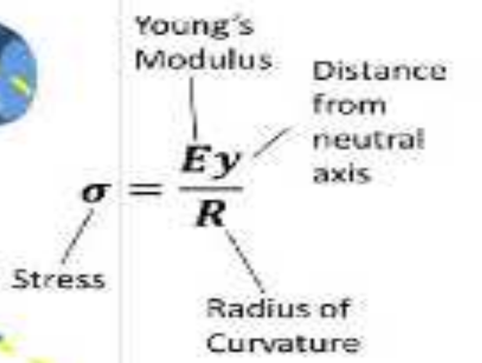


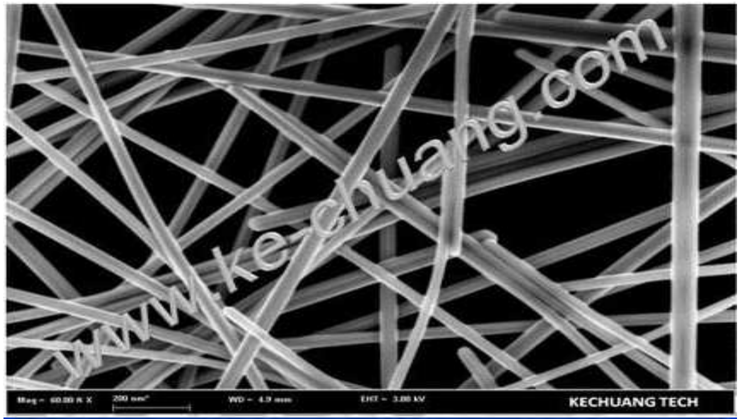
The electrons ad holes move in different phases and are separated by a phase boundary

•M. Gratzel

Flexibility – Transparent Conductors







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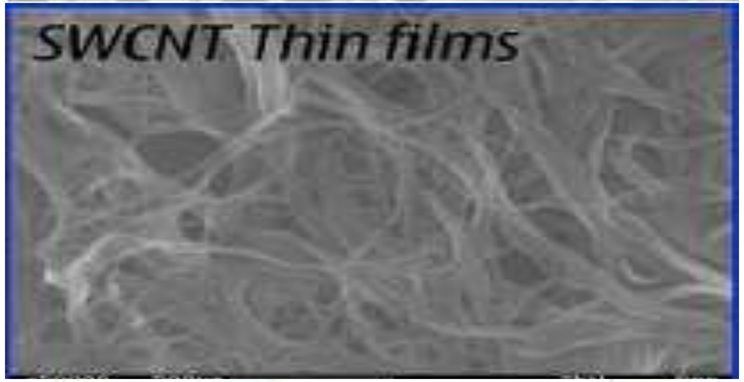

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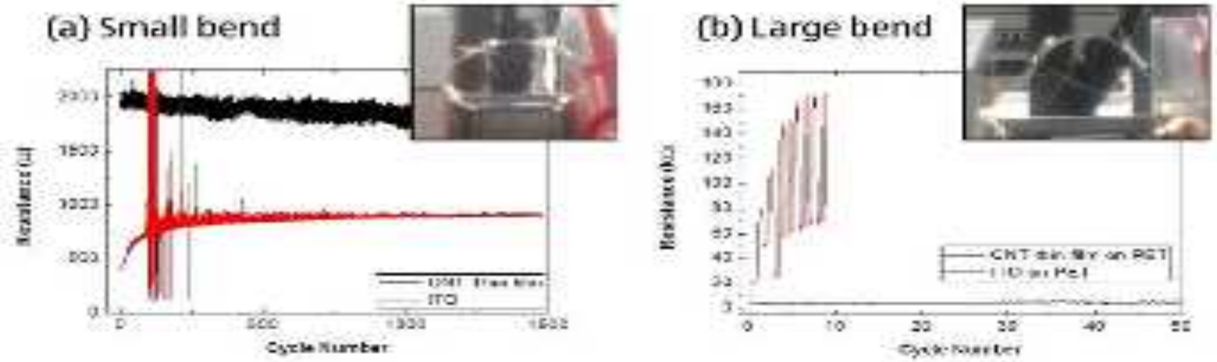
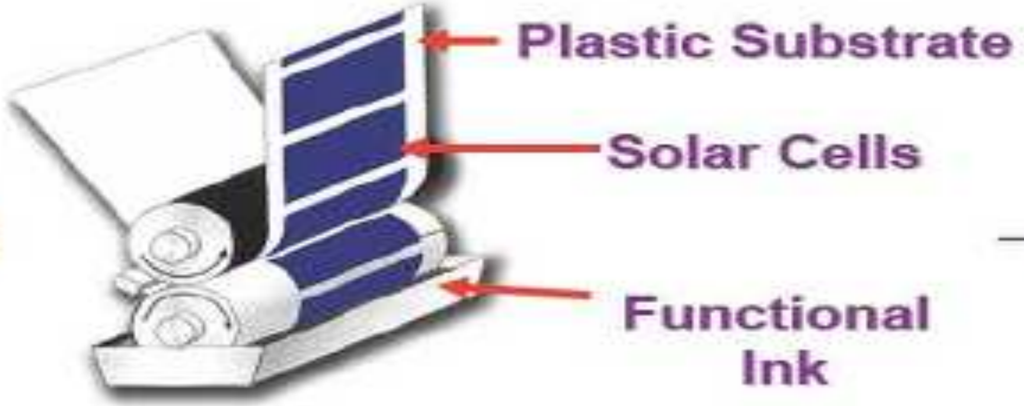
- **Indium Tin Oxide (ITO) traditional transparent conductor. But indium becoming scarce/limited supply**
- **Crystalline nature leads to poor mechanical performance (flexibility) due to cracking**
- **Vacuum deposition**
- **A solution nanowires**
- **Silver nanowires or carbon nanotubes form an excellent flexibility tolerant alternative to ITO**



Printability – new manufacturing paradigm

"inks" ---- with electronic functionality!

The Dream →



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Sri Lanka Institute of Nanotechnology formed in 2008 to catalyze nanotechnology for industry

Equity Ownership **50%** SLINTEC **50%**

SLINTEC is a **Private Company** formed through a **Public-Private Partnership** between the Government of Sri Lanka and six leading Private Sector companies.

Vision

"Discoveries with worldwide impact

to enable valued added manufacturing"

Directive

1. Build a world-class **Research & Development** centre specialized in Nanotechnology & Advanced Technology
    1. Make products more competitive using Nano & advanced technologies.
    2. Add value to Sri Lanka’s mineral resources.
2. Build a **Nanotechnology and Science Park** for research, development and commercialization of innovations

Holistic Research Priority : Achieving Sustainable Economic Development by Addressing Urgent Issues

Safe Drinking Water

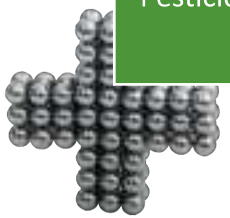
Healthcare & Wellbeing

Affordable Food Security

'Smart Technology on Bedrock Science'

Strategic Research & Innovation Focus Areas

Agriculture	Water Purification	Apparel	Healthcare	Mineral Resources
Advanced Plant Nutrients, Fertilizers & Agrochemicals	**Nano-composites, Nano-sorbents, Nanoparticles, Nano-membranes**	**Smart Textiles**	**Nutraceuticals**	**High Value Mineral Processing**
Nano-Fertilizer	Developing Nanomaterials for water purification	Textiles for Wellbeing	Turmeric Anti-Bacterial	Titanium
Targeted Plant Nutrient Release	Carbon nanotubes (CNTs) for water purification	Textiles for Water and Energy Conservation	Manioc Anti–Cancer	*Titanium Dioxide (TiO2)*
Integrated Plant Nutrient Systems	Electrochemical methods for water purification		Karawila Alleviation of Diabetes	*Montmorillonite (MMT)*
Targeted Release of Pesticides and Insecticides	Developing sensors for testing water quality			*Graphite*



Focused funded research with industry to improve existing and develop new products

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Thank you