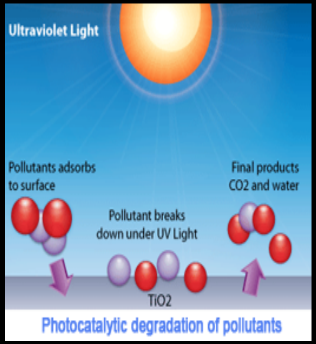
Advanced application of Thin Films part 1

Jari Koskinen

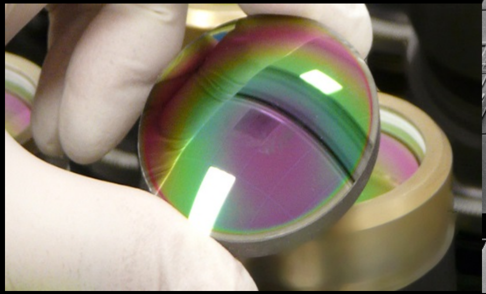
Function and utility

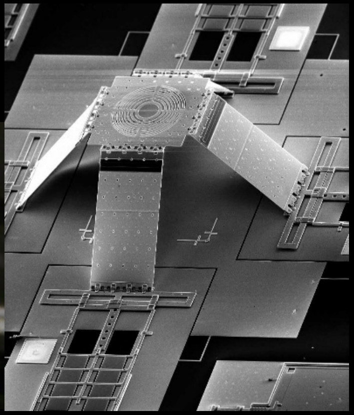


Titanium Dioxide: Photocatalytic activity

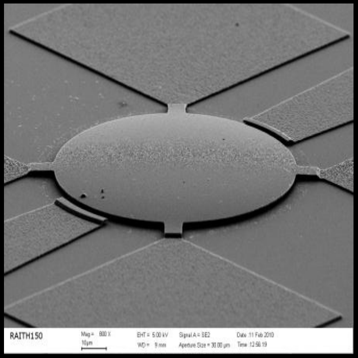
Indium Tin Oxide, ITO: Defrosting coating

Optical systems, optical MEMS





Microelectromechanical systems, MEMS



Applications of thin films

- Photo voltaic
- Energy harvesting (piezo)
- Optical coatings
  - Tunable transmission
- Magnetic Films for Data Storage
  - Magnetic discs
- Sensors
  - Gas sensors
  - Electro chemical sensors
- Photocatalytic thin films

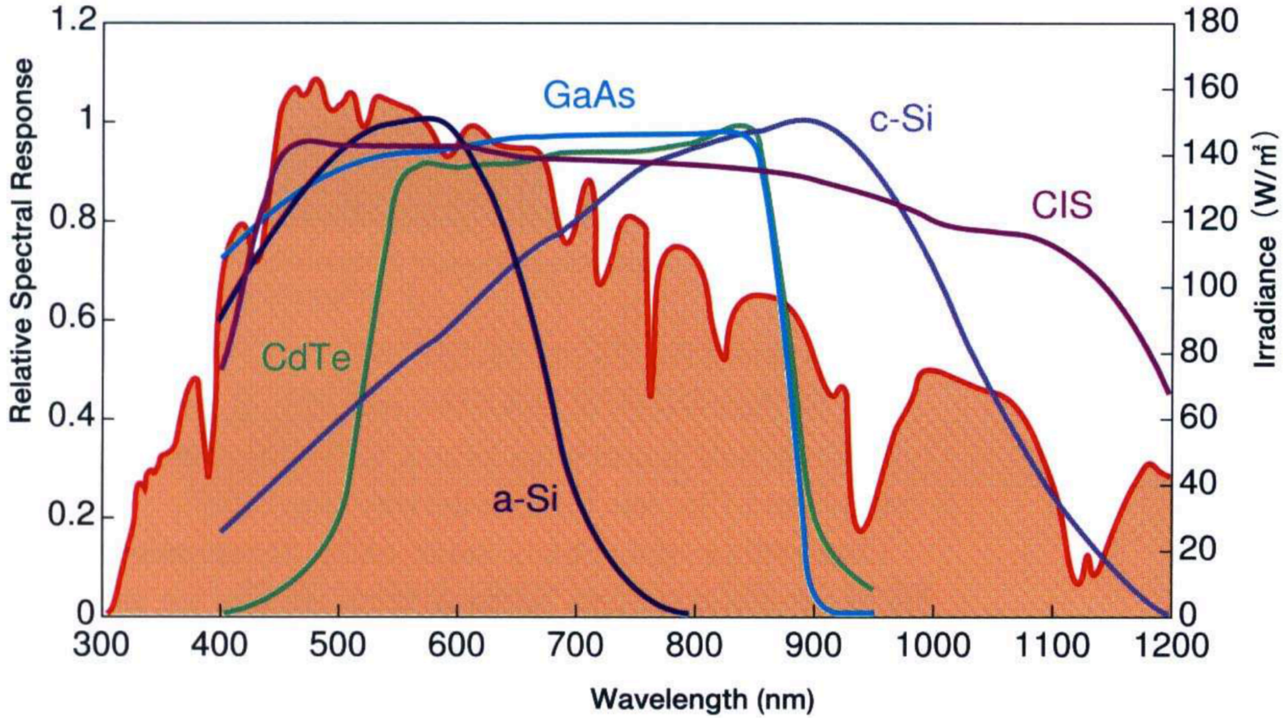
Solar PV large area, decorative

http://www.solar.kamtexindustries.com/Articles/types-of-commercial-solar-panels-and-their-structures/Thin-film-glass-laminated-Solar-panel.html

Solar Cell Technologies

- Crystalline Silicon solar cells
  - Single, Multi, Ribbon
- • Thin Film solar cells
  - Silicon, Cu_2S , a-Si, m-Si,n-Si, CdTe, CIGS,CNTS
- • Concentrating solar cells
  - Si, GaAs
- • Dye, Organic ,Hybrid & other emerging solar cells
- • New Ideas

Spectral response of solar cells

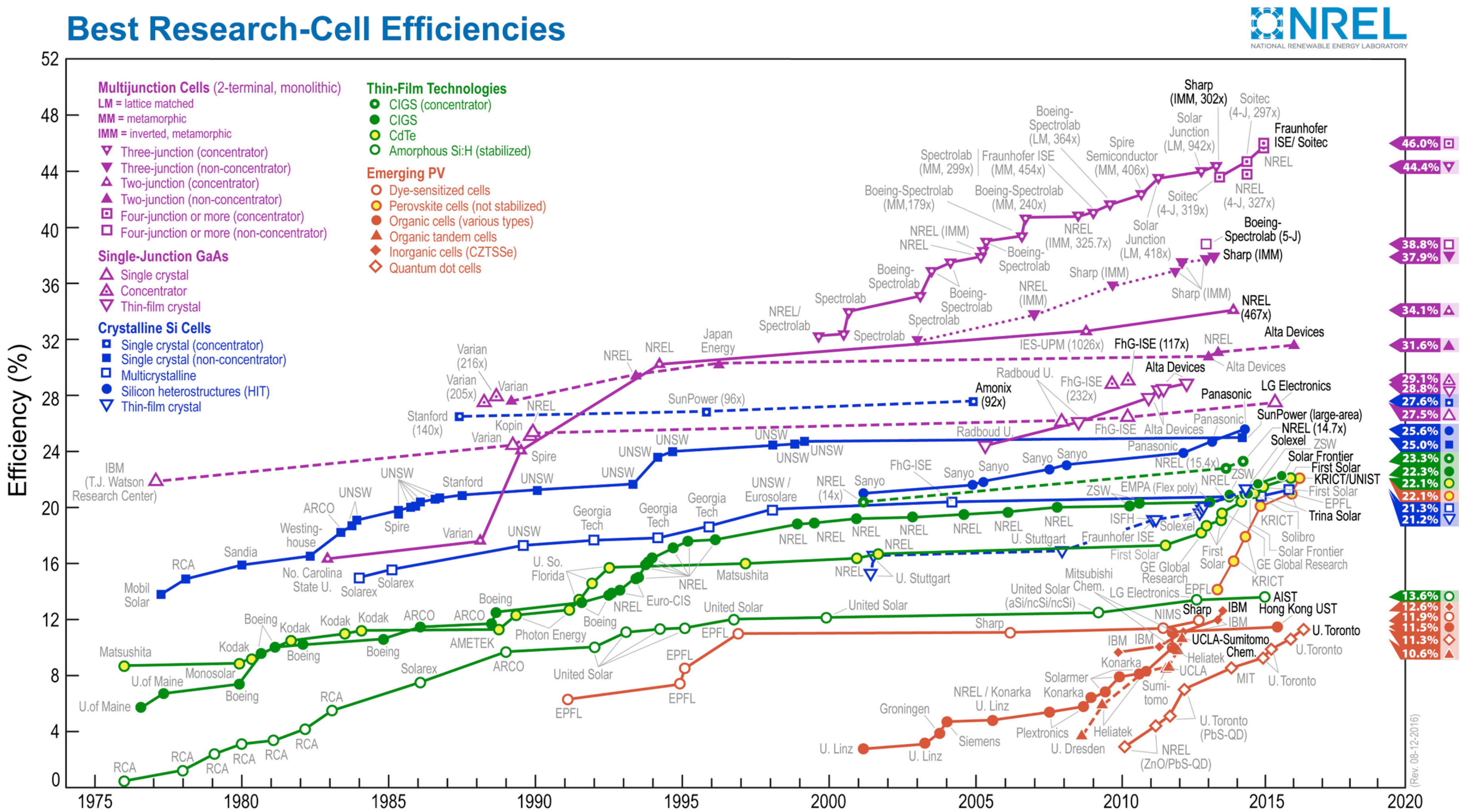


Source: unknown

Laboratory for Thin Films and Photovoltaics:
Courtesy :Ayodhya Tiwari

EMPA
Swiss Federal Laboratories for Material Testing and Research

Best Research-Cell Efficiencies



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Aalto University
School of Chemical Technology

28/10/13

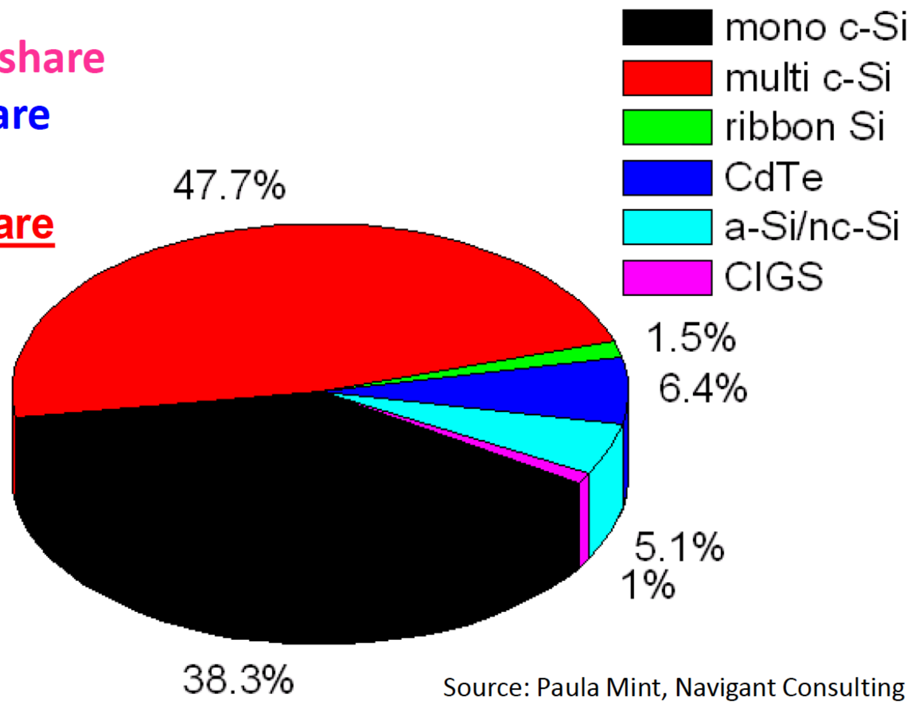
Solar module production for different technologies

CIGS is emerging with about 1% share

CdTe is leading with over 6% share

a-Si:H: About 5% share

C- Si dominates with ~ 90% share



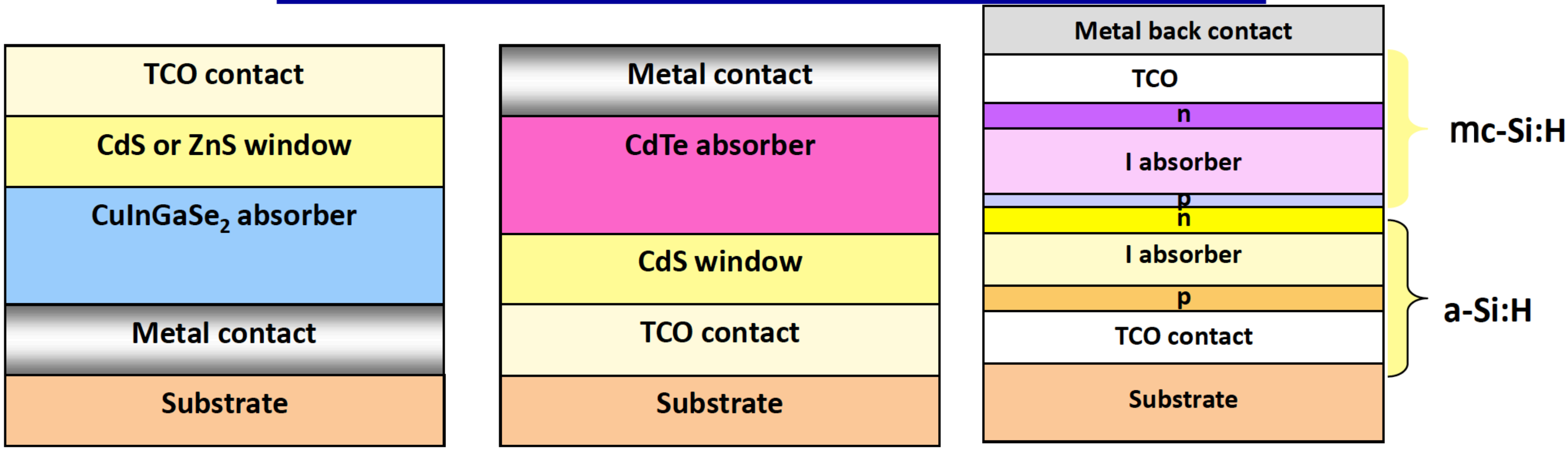
Source: Paula Mint, Navigant Consulting

EPIA expects thin film shares will grow:
20% in 2010 with about 4 GW
25% in 2013 with about 9 GW

Why thin film solar cells?

- **SMALL THICKNESS REQUIRED DUE TO HIGH ABSORPTION, SMALL DIFFUSION LENGTH & HIGH RECOMBINATION VELOCITY**
- **MATERIALS ECONOMY, VERY LOW WEIGHT PER UNIT POWER**
- **VARIOUS SIMPLE & SOPHISTICATED DEPOSITION TECHNIQUES**
- **A VARIETY OF STRUCTURES AVAILABLE : AMORPHOUS, PLOYCRYSTALLINE, EPITAXIAL**
- **TOPOGRAPHY RANGING FROM VERY ROUGH TO ATOMICALLY SMOOTH**
- **DIFFERENT TYPES OF JUNCTIONS POSSIBLE –HOMO, HETERO, SCHOTTKY, PEC**
- **TANDEM AND MULTI JUNCTION CELLS POSSIBLE**
- **IN-SITU CELL INTEGRATION TO FORM MODULES**
- **COMPATIBILITY WITH SOLAR THERMAL DEVICES**

Thin Film CIGS, CdTe, a-Si Solar Cells

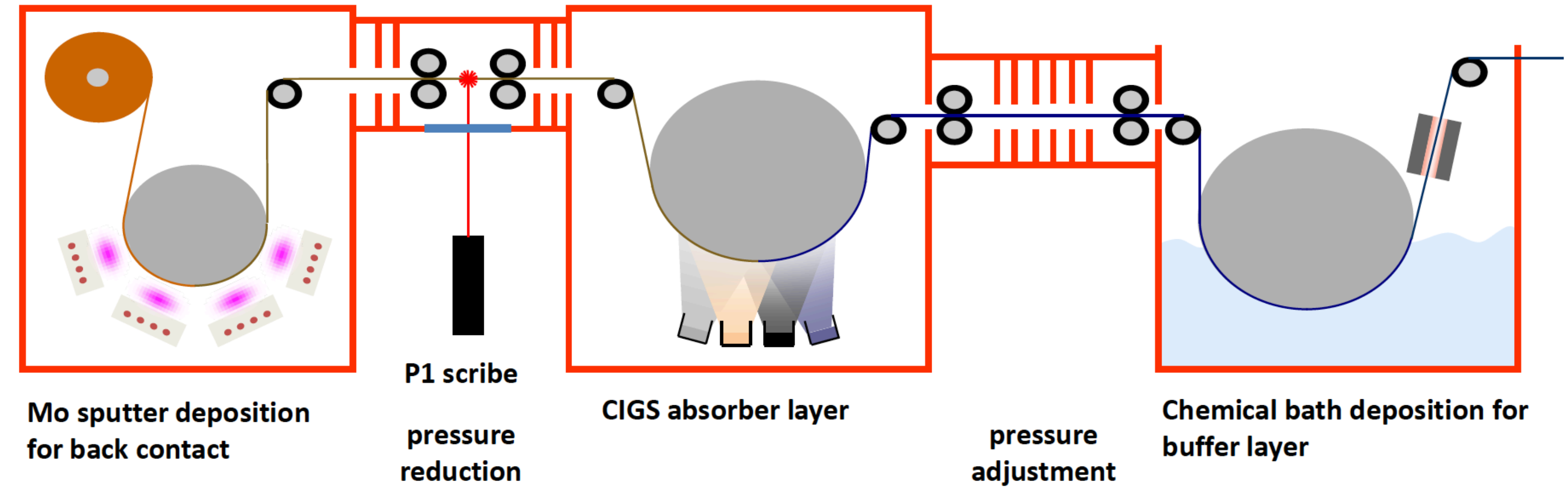


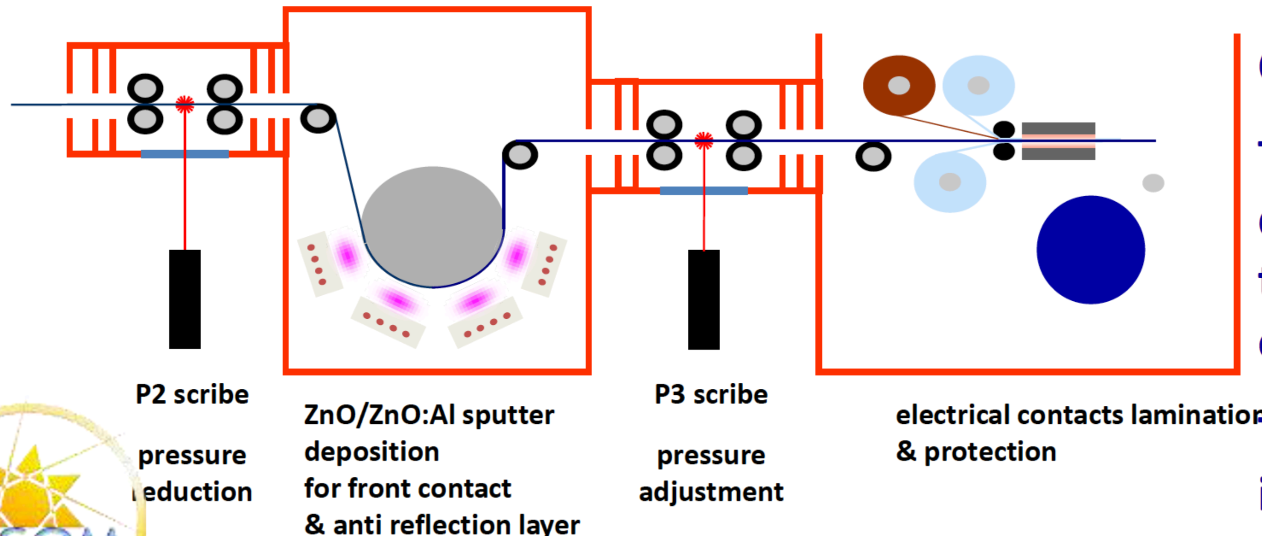
CIGS	CdTe	a-Si
Highest: 20.3%	Highest: 16.5%	Highest: 13.3%
Cell area: ~0.5 cm^2	Cell area: ~1 cm^2	Cell area: ~0.25 cm^2
Typical range:	Typical range:	Typical range:
Cells: 12% - 20%	Cell: 10% - 16.5%	Cell: 8% - 13.3%

Lower efficiency of large area solar modules

CIGS	CdTe	a-Si
Module: 8% - 13.5%	Module: 9% - 11%	Module: 4% - 9%
Highest: 15% - 16%	Highest: 11.5%	Highest: 10.3%

Roll-to-roll CIGS solar module production concept





Challenge:

Transfer of static deposition processes to dynamic deposition on moving foils

Thermal mismatch induced stress

FLISOM

EMPA

Laboratory for Thin Films and Photovoltaics
(Courtesy : Ayodhya Tiwari)

Swiss Federal Laboratories for Material Science and Technology

NANOSOLAR

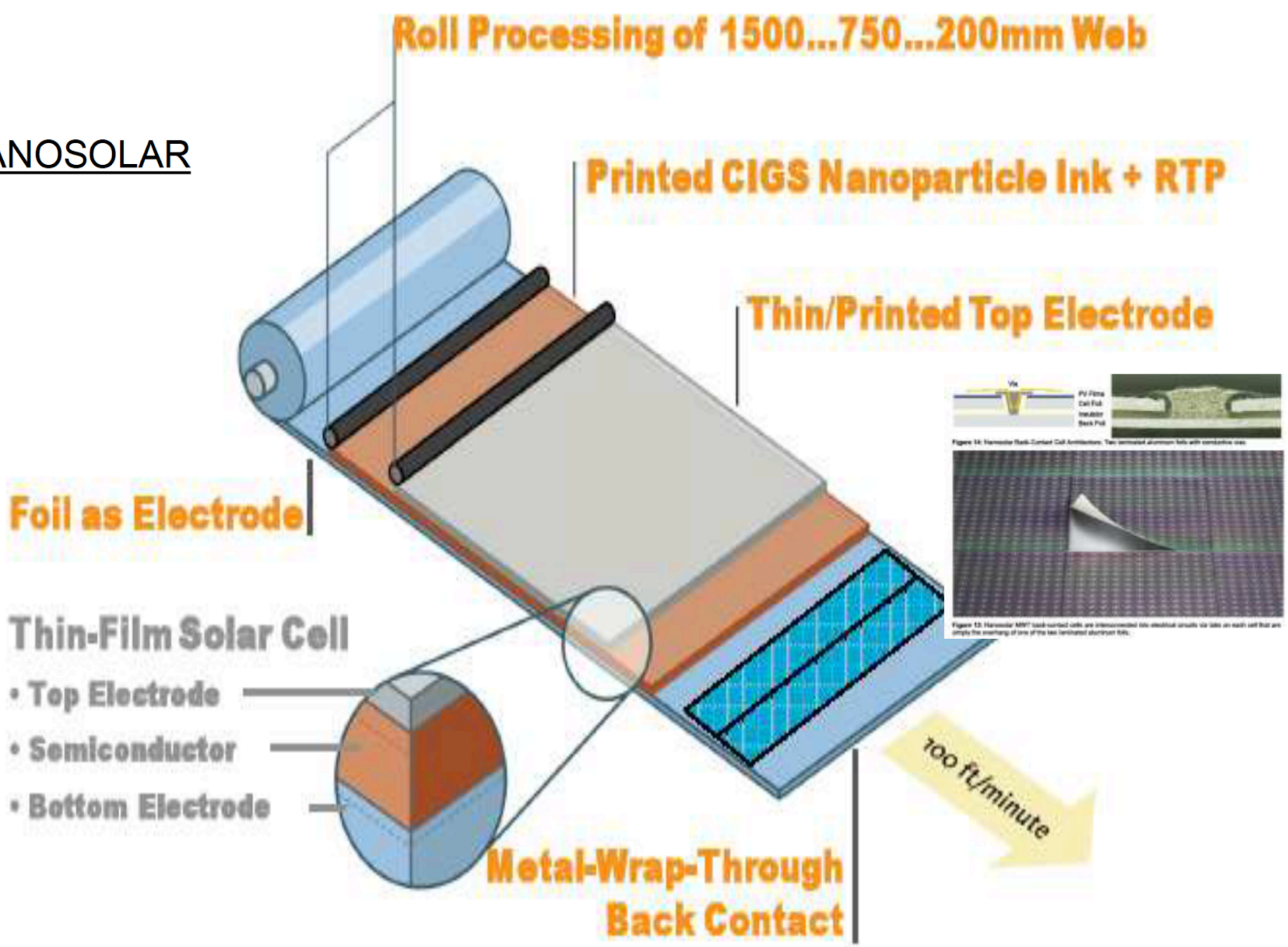
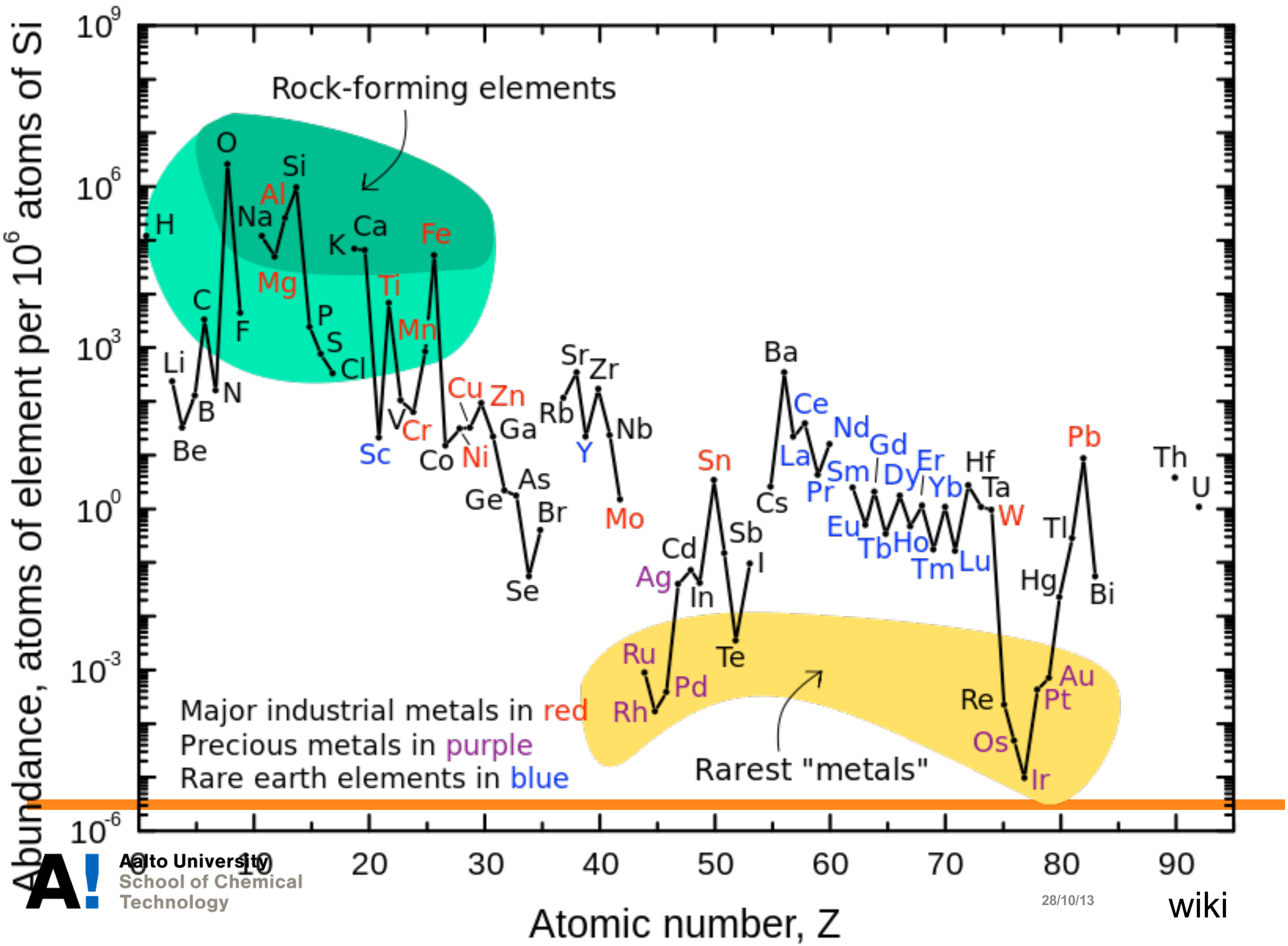


Figure 1: Nanosolar combines a host of innovations to deliver a distinct overall cost reduction.

Rare earth elements



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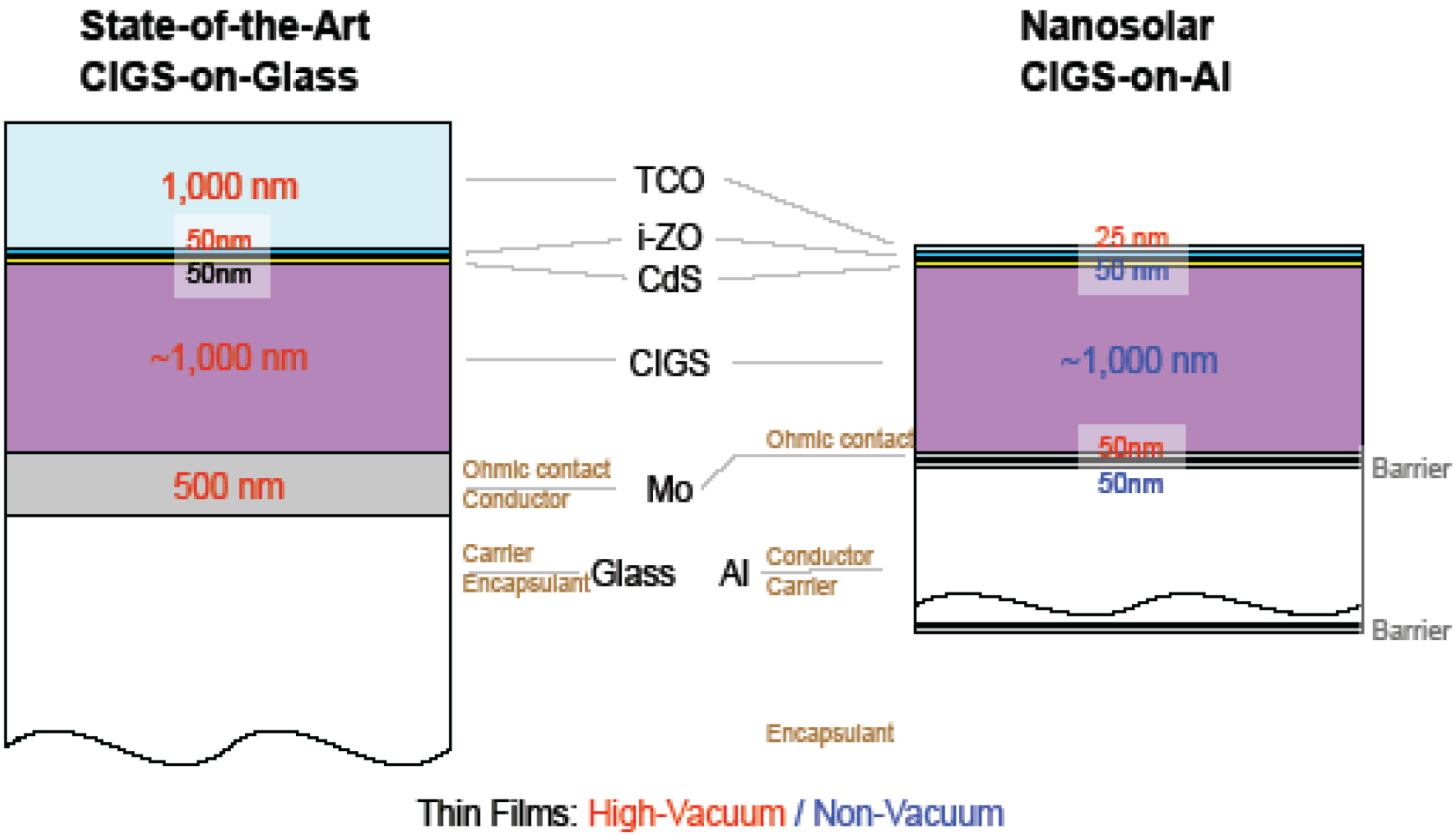

Figure 4: Comparison of State-of-the-Art CIGS versus Nanosolar's CIGS-on-Aluminum. Thickness numbers in red indicate depositions using a high-vacuum deposition technique. The state-of-the-art stack requires close to 3000nm of high-vacuum processing whereas Nanosolar's stack requires less than a tenth of that.