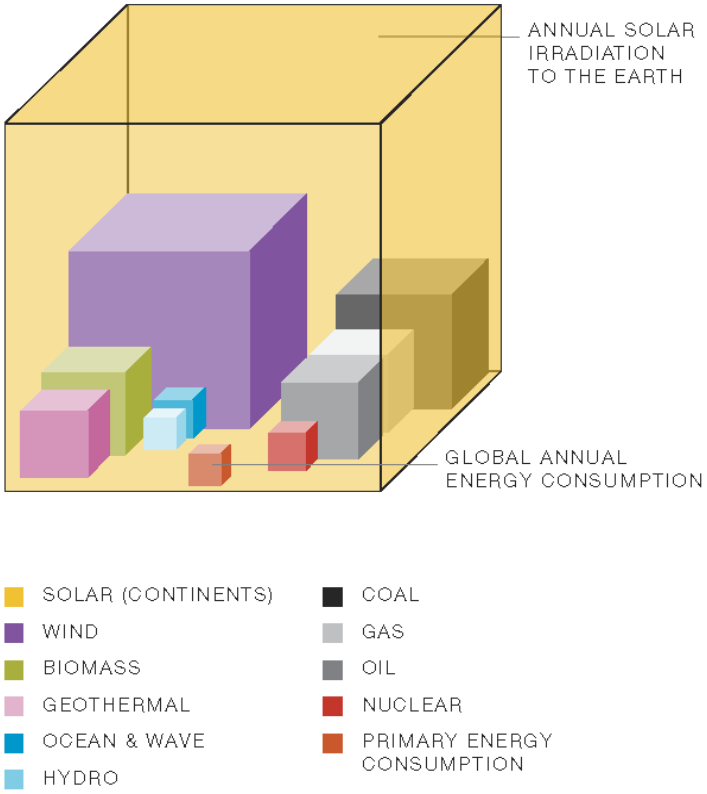
Problems with current energy supply

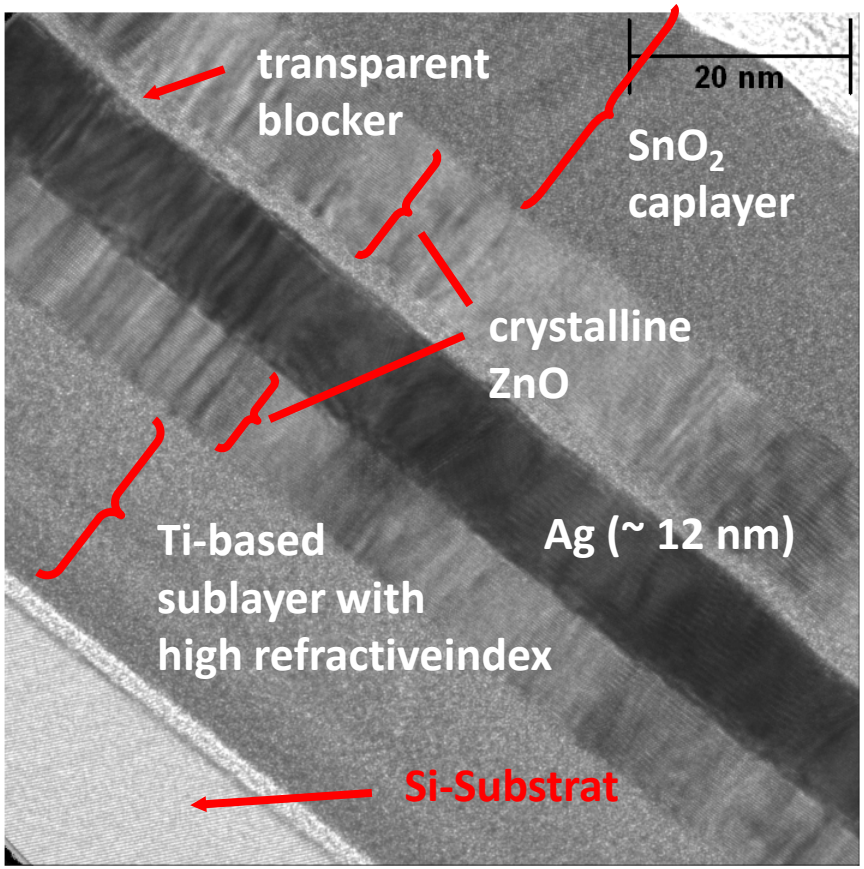


Quelle: International Energy Agency (IEA)

- Total energy demand (2010):
  ~1,5 x 10^{14} kWh/a
  ~ 17 TW continiously
  ~ 540 EJ/a
  - electricity: ~60 EJ/a
  - till 2050: doubling of energy demands are awaited
  - for it, the construction of 1 GW/Tag is necessary!
- The main promise have the renewable energy sources!

Why Thin Films?

HR-TEM, Low-E Schicht auf Si:



B. Szyszka et al., Glasstech Singapur 2004

... weights 0,1 g pro m².

... costs 1,5 Cent pro m².

... reduces the warm-losses from 3 W/m²K

to 1,1 W/m²K.

... saves during heat-season for single-family house

(windows-area 20 m²) about 350 l fuel oil.

... saves during garantied window's life-time (30 years)

x 4000 more energy than was used for fabrication

of thin film (includng deposition system).

Thin Films in Energy Saving Technologies - I

I. Overview of the film fabrication techniques.

I.1. Vacuum technique.

I.1.a. Vacuum equipment.
I.1.b. Gas dynamics, diffusion.
I.1.c. Energy of particles.

I.2. Plasma technique.

I.2.a. Equipment (generator, magnetron).
I.2.b. Plasma properties.
I.2.c. Reactive and nonreactive sputtering process.

I.3. Film growth mechanisms: thermodynamics and kinetics of the film growth resulting in different microstructures.

I.4. Overview of Plasma Deposition Methods.

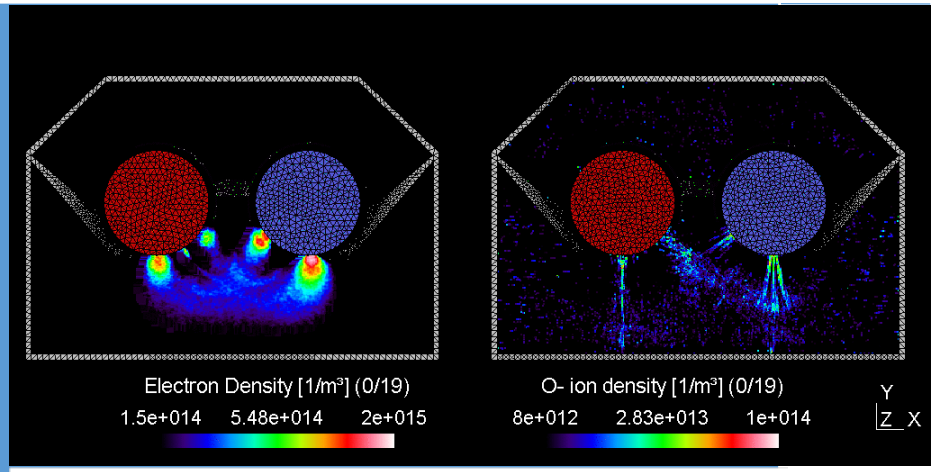
I.4.a. DC/MF/RF Magnetron Sputtering.
I.4.b. Megatron, HIPIMS, other techniques.

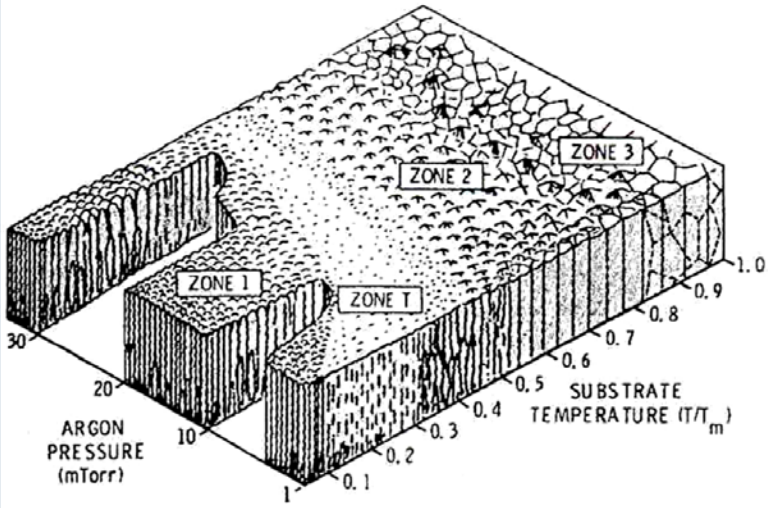
I.5. CVD – Chemical vapor deposition.

I.5.a. CVD principles, theory.
I.5.b. Hardware of CVD (evaporation systems, hot wall, cold wall reactors, R2R).
I.5.c. Examples of CVD processes, industrial use.
I.5.d. PECVD (plasma enhanced CVD), APCVD (atmospheric pressure CVD), water assisted CVD.

I.6. Overview of other vacuum methods.

I.6.a. PLD (pulsed laser deposition).
I.6.b. Texture generating methods: ISD (inclined substrate deposition), IBAD (ion beam assisted deposition).
I.6.c. ALD (atomic layer deposition).





I.7. Overview of some wet-chemical methods (sol-gel, spray pyrolysis, ink-jet printing, spin-coating, dip-coating).

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Thin Films in Energy Saving Technologies – II, III

II. Overview of some important instrumental analytics for thin films.

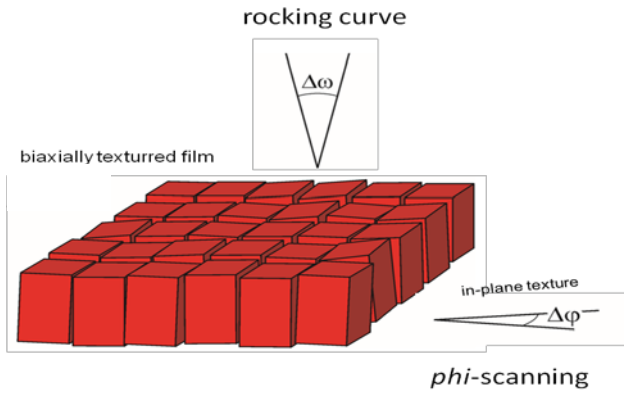
II.1. XRD (X-Ray Diffraction).

II.1.a. Texture analysis, determination of sizes of coherent scattering areas.
II.1.b. Determination of stresses in the film.
II.1.c. Determination of crystalline, polycrystalline and amorphous parts of the film.

II.2. Electron diffraction methods: EBSD, RHEED/LEED.

II.3. Analysis of composition: EDX/EPMA, XPS.

II.4. Analysis of microstructure: SEM, AFM.



III. Superconductive wires.

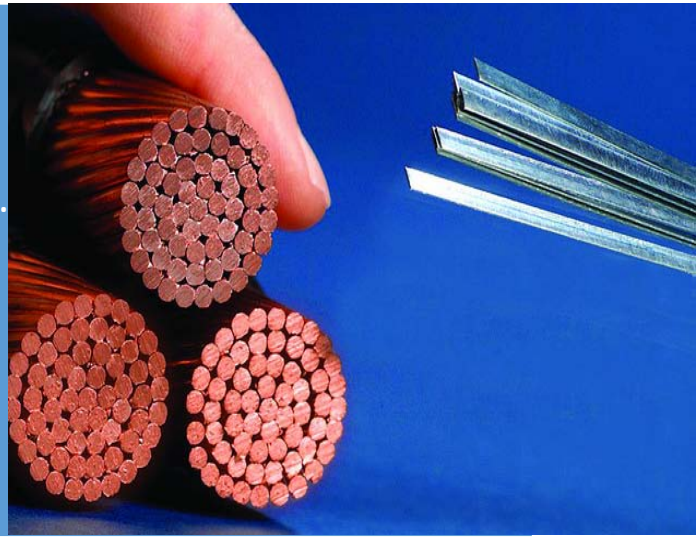
III.1. Superconductivity phenomenon, history, materials.

III.2. 1st and 2nd generation (G) of high temperature superconductive (HTS) wires.

III.2.a. Comparison of superconductive materials and concepts used in 1G and 2G-HTS-wires.
III.2.b. Overview of fabrication technologies for 2G-HTSW.

III.3. Application of HTS-Wires.

III.3.a. Awaited profit, cooling systems, very future technologies.
III.3.a. Cables, FLCs (fault-current limiters).
III.3.b. Generators, motors.
III.3.c. Energy reserves, Inductive heaters.



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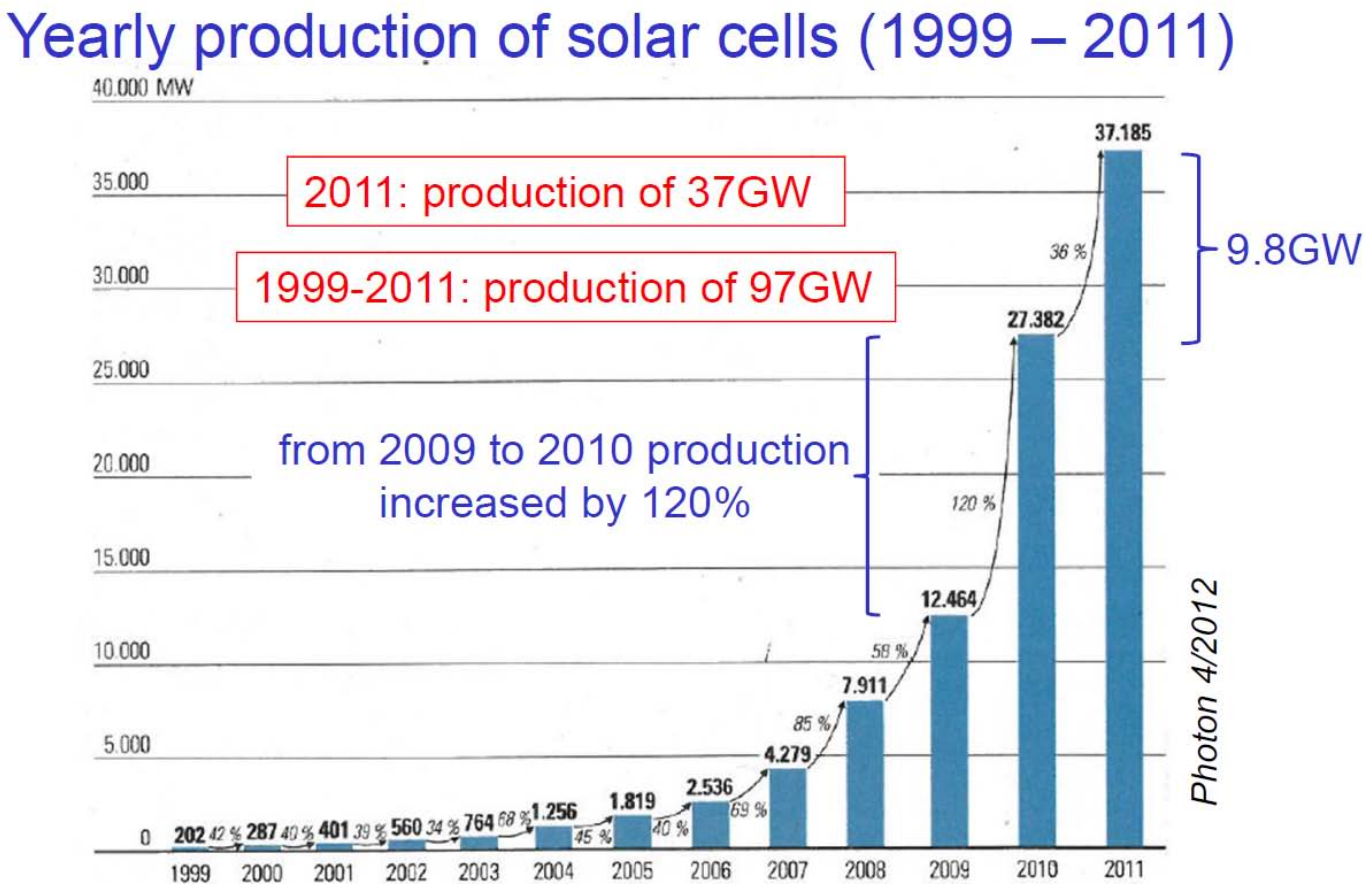
Photovoltaics market grows…



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Thin Films in Energy Saving Technologies - IV

IV. Photovoltaics.

IV.1. Basics and overview of existing technologies.

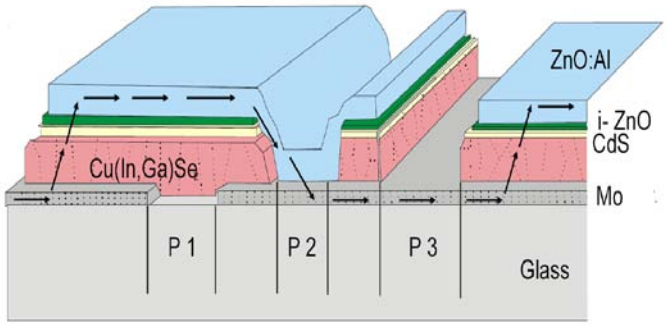
IV.2. Main thin film technologies.

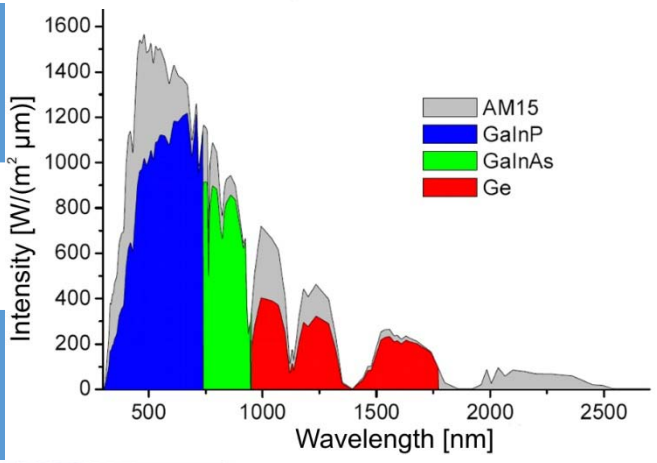
IV.2.a. a-Si/mc-Si tandem cells, structure, production.

IV.2.b. CIGS based cells, structure, production.

IV.2.c. TCO (transparent conductive oxides) in solar cells.

IV.3. Characterization of efficiency (sun simulator, I-V curves, mapping).





V. New concepts and materials in energy saving technologies.

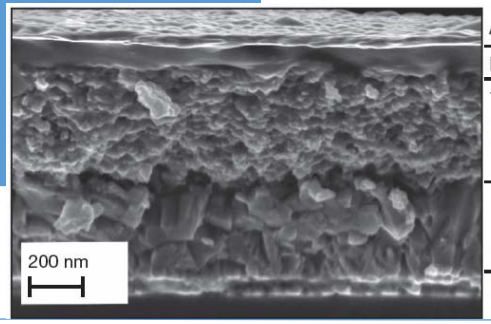
V.1. New concepts and materials in Photovoltaics (PV).

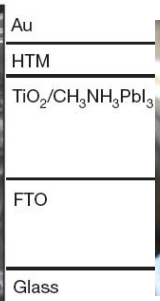
V.1.a. Hybrid organometallic halide perovskite absorber based PV.

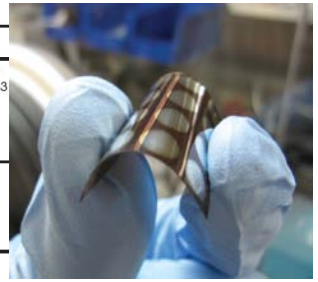
V.1.a. Dye-sensitized solar cells, organic PV.

V.1.c. New concepts of batteries.

V.2. Oxide electronics: advantages, state-of-the-art.







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Thin Films in Energy Saving Technologies – **Load / Exams**

Themes	Contact work hours							Time and tasks for individual work	
	Lectures	Consultations	Seminars	Practical work	Laboratory work	Placements	Total contact work	Individual work	Tasks
1. Overview of deposition techniques (PVD, PLD, CVD, PECVD, ALD, spin coating, dip coating) and consideration of films' growth mechanisms.	3						**6**	**0**	Study of theoretical material (STM).
2. Instrumental analytics of tin films (XRD- stresses' analysis, mechanical properties, EBSD, SEM, AFM, EDX, EPMA, XPS).	3		1	2	2		**8**	**12**	STM. Familiarization with XRD technique. Optional: SEM / EDX, profilometry, AFM.
3. Superconductivity, HTS-wires, application.	6		1				**14**	**0**	STM. Observation and discussion of superconductivity effects.
4. Photovoltaic, thin film technologies (Si, CIGS), dedicated instrumental analytics.	6			2	2		**12**	**12**	STM. Familiarization with optical and electronic properties of materials.
5. New materials in energy saving technologies (OPV, oxide film electronics, etc.)	2		2	2			**8**	**6**	STM. Analysis of various methods of digital modulation.
Total	40		8	18	12		**48**	**30**	

Exams: weight, %

Running control 1	40	10th week
Running control 2	20	14th week
Running control 3	40	18th week