EMPA
Materials Science & Technology

Materialien und Technologien für eine nachhaltige Zukunft

Alex Dommann

Heerbrugg, 20. August 2014

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Federal Department of Economic Affairs, Education & Research (EAER)

Board of the ETH Domain

Eawag | Empa | EPFL | ETHZ | PSI | WSL

Materials Science & Technology

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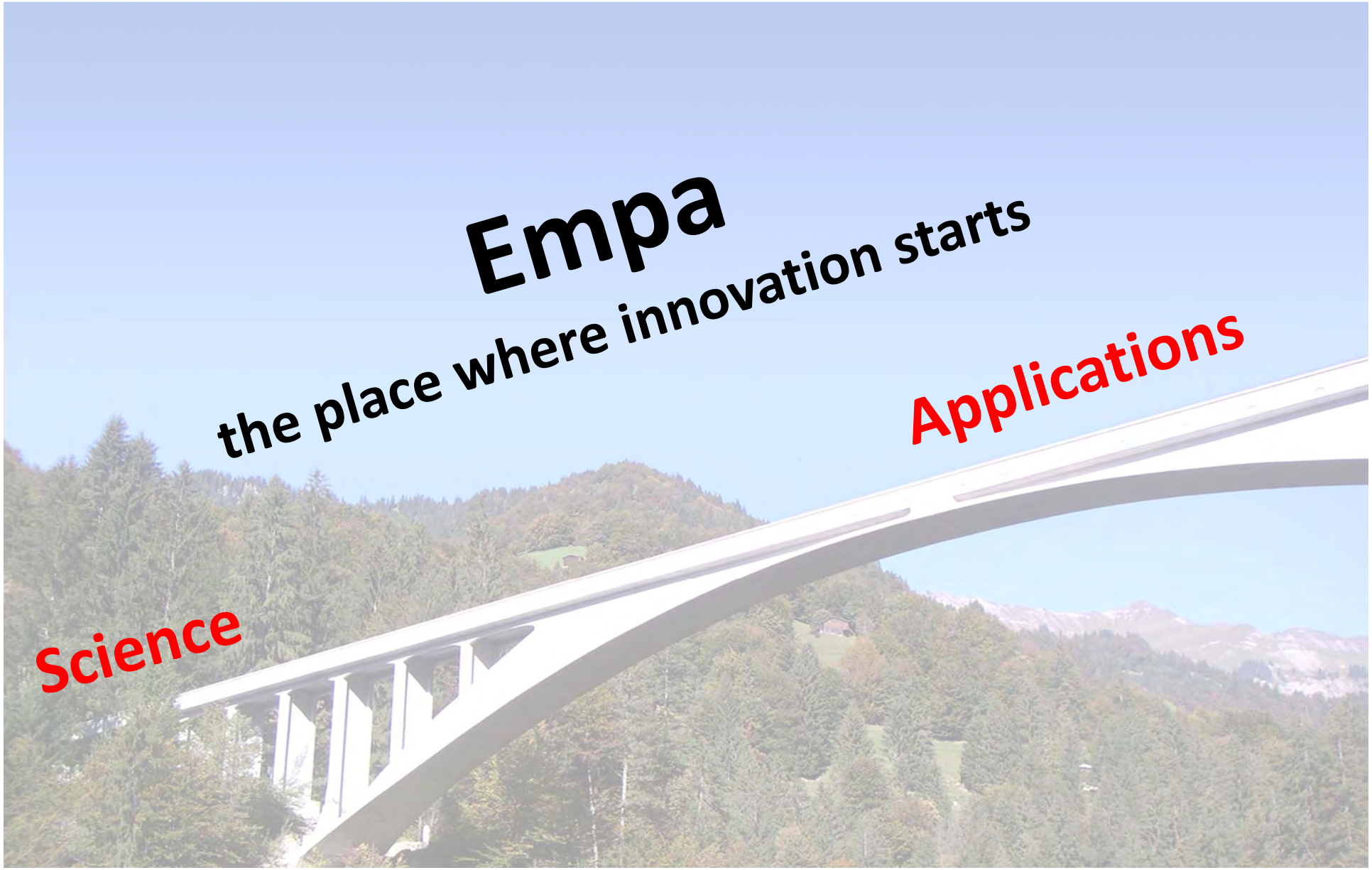

Die Empa in Zahlen (2013)

EMPA
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- 3 Standorte — Dübendorf, St. Gallen, Thun
- 5 Departemente — 28 Forschungsabteilungen
  960 Mitarbeitende (880 FTE; Frauenanteil rund 30%)
  davon 29 Professoren
  190 Doktorierende
  40 Lernende
  plus: 200 DiplomandInnen & PraktikantInnen
- Budget — 93 Mio. CHF Finanzierungsbeitrag Bund
  63.5 Mio. CHF Drittmittel
- Output — > 520 referierte ISI-Publikationen
  90 Seminare & Konferenzen der Empa-Akademie
- Drittmittelprojekte — > 60 laufende Projekte in den EU-Rahmenprogrammen
  rund 110 laufende SNF-Projekte
  rund 110 laufende KTI-Projekte

USG-/CTI-Study*
TOP-10 highly reputed European R&D Organizations

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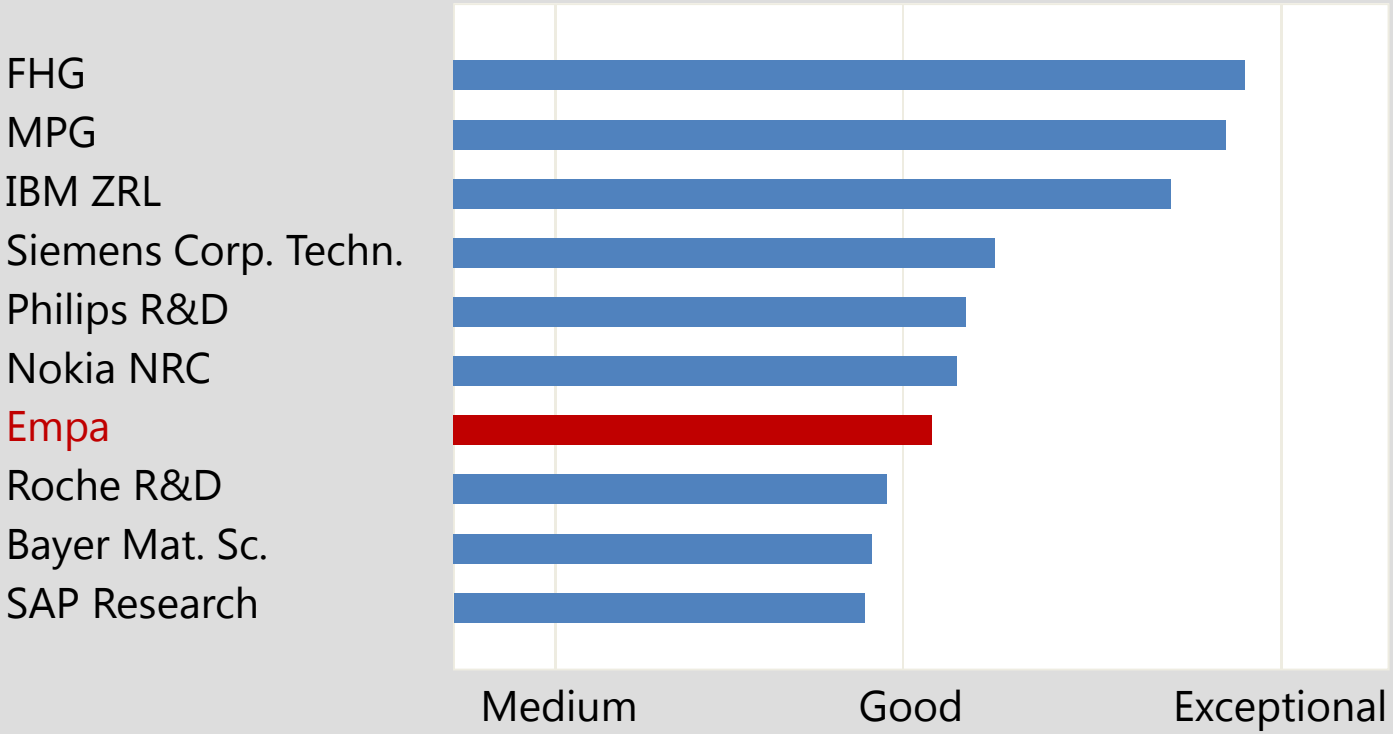

* Survey on the Awareness of R&D Organizations, Wolf-Christian Rumsch, Universität St. Gallen, 2008

Empa - the place where innovation starts

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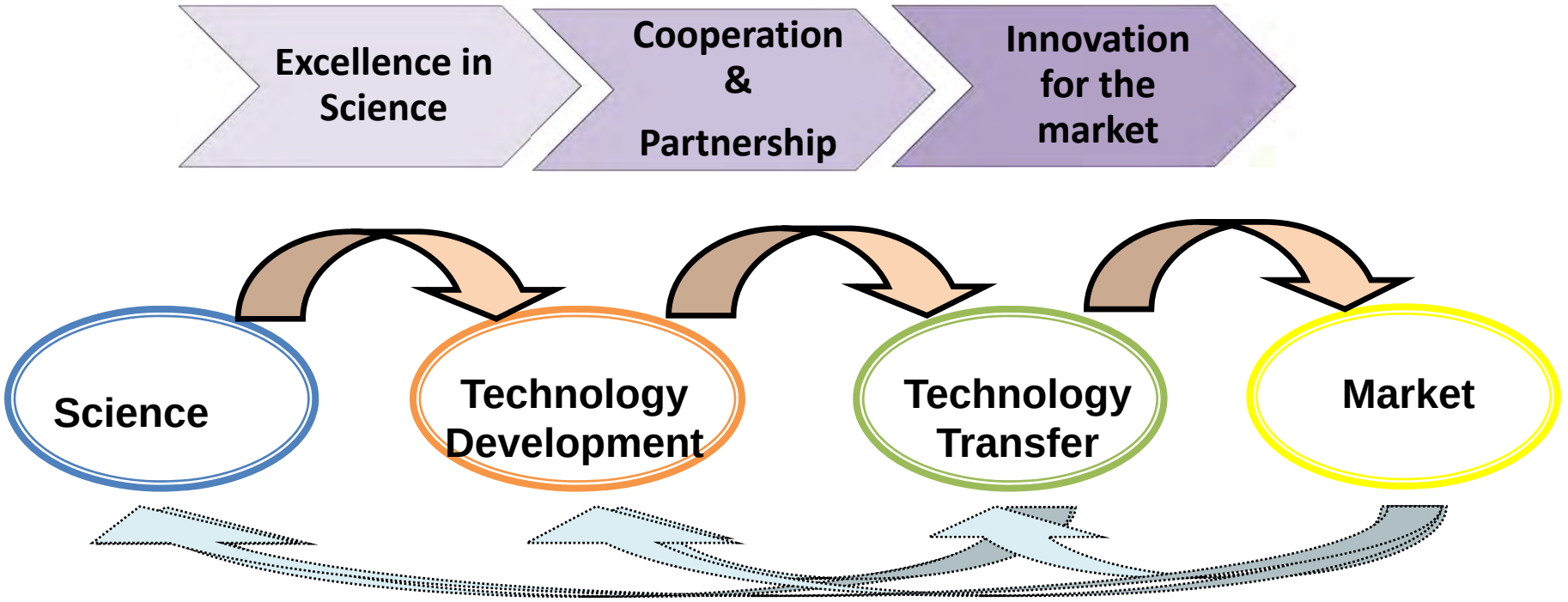

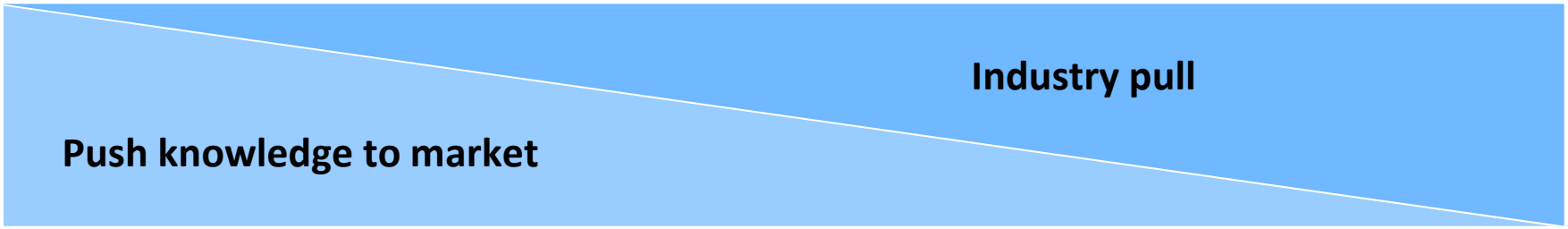

EMPA- accelerate progress by sharing know how

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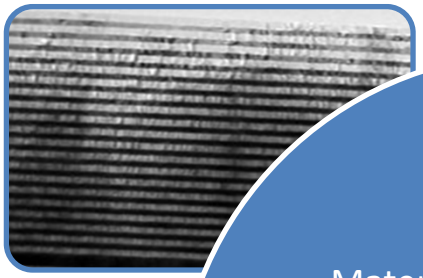
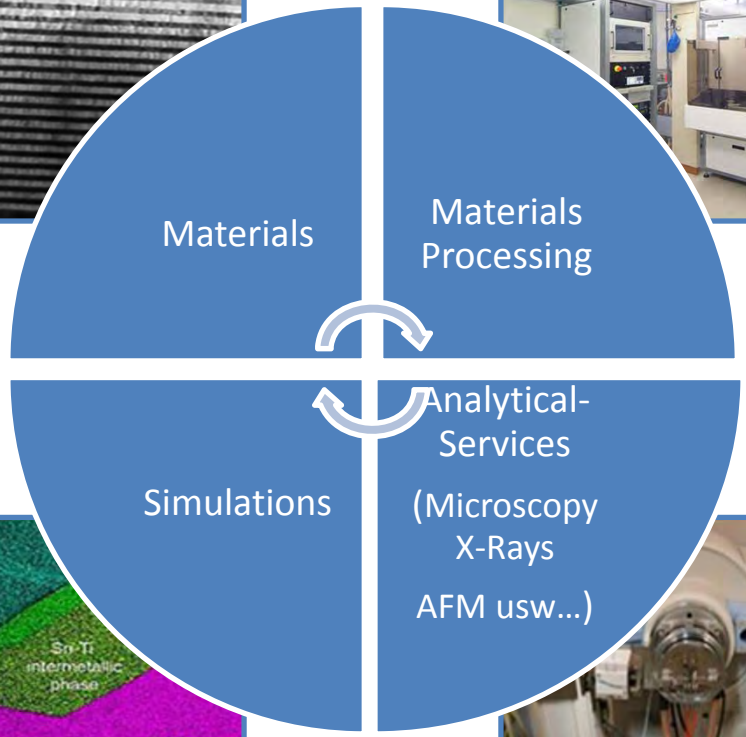
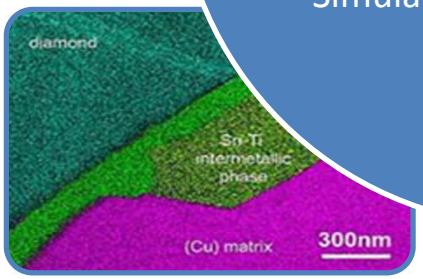
Interfacial design of nano-structured materials



Multi-layer and system fabrication





Model simulations of joining processes

Materials behavior by in-situ studies

Integrated Knowledge & Technology Transfer
From Science to Business

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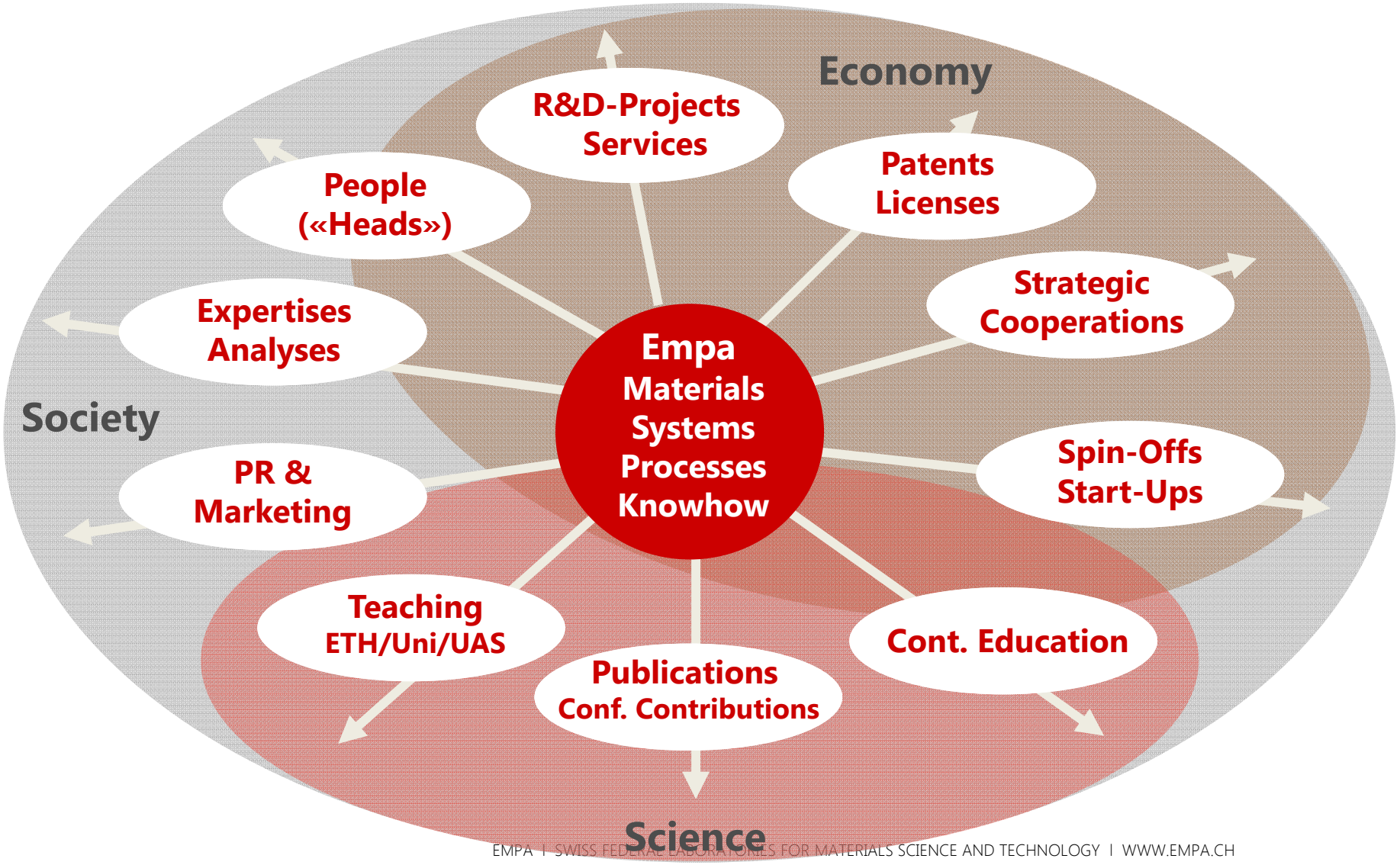

Empa's Partner (Auswahl)

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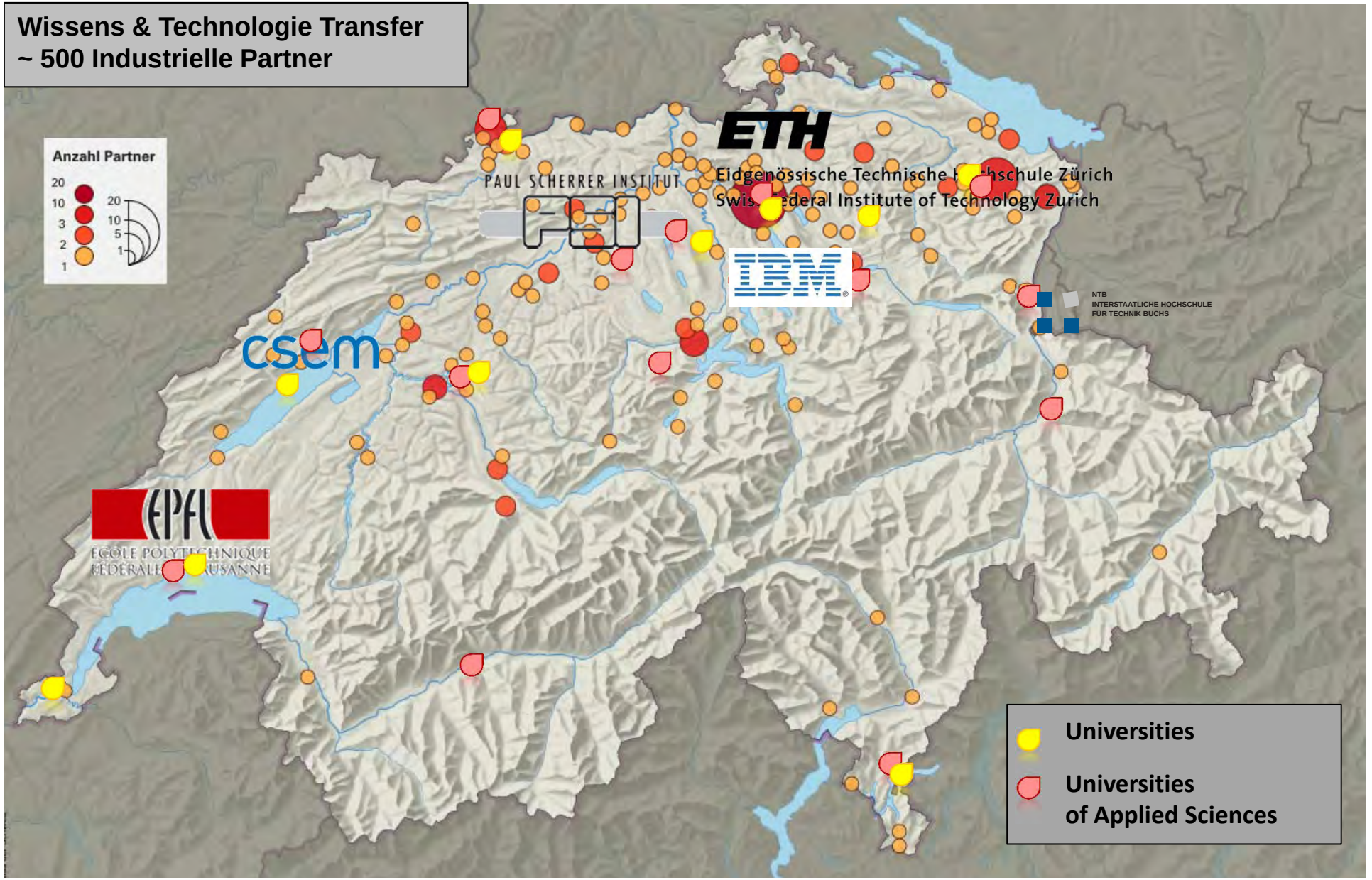
Wissens & Technologie Transfer
~ 500 Industrielle Partner



Unsere Vision

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Empa's Research Focus Areas

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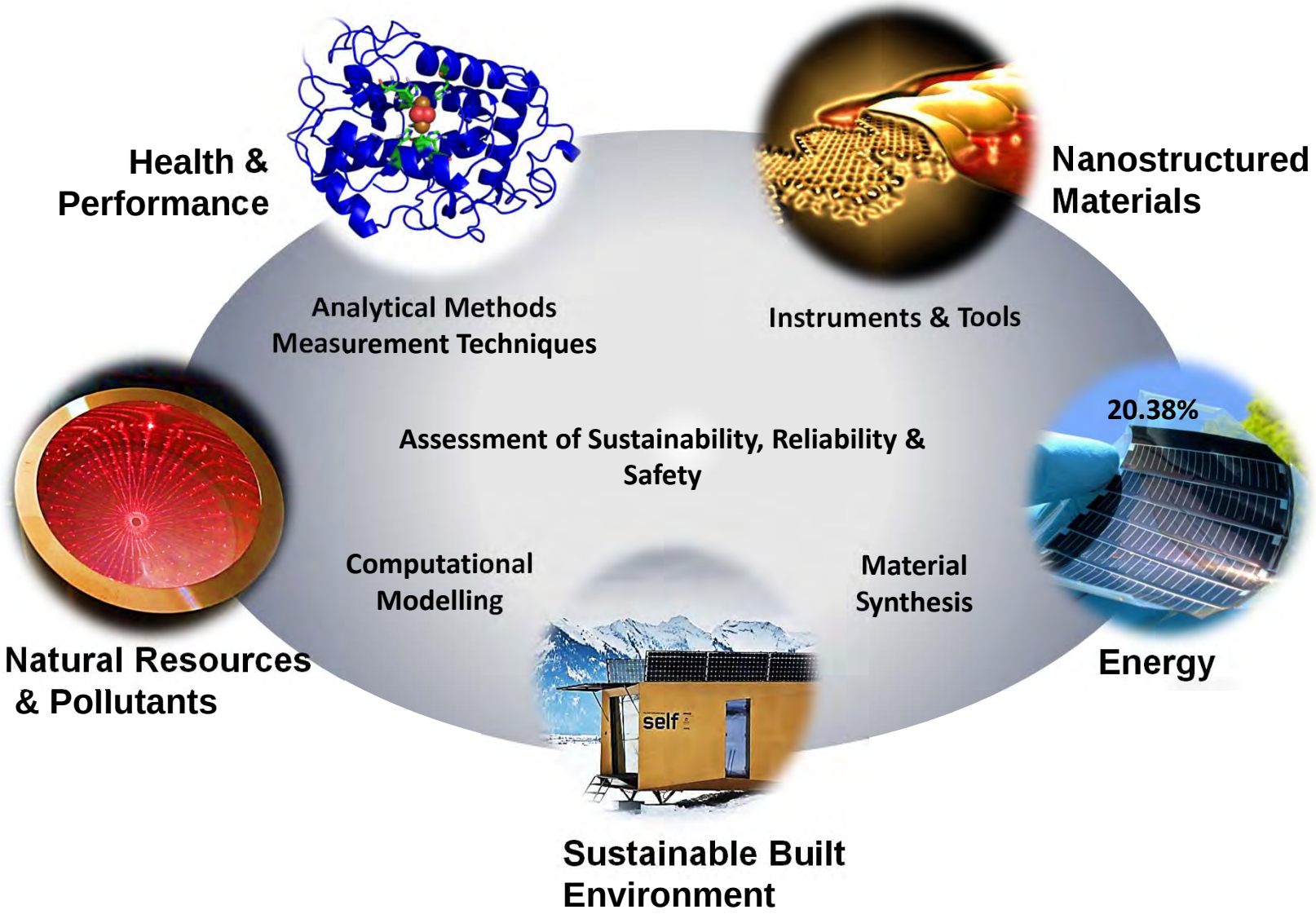
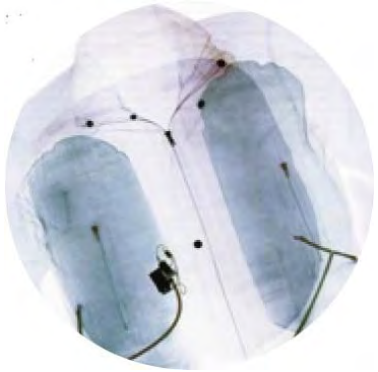


Gesundheit & Leistungsfähigkeit

Gesundheit & Sicherheit
Leistungsfähigkeit
Schutz
Verarbeitung

Neuartige Implantate & funktionalisierte Oberflächen

Plasmatechnologie
für Nanokomposit-Beschichtungen von Fasern, z.B. für medizinische Textilien



«Smarte» Bekleidung
zur Überwachung der Körperfunktionen und für Temperaturmanagement

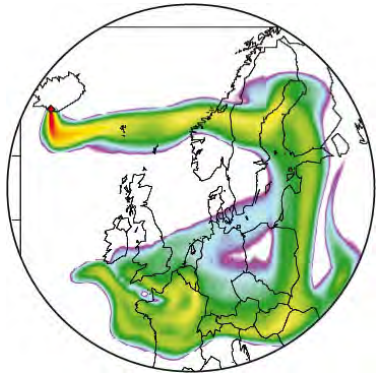
Bioreaktoren / Biokatalyse
Massgeschneiderte Enzyme für industrielle Anwendungen

Flamm-hemmende Materialien

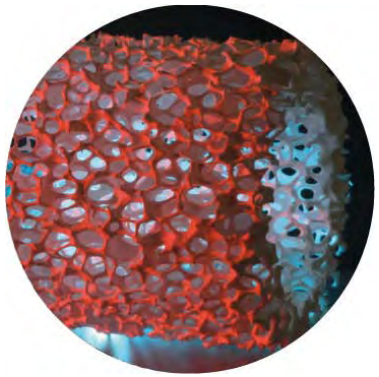
Natürliche Ressourcen & Schadstoffe

Ausbreitung von Luftschadstoffen
Interaktion von Schadstoffen & Materialien
Nachhaltige Mobilität & Transport
Abgasnachbehandlung
«Clean Production»

- **Satelliten- & Boden-gestütze Messungen von Luftschadstoffen**



Kontinuierliche **Luftüberwachung** zur Vorhersage von Schadstoff-wolken (z.B. Vulkanasche)



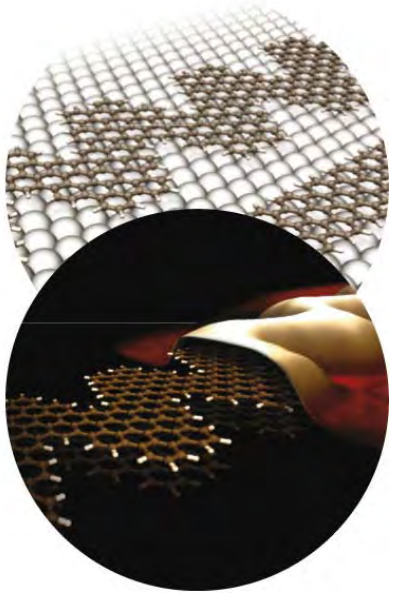
Schaumkat
neuartiges Trägermaterial aus Keramik für Abgas-katalysatoren mit einem bis zu 5-fach geringeren Edelmetallgehalt

hy.muve
ein Wasserstoff-betriebenes Kehrfahrzeug im Alltagstest in Schweizer Städten

Nanostrukturierte Materialien

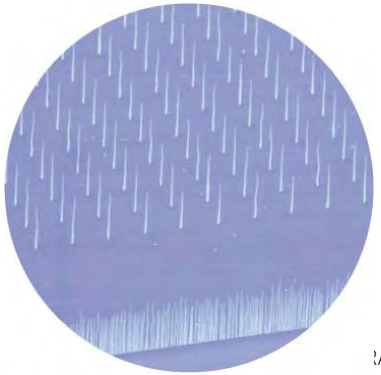
Nanokomposite & Nanopartikel
Nanostrukturierte Dünnfilme & Beschichtungen
Mikro- & Nano-Fabrikation
Mikro- & Nano-Charakterisierung

Nanostrukturierte Oberflächen für hocheffiziente Solarzellen



Nano-Elektronik
Bottom-up-Synthese von Nanobändern für Graphen-Transistoren

Neue Instrumente & Geräte
für Materialanalysen mit einer Auflösung im Nanometerbereich, z.B. Rasterkraftmikroskop (AFM) in Kombination mit einem «physical properties measurement system» (PPMS)



Kohlenstoffnanoröhrchen
als Elektronenfeldemitter,
z.B. für Feldemissionsdisplays
(Kooperation mit Sony)

Sustainable Built Environment

Materialien
Strukturen & Systeme
Nano → Makro

Null-Energiegebäude auf dem Empa-Eawag Campus

Entwicklung von
neuartigem **Beton**

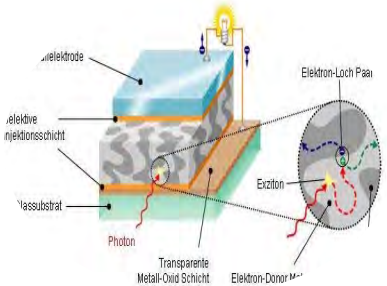
Materialien & Technologien
für **erdbebensichere**
Gebäude

self
ein innovatives Wohn-
Modul, das sich selbst mit
Energie & Wasser versorgt

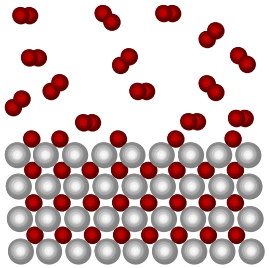
Energie

Energieverbrauch
Energieumwandlung
Energiespeicherung
Nachhaltigkeitsbewertungen

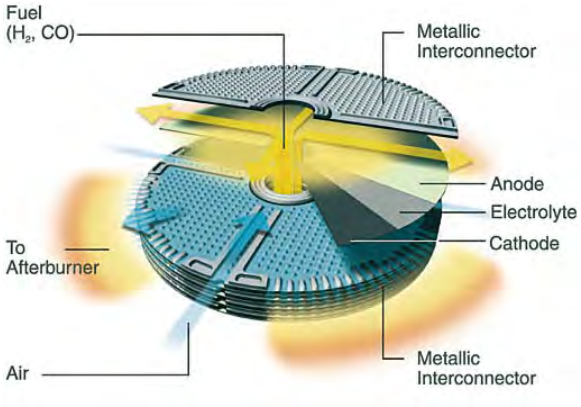
Hocheffiziente, kostengünstige flexible Dünnschichtsolarzellen



Organische Solarzellen



Entwicklung neuer Materialien zur **Wasserstoffspeicherung**



Feststoffbrennstoffzellen für den kombinierten Wärme- & Strombedarf von Gebäuden

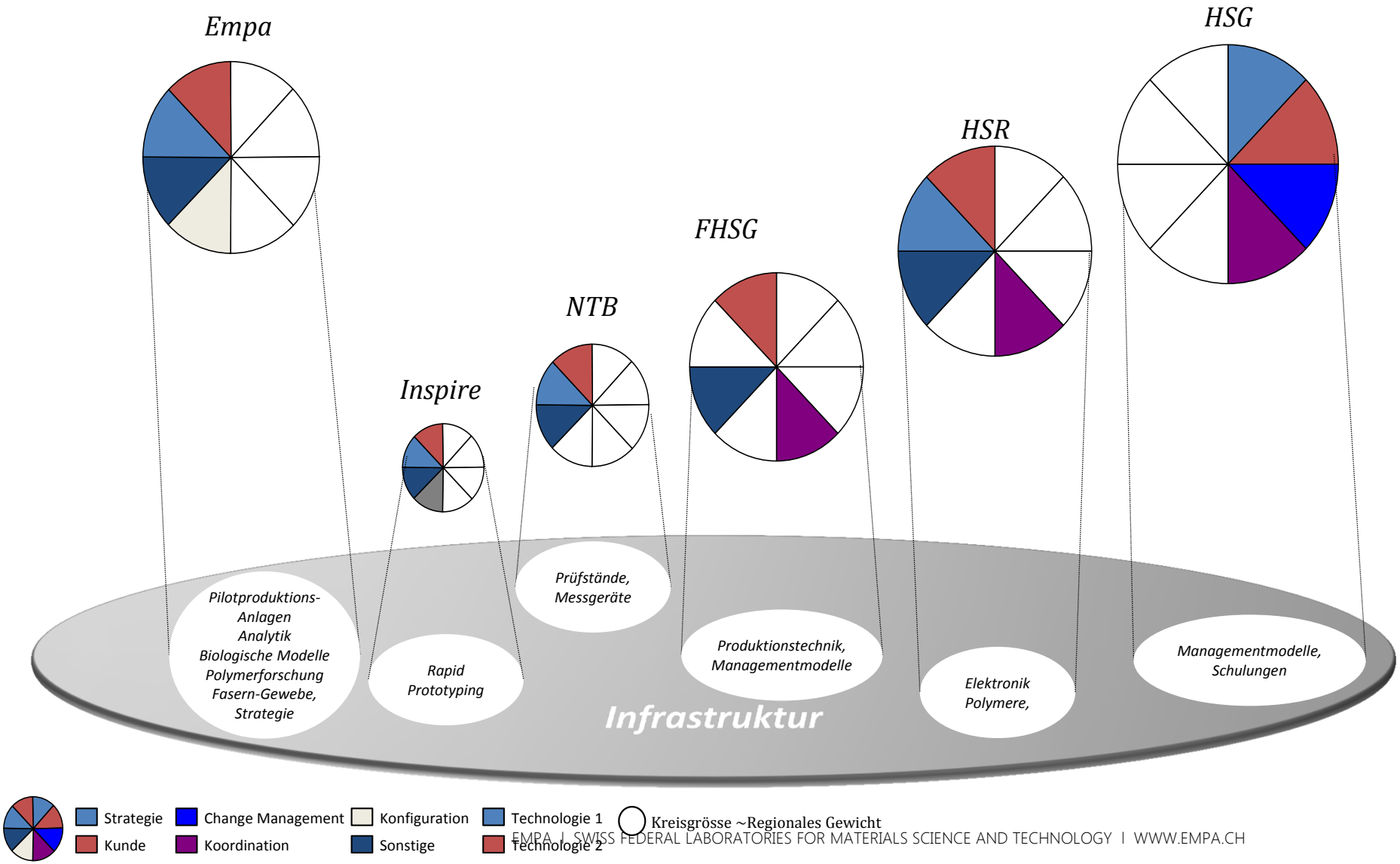
Lebenszyklusanalysen (LCA) & «Sustainability Quick Check», z.B für Biotreibstoffe

Ostschweiz

1.1 Innovationsschwerpunkte - Unternehmen

Standortportfolio - Übersicht

1.3 Sachgerechte Vernetzung – NWS OST



Coating Center @ Empa

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Private Public Partnership

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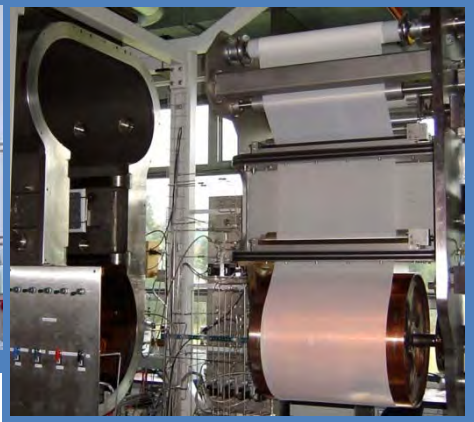
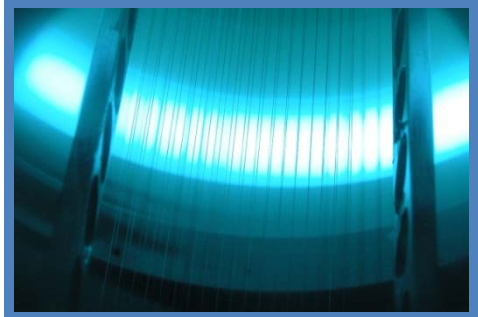
- R&D in Coating Technologies
- Advanced Surface Analytics

Swiss Coating Center @ Empa





IBM
ionbond
glaströsch
Tetra Pak
swiss TEXTILES
Swiss Industry
oerlikon
SULZER
swatch
BASF
The Chemical Company

Stress/Failure Analysis (B. Weisse)

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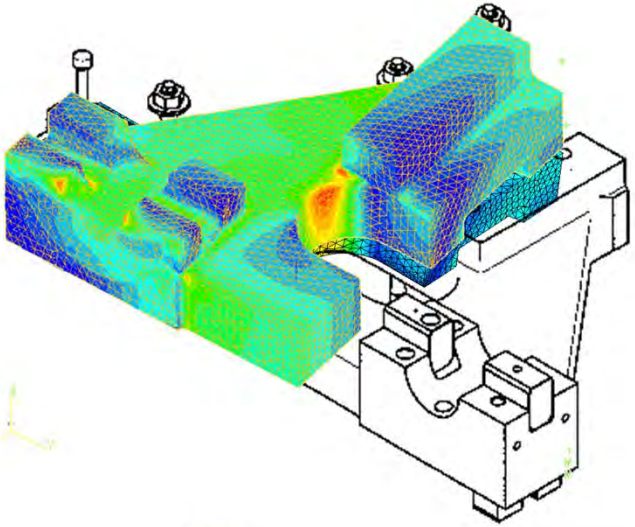
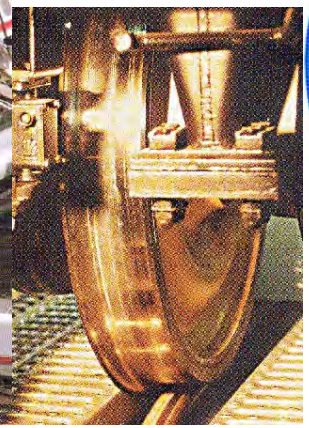
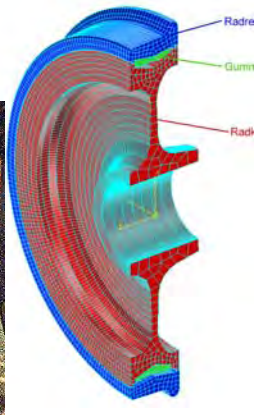
Numerical Simulation

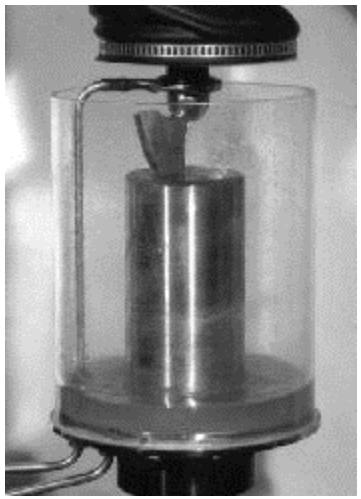


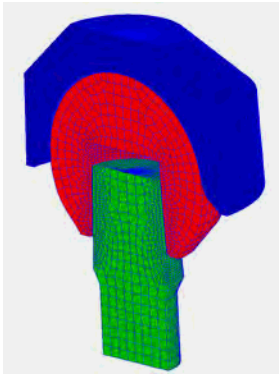
Structural Optimization

Failure Analysis









Affolter et al.2009, *Proc Inst Mech Eng H, J Eng in Medicine 223, 237-248*

Biomechanics

Group Polymer Composites (G. Terrasi)

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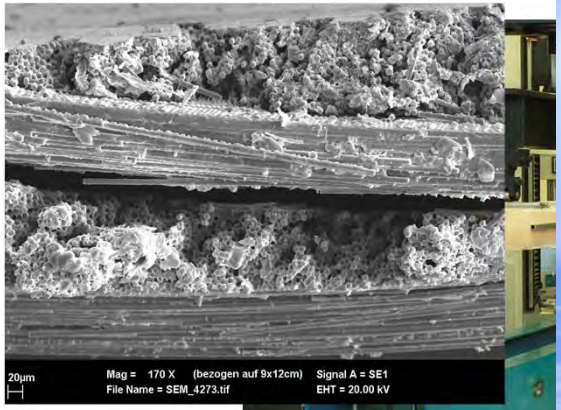
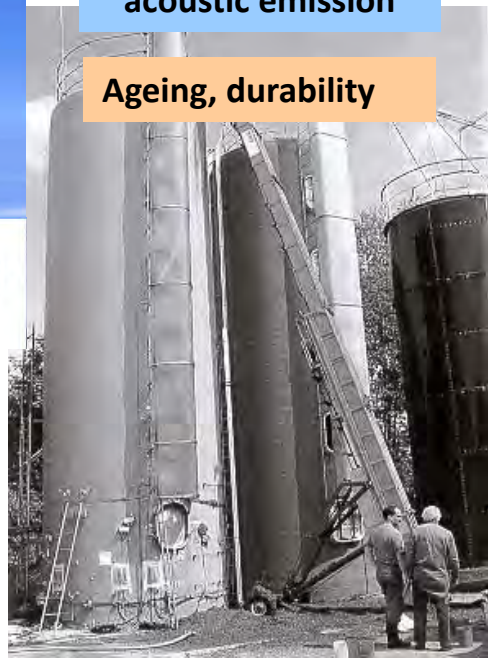
Materials – Components – Systems



acoustic emission

Ageing, durability



Laminate characterisation

nano composites: strengths and fracture toughness of duromers

fracture mechanics

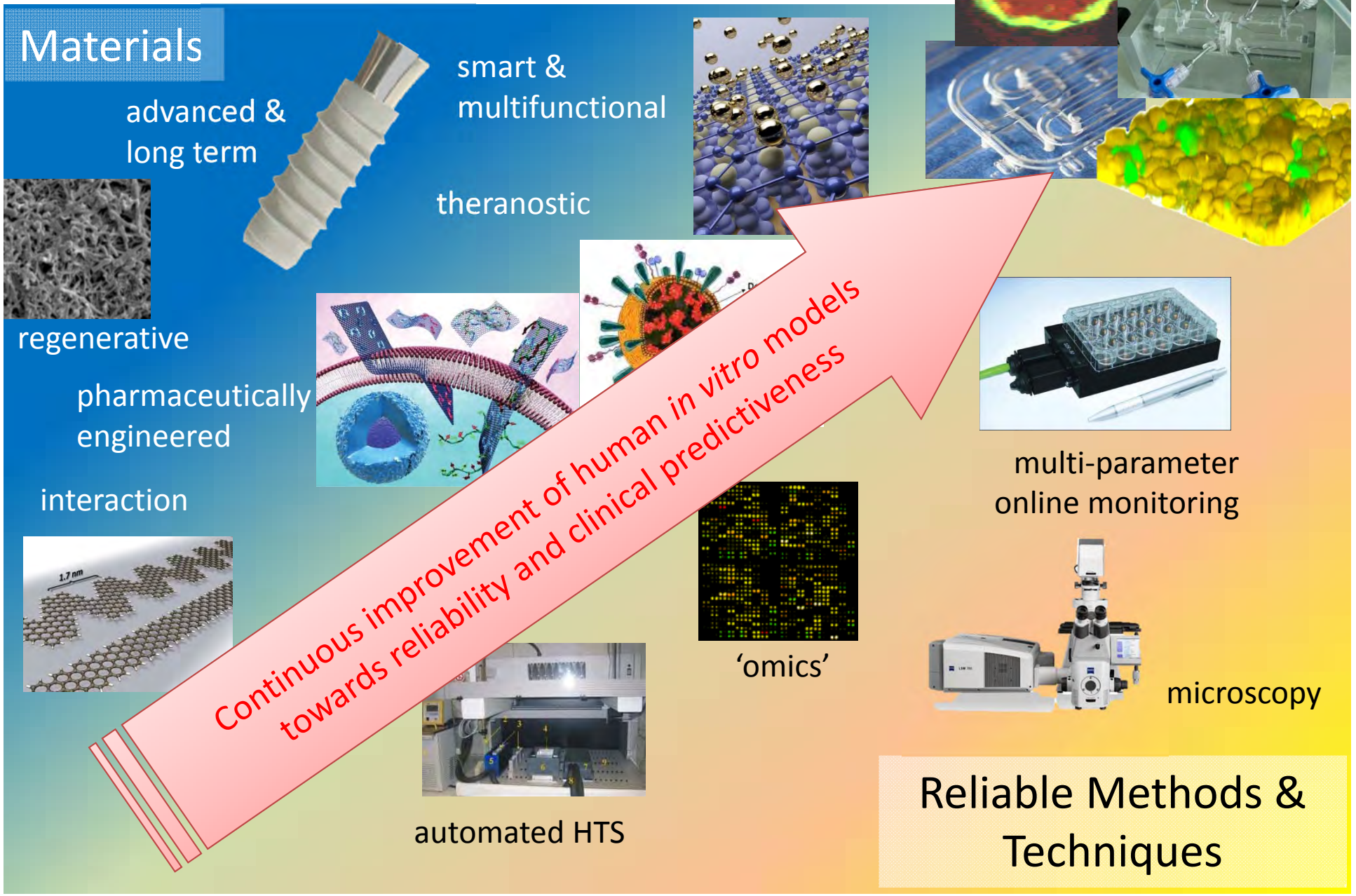
Materials Engineering

Characterisation
Physical-mechanical

NDT - SHM

Terrasi et al., *J Composite for Construction 2011, No. 15, 126-135*

Materials Biology



NEST – a holistic platform for construction

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

EPFL
ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

eawag
aquatic research

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Future Mobility

Photovoltaic / Wind

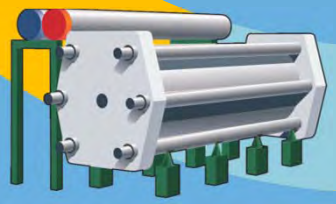
CNG / Biogas

Excess Energy

electricity

Elektro mobitity

Elektrolyse



hydrogen

Mixing

Bio-CNG

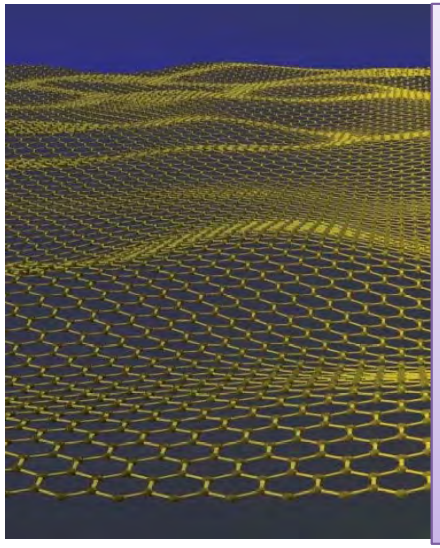
cogeneration
of heat & power

CNG/ hydrogen

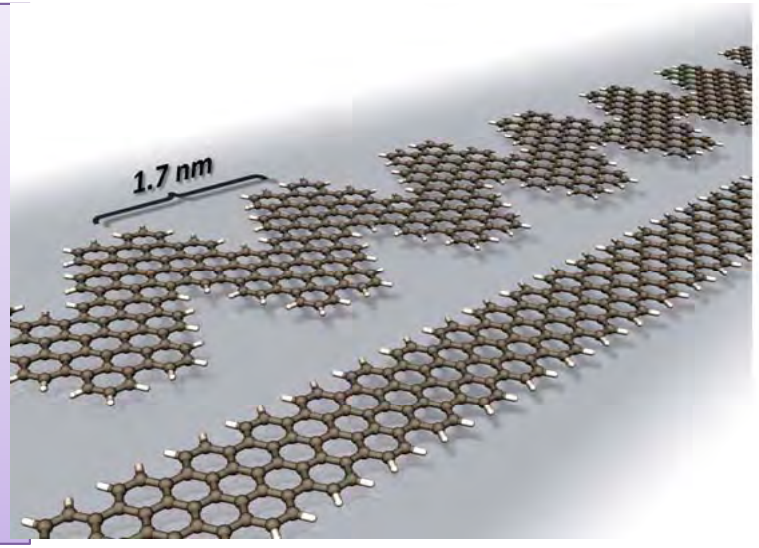
Hydrogen fuel cell

Scientific Excellence: *Carbon Based Electronics*

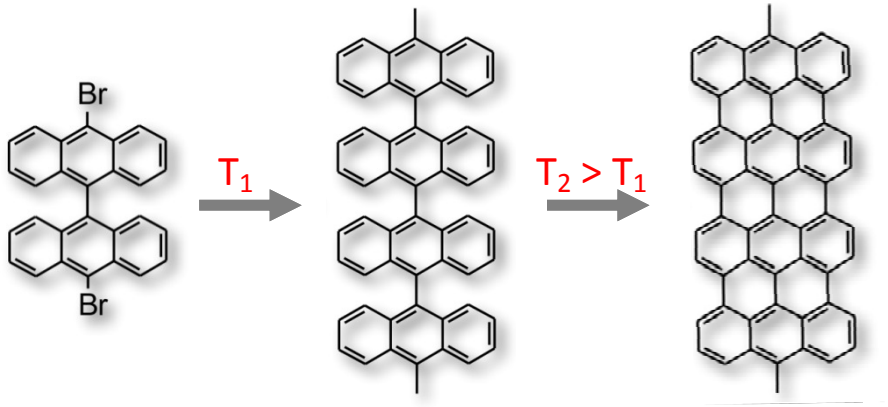
Atomically Precise Graphene Nanoribbons

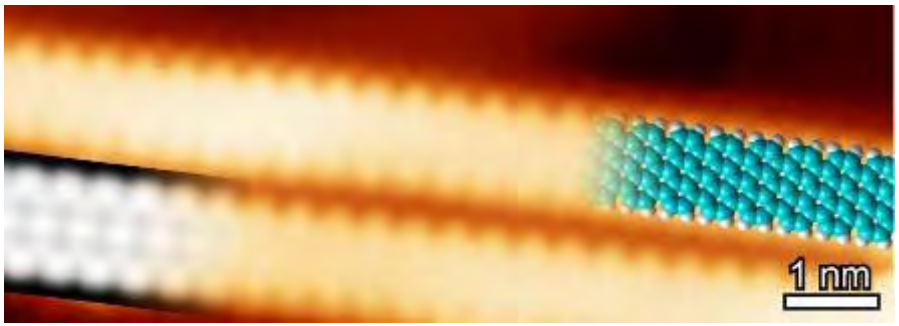


- Thermal conductivity:
  - Graphene ~ 5000 $Wm^{-1}K^{-1}$
  - Silicon ~ 150 $Wm^{-1}K^{-1}$
- Electron mobility:
  - Graphene < 200'000 $cm^2V^{-1}s^{-1}$
  - Silicon 1400 $cm^2V^{-1}s^{-1}$



On-Surface Synthesis of Graphene Nanoribbons





Atomically Precise bottom-up Fabrication of Graphene Nanoribbons
J. Chai, R. Fasel et al., Nature, **466** (2010) 470 - 473

Micro- and Nano-Characterization

Advanced Analytics

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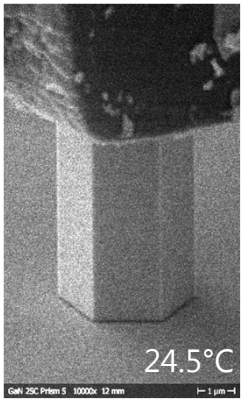
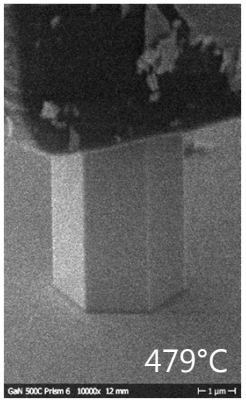
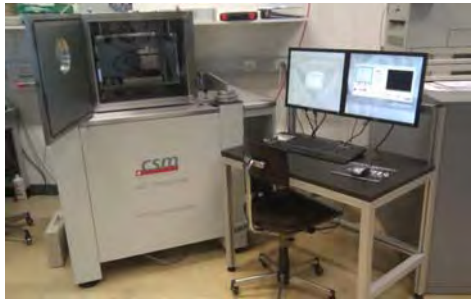
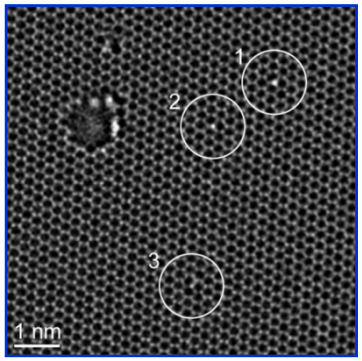


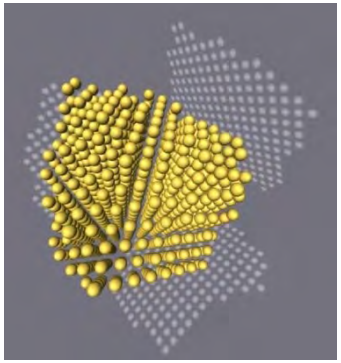




High-Temperature Nanoindenter
Commercialization start in 2013
(CSM instruments, CH)



Graphene Monolayer

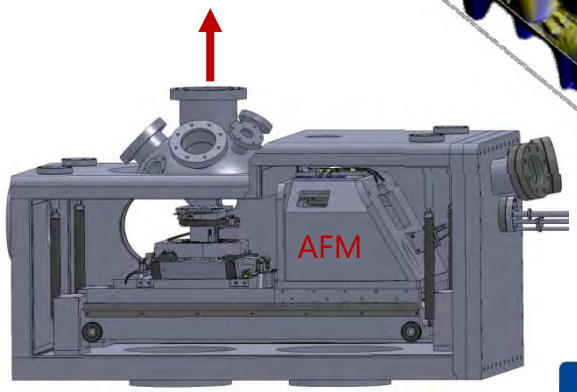


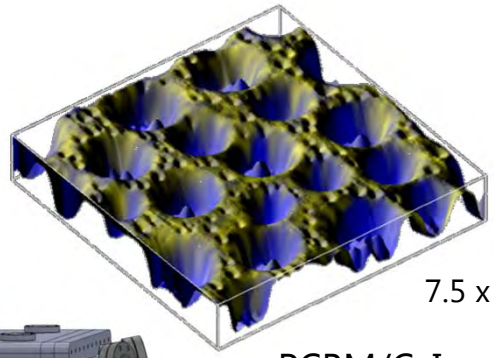
Ag NP (748 atoms)

PRL, **108** (2012) 047601
Nano, **6** (2012) 7077
Nature, **470** (2011) 374
Adv. Mat., **22** (2010) 4467
Nature Chem., **4** (2012) 287
Angw. Chem. (int. ed.) **48** (2010) 8890

3D NanoChemiscope
(EU-FP 7 project)

ToF-SIMS





7.5 x 7.5 µm²

PCBM/CyI polymer blend
- PCBM (yellow)
- CyI (blue)

IBM/Empa joint venture
Operation of a High-end TEM
Start: 1.2.2013

Idea of a Swiss Coating Center

Surface Analytics @ Empa

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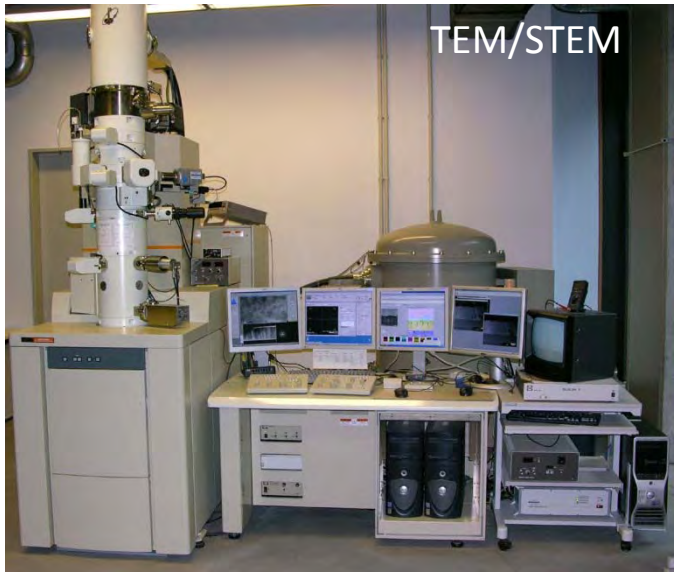
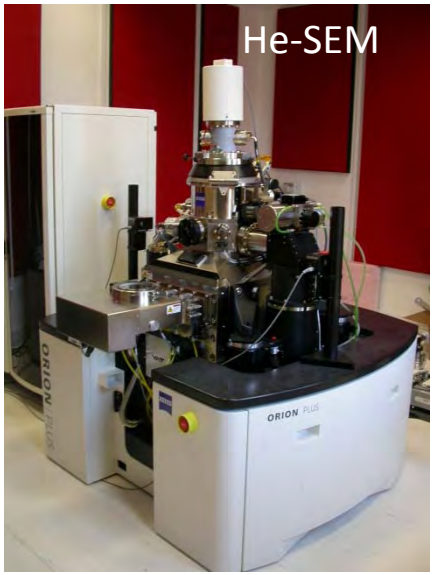
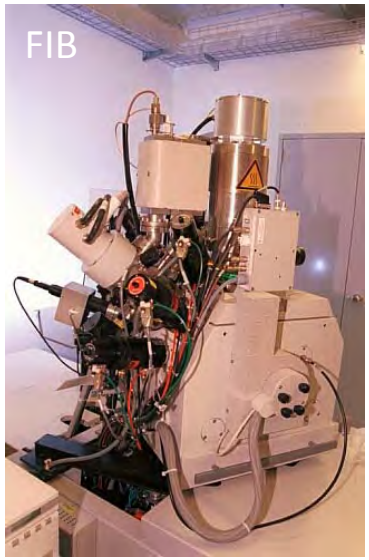
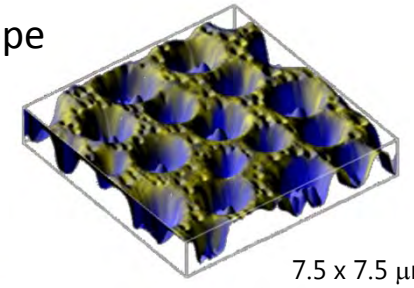




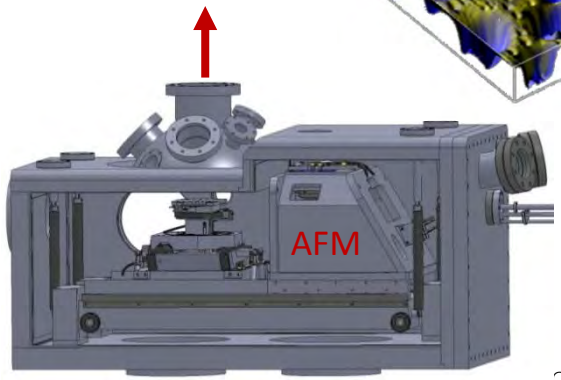


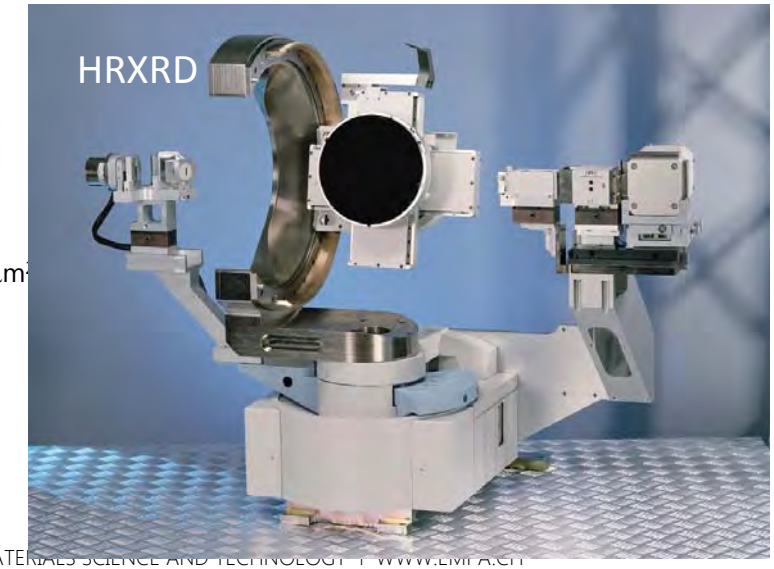
3D NanoChemiscope



7.5 x 7.5 µm²

ToF-SIMS





Electron Microscopy Center
Equipment

- 2 TEMs
  - Philips CM30
  - Jeol JEM 2200FS (analytic STEM/TEM)
- 2 SEMs
  - FEI XL30 ESEM
  - FEI NovaNanoSEM
- Sample preparation
  - 2 Ion mills
  - Polishing machine
  - Coater (etc.)
- Analysis
  - 2 Mac Workstations
    - MacTempas
    - CrystalKit
    - Exit-wave reconstruction for in-line holography
    - Simulations (xHREM, EMS, own programs)
  - Tomography workstation

Center for X-ray Analytics

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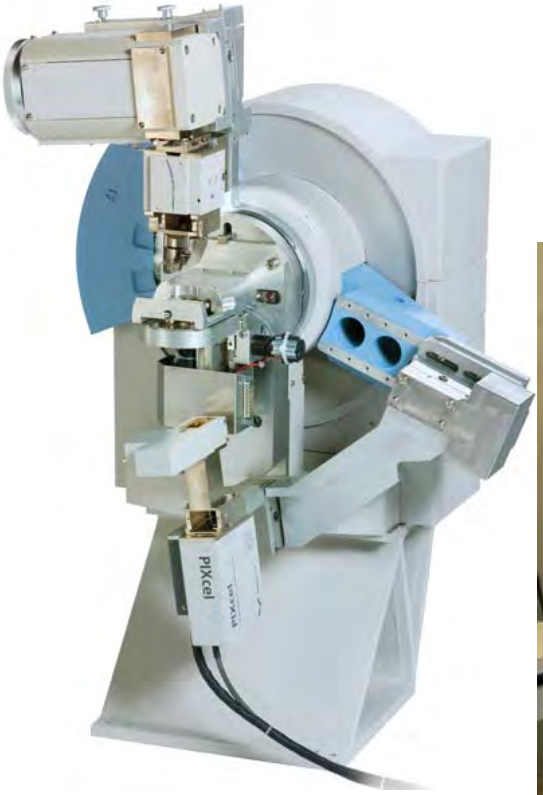
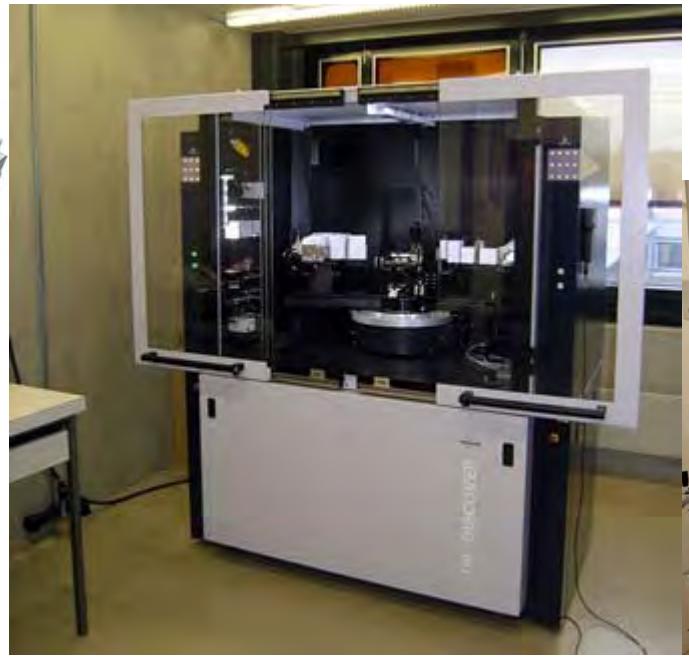
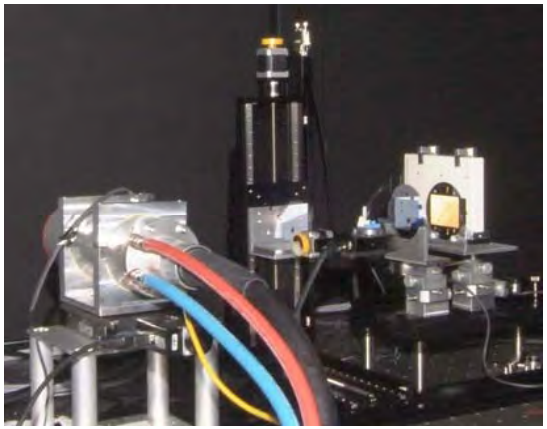
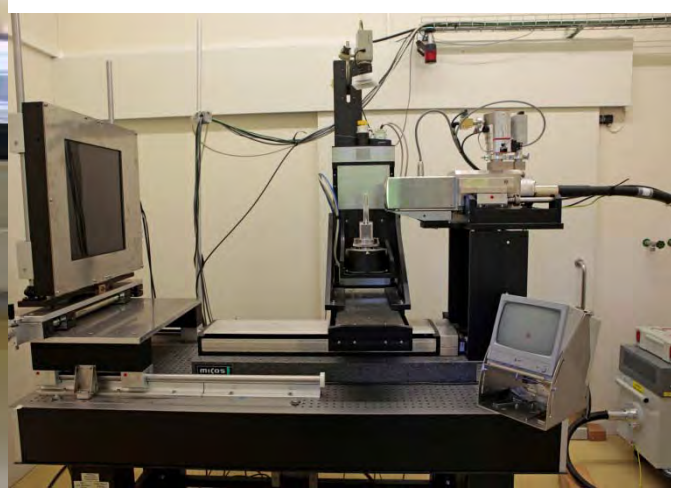
1. 1. 2014

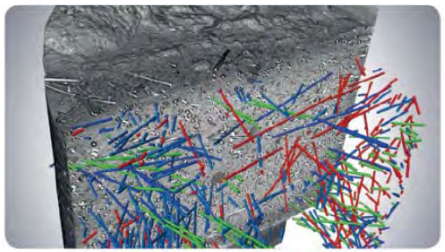




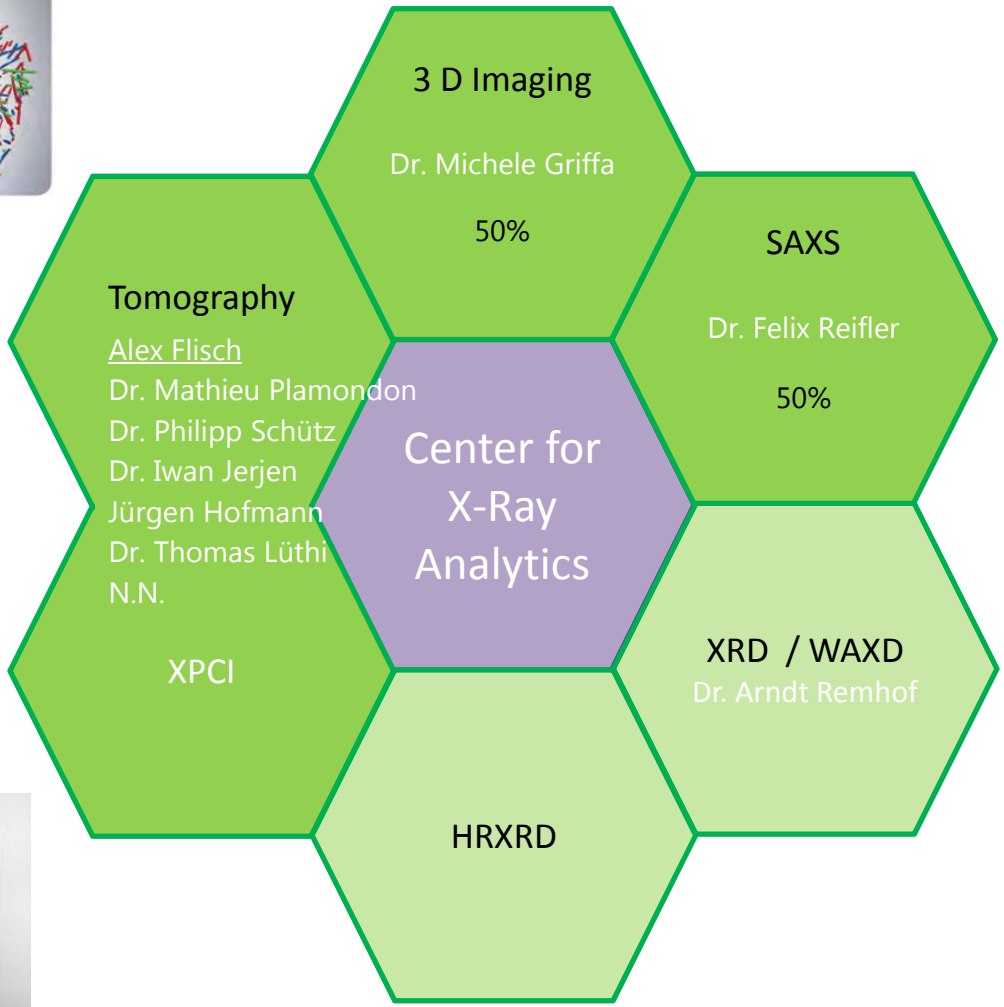


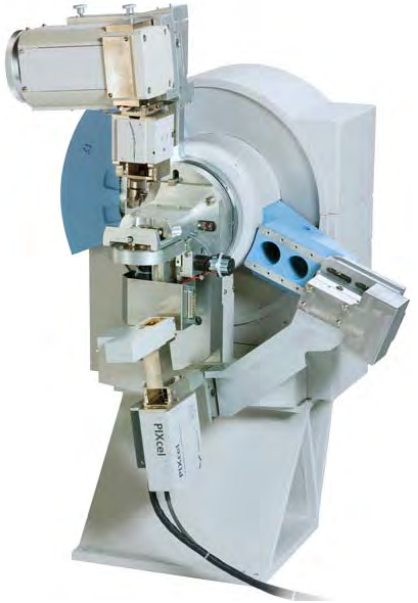


Center for X-ray Analytics



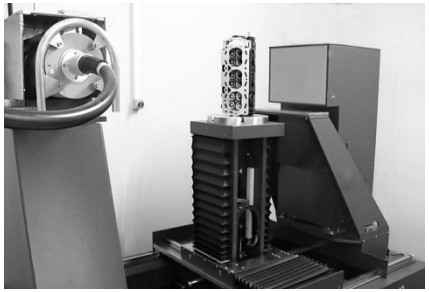
Empa Platform for Image Analysis (eπA)





HRXRD - SAXS – WAXD (in evaluation)

3D-CT with 450 kV X-ray source and flat panel detector



From Science to Application:

Inorganic Flexible Thin Film Solar Cells

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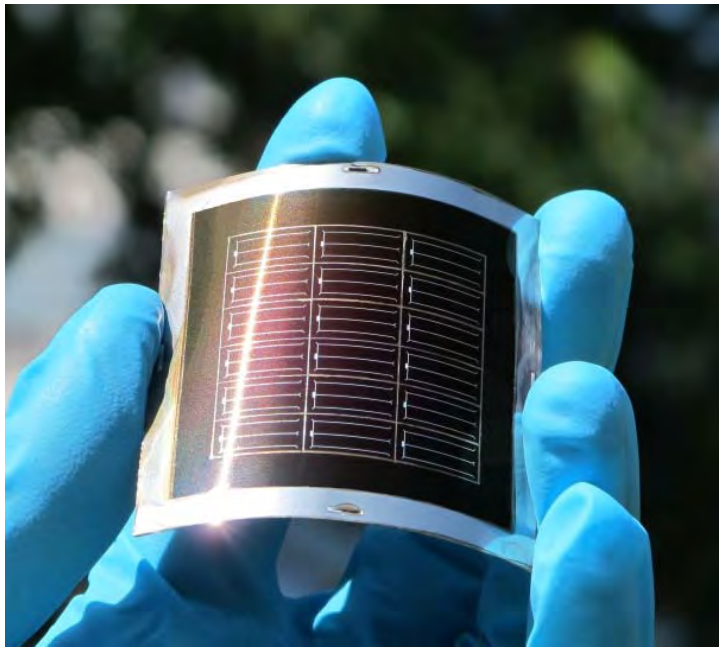
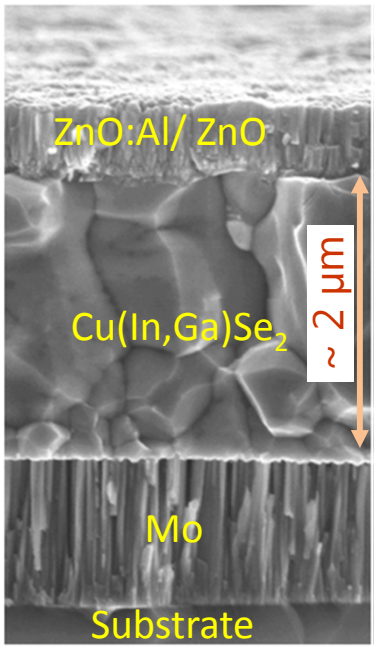
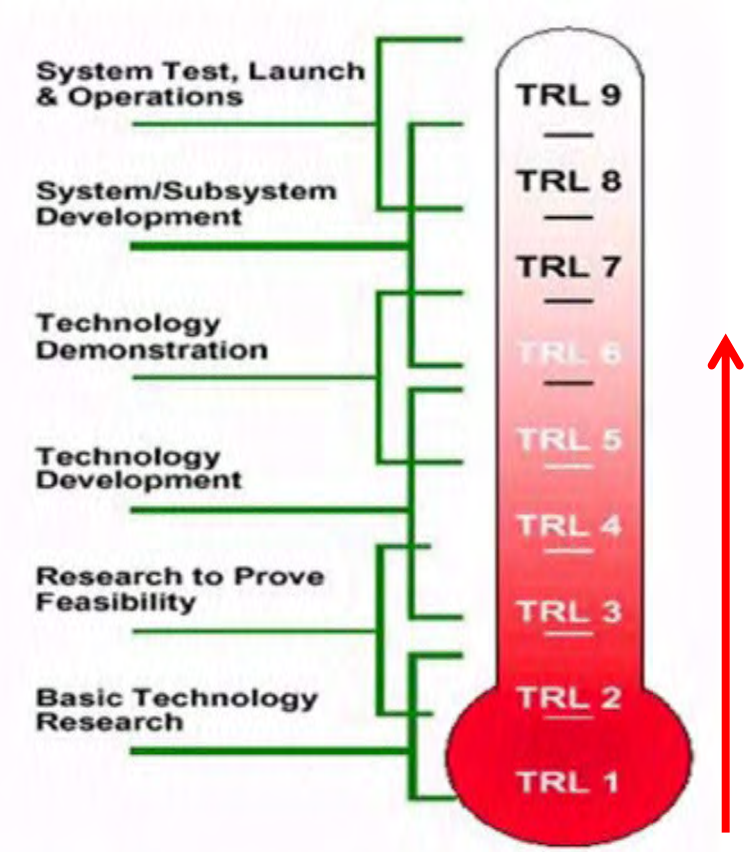




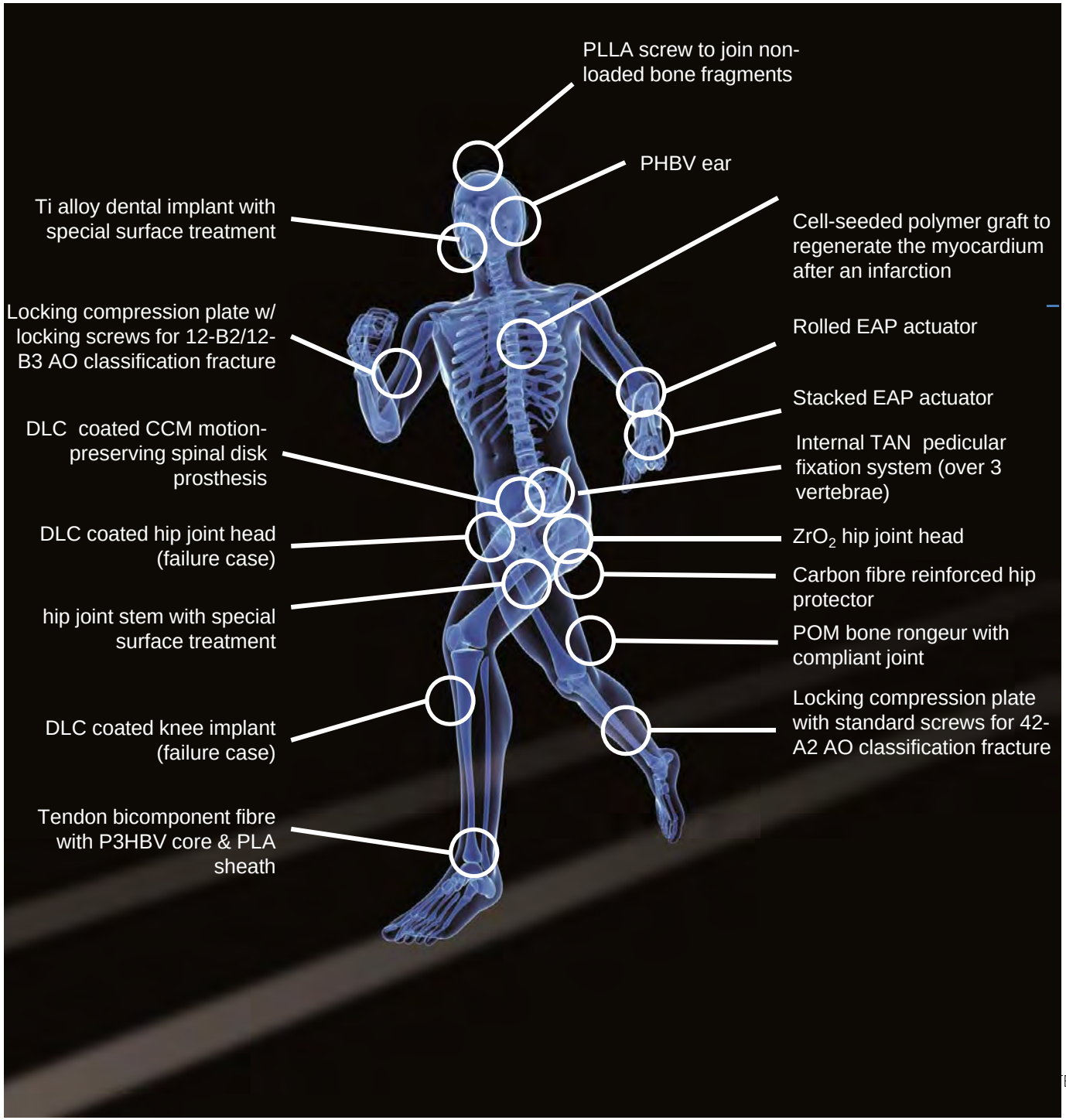
Technology Readiness Level (TRL)



18 years

Empa's world records:

- **CIGS: η = 20.38% (2012)**
  (Polycrystalline Silicon η = 20.4%)
- CdTe: η = 13.80% (2011)



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MedTech

Combining the expertise of more than 10 Empa laboratories

Materials meet Life

EMPA
Materials Science & Technology

Materials

meet

Life

Materials meet Life

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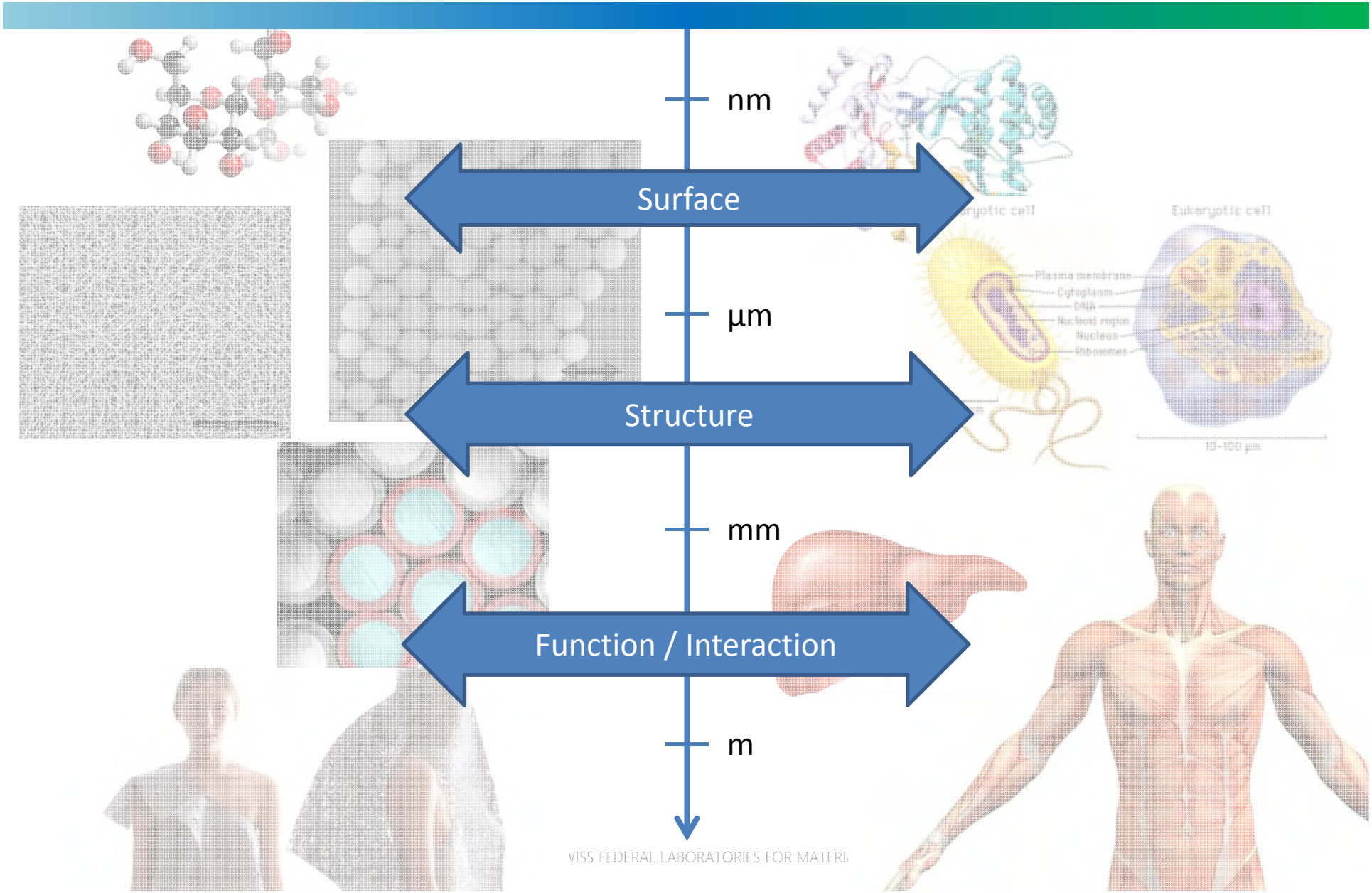
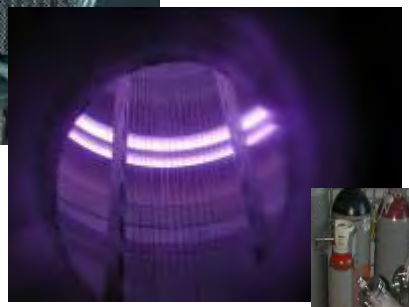
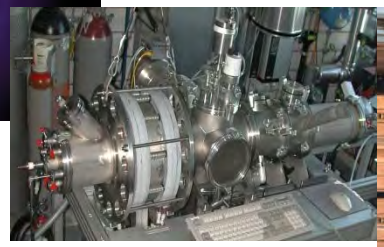


Plasma Metallization transferred to industry

Innovation



Research



Technology

Transfer

Product

Example:

Metallized fiber with unchanged textile character

Textile embedded electrodes

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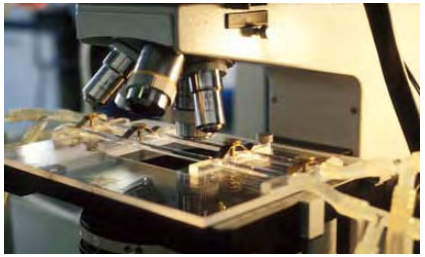
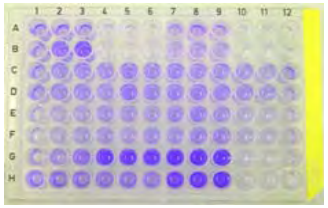
MedTech Award 2006: ECG sensor shirt

- **Electrocardiogram (ECG) measurements**
- **Muscle stimulation**

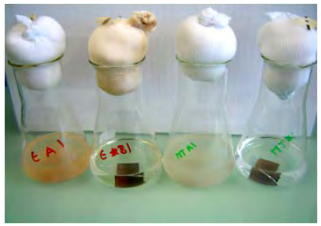
Test systems for biofilm activities



Flow cells



Microtiterplate



Batch Test

Test systems to study biofilm and antifouling materials

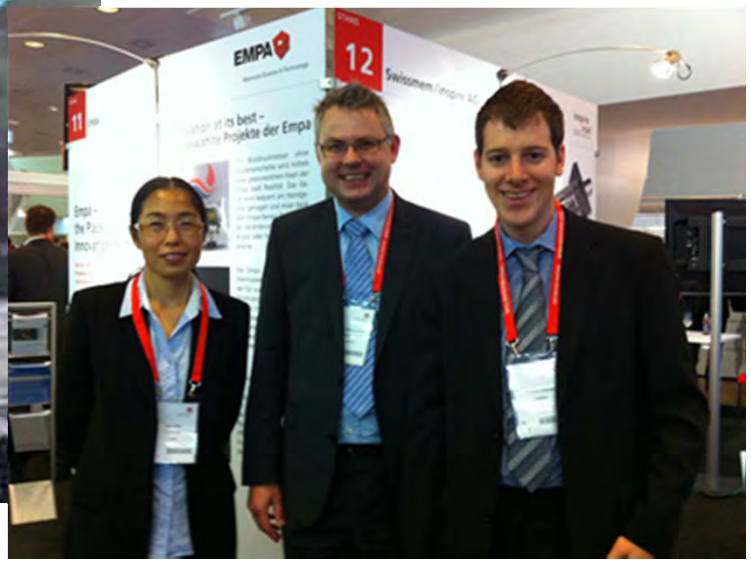
Bioreactor

Condensation plates

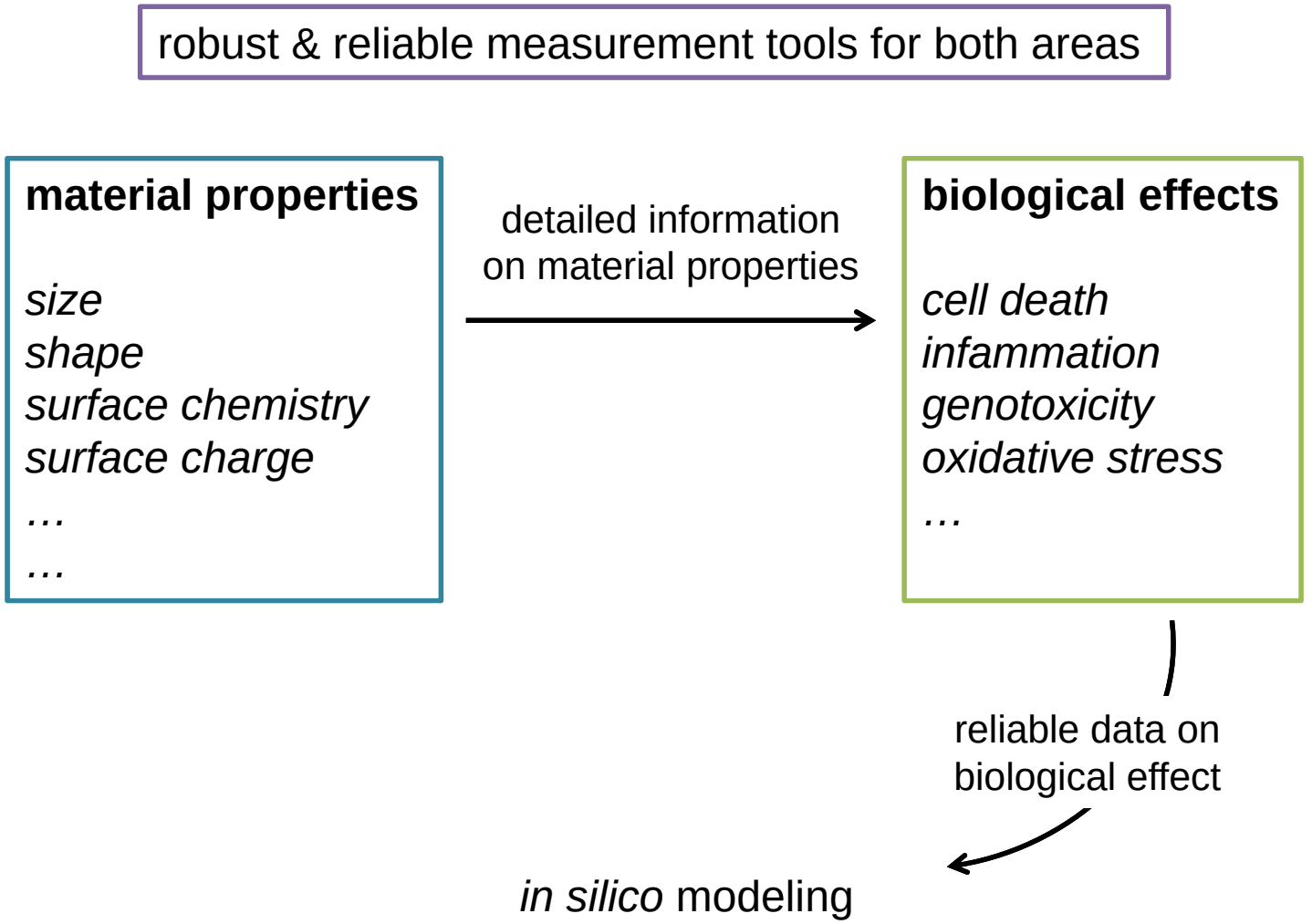
Swiss Technology Award für ein Projekt mit Empa-Beteiligung

Geruchsfreie Bekleidung dank Innovation der SANITIZED AG

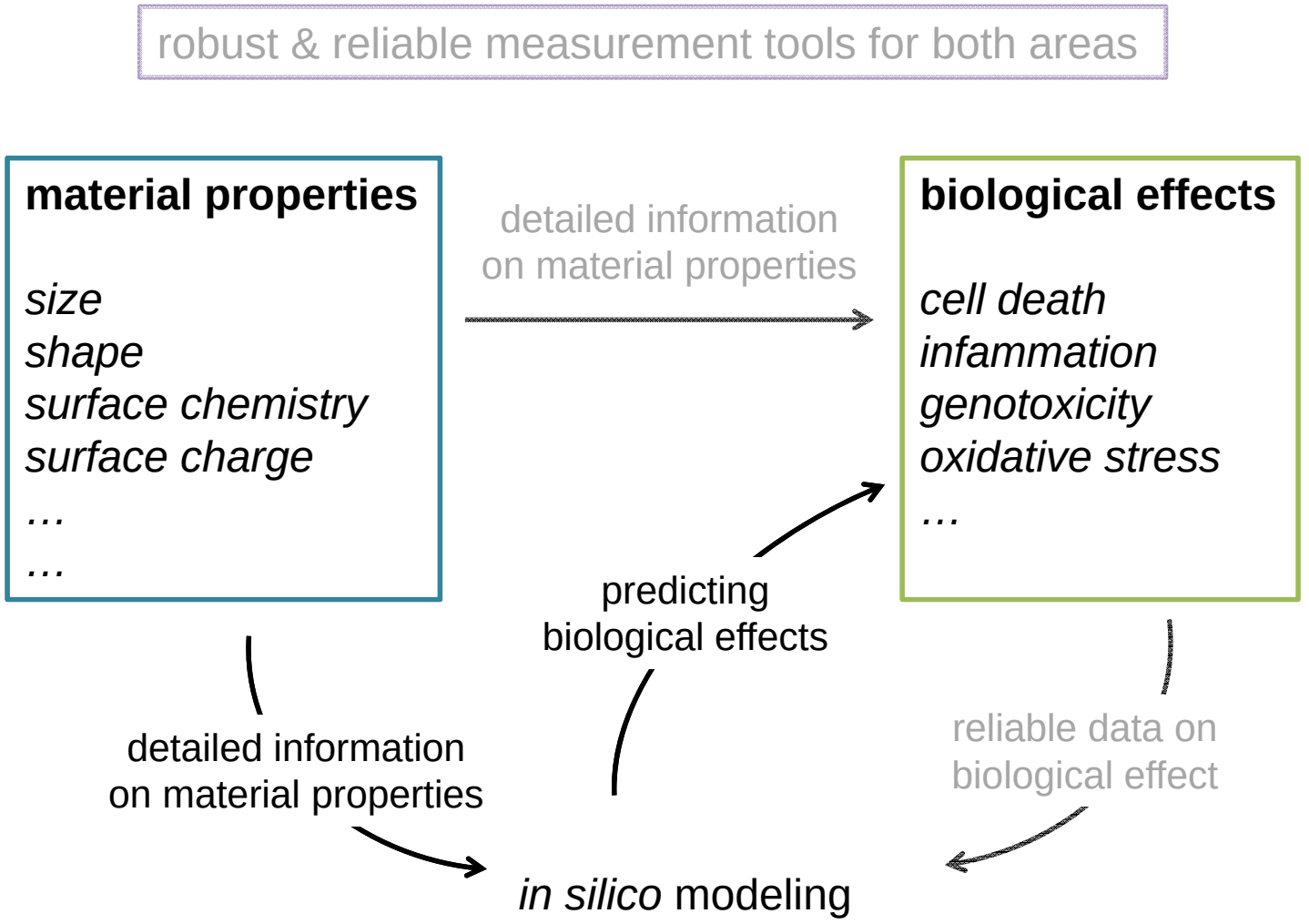
Sabrina Schmidt-Emrich, Stefanie Altenried, Kathrin Grieder, Philipp Stiefel, Nadja Schulthess, Qun Ren, Linda Thöny-Meyer



The Future Challenge: *predictive toxicology*



The Future Challenge: *predictive toxicology*

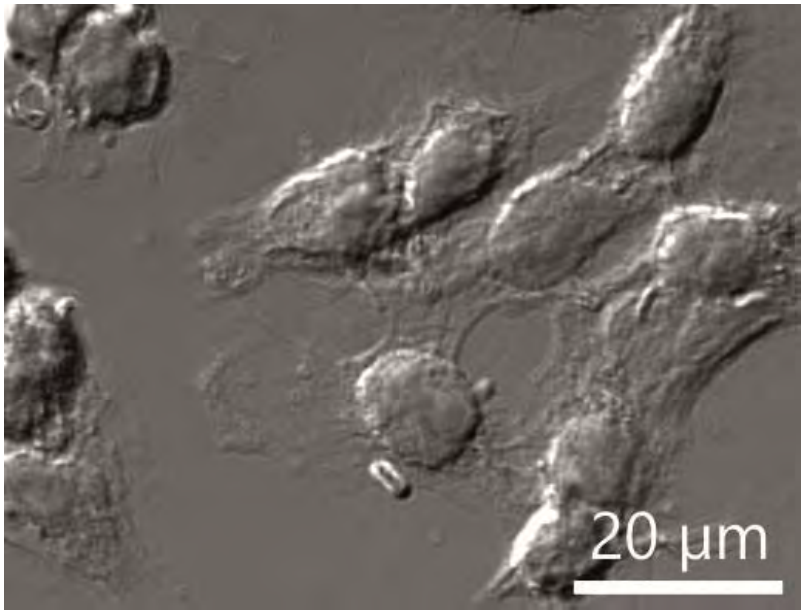


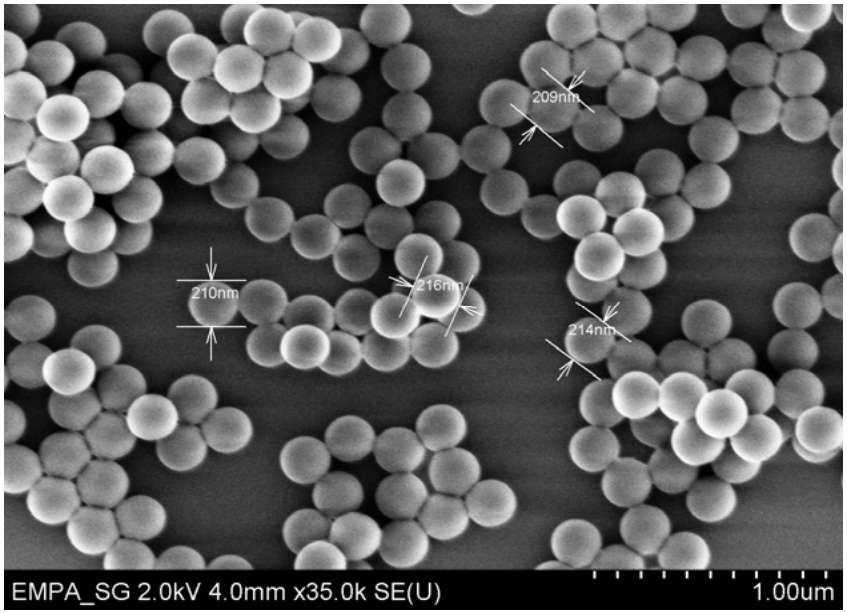
Measurement science in biology

Insights from interlaboratory comparisons

A549 cells:
- subclone-A
- subclone-B

amine-modified **Polystyrene beads**

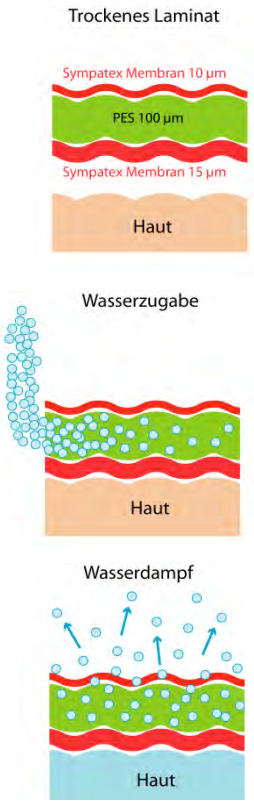




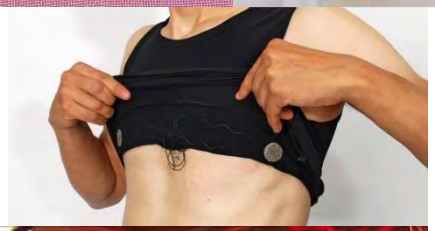
Select R&D-Projects

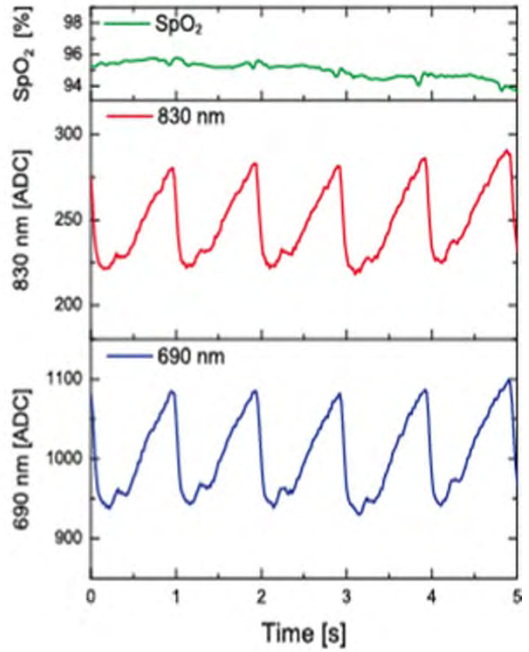
Cooling garments for MS Patients for improving mobility

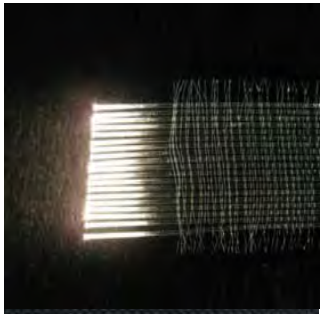
- Winner of the Serono Charity Award 2006
- Successful transfer to industry
- Founding of a new company UNICO for precooling applications in sports

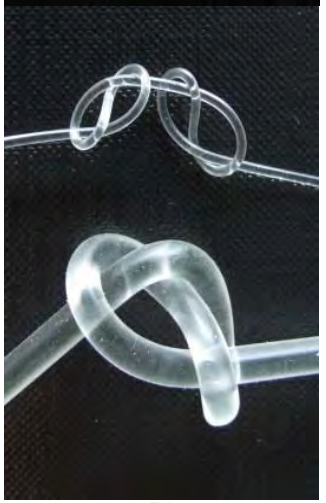


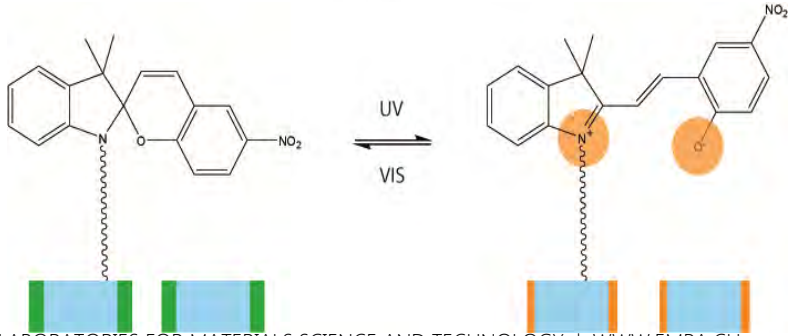
Select R&D-Projects
Textile Sensors and Body Monitoring











Select R&D-Projects

Pilote Suit for Extreme Conditions: Solar Impulse

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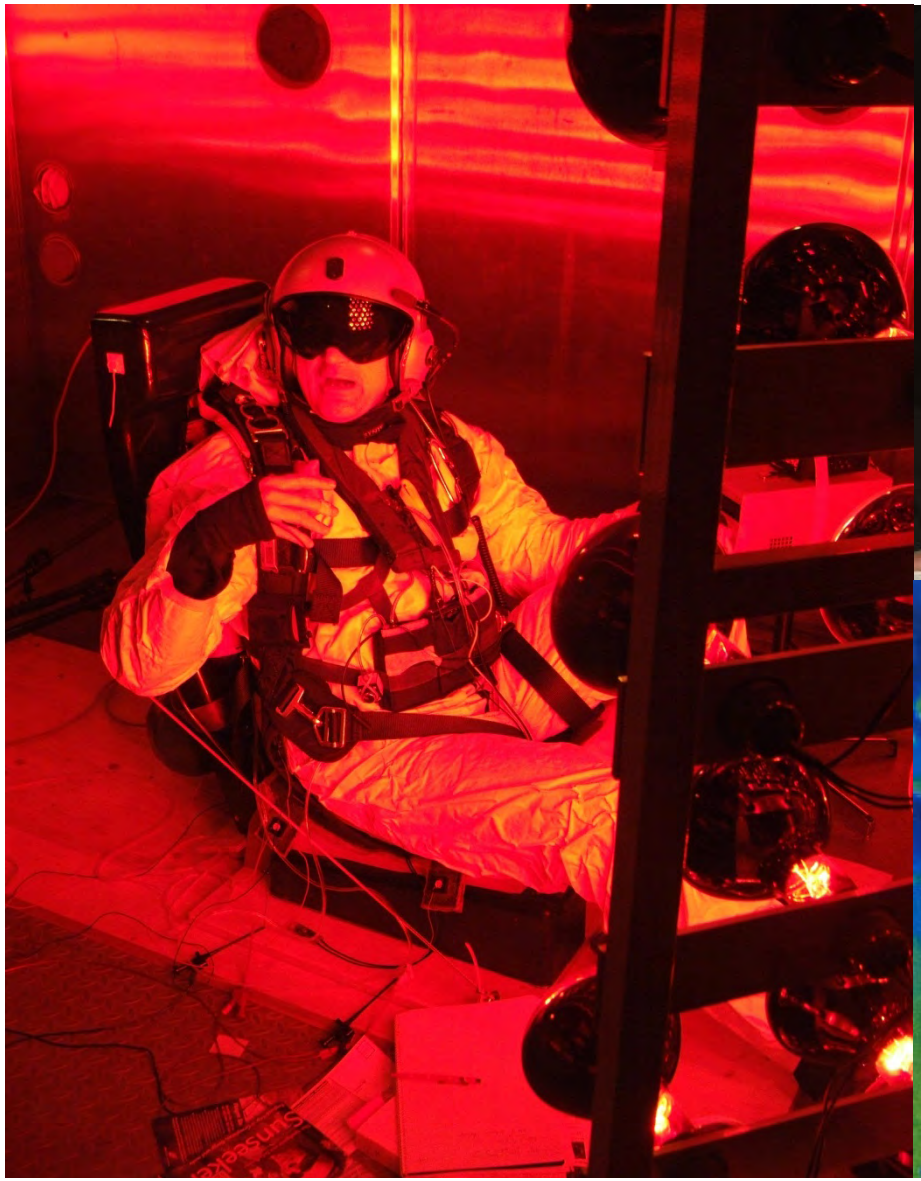
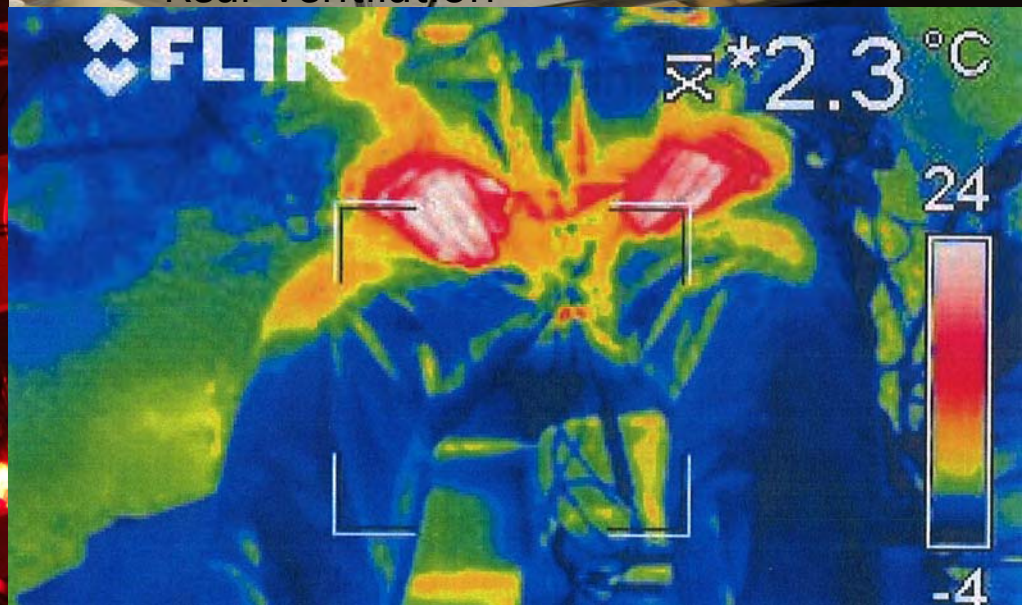


- Tailor-made Protective Clothing Consisting of Down-filled Chambers & Breathable Membranes
- Variable Isolation via Micropumps (Inflating/Venting)
- Special Seat Construction with Active Rear Ventilation



Select R&D-Projects
Artificial Turf of the 4th Generation

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Lisport Long-Term Test

Low Friction and high

… and still faultless after 5000 Lisport Cycles.

tisca tiara
swiss carpets

On the Market since Fall 2010

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