

# EMPA: Advanced Fibers

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Chemistry Group  
Laboratory of Advanced Fibers

EMPA Swiss Federal Laboratories for Material Science and Technology

Dissemination conference of FP7-REGPOT-2008-1-229801:T-Pot project  
Unlocking the Croatian Textile Research Potentials  
Zagreb, 16<sup>th</sup> February 2012

# History of Empa

## 1880 – Founded in Zürich

«Institute for the Testing of Building Materials at the Swiss Institute of Technology»







# Empa within the ETH Domain

Federal Department of Home Affairs FDHA



Board of the ETH Domain



Eawag

Empa

EPFL

ETHZ

PSI

WSL





# Empa in Numbers (2009/2010)

**3 Sites** Dübendorf, St. Gallen, Thun

**6 Departments** 37 Laboratories  
940 Employees (860 FTE; about 30% Women)  
of which 24 Professors  
140 PhD Students  
40 Apprentices  
plus 200 Master Students & Interns

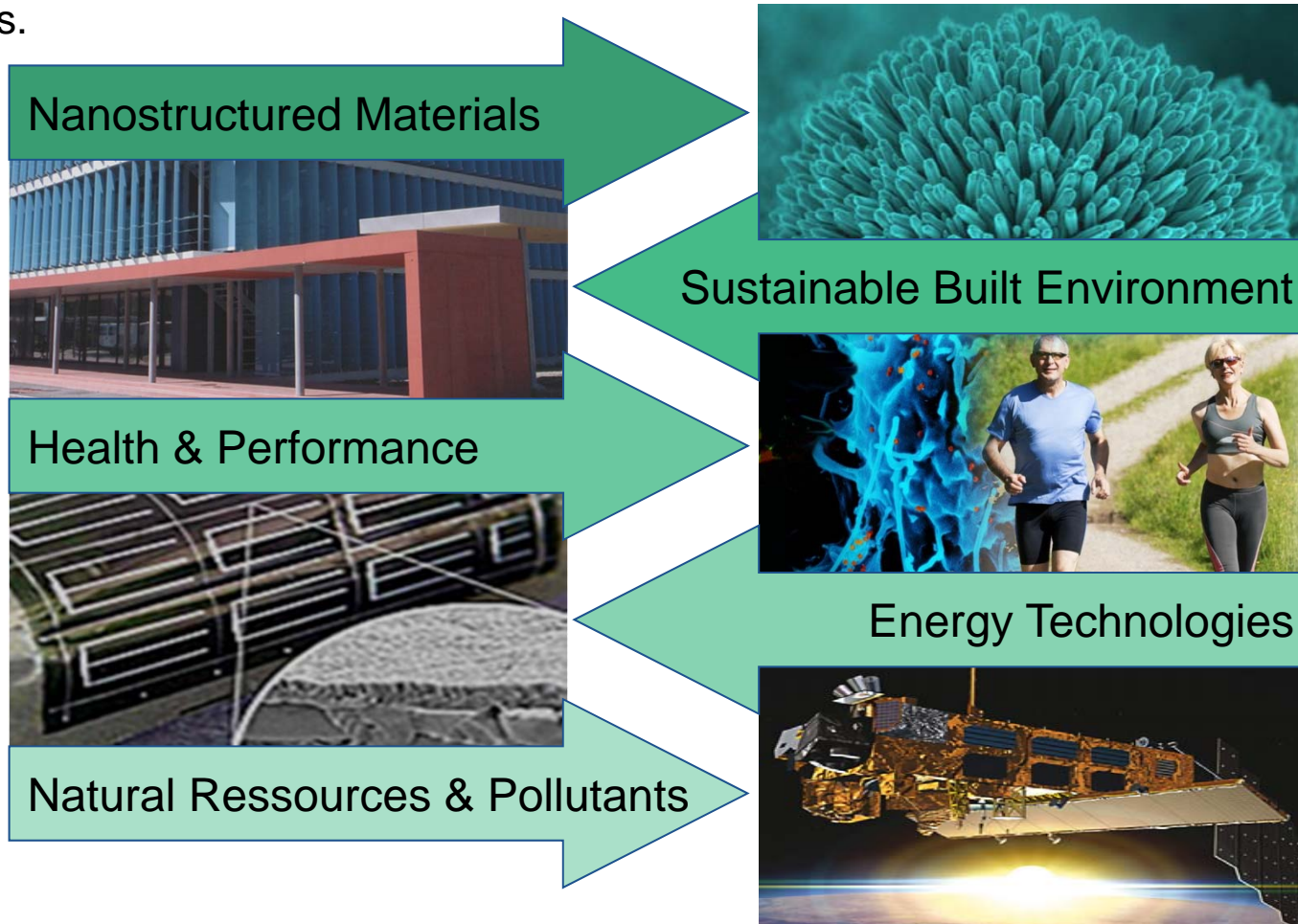
**Budget** 92 Mio. CHF Public Funding  
51 Mio. CHF Third Party Means  
of which 36 Mio. CHF R&D, 15 Mio. CHF Services

**Scientific Output** > 470 Peer-reviewed (SCI/E) Publications  
85 Seminars & Conferences at Empa-Akademy

**Third Party Projects** > 50 running Projects EU Framework Programmes  
> 85 running SNSF Projects  
> 70 running CTI Projects

# Empa Research Focal Arias

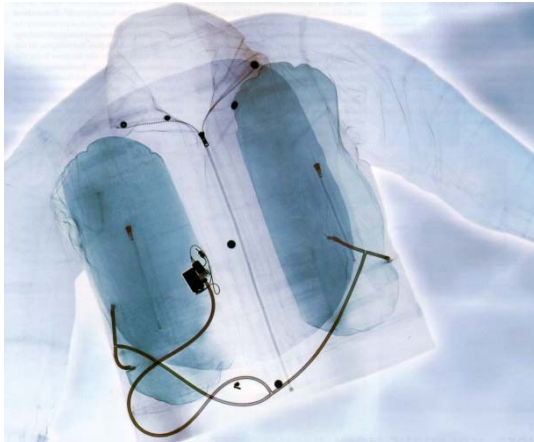
The aim of Empa's activities is to transform research results and scientific knowledge into innovations.





# Research Focus Areas

## Health & Performance



Health & Safety



**Fibers**

**Advanced**

Performance



Processing

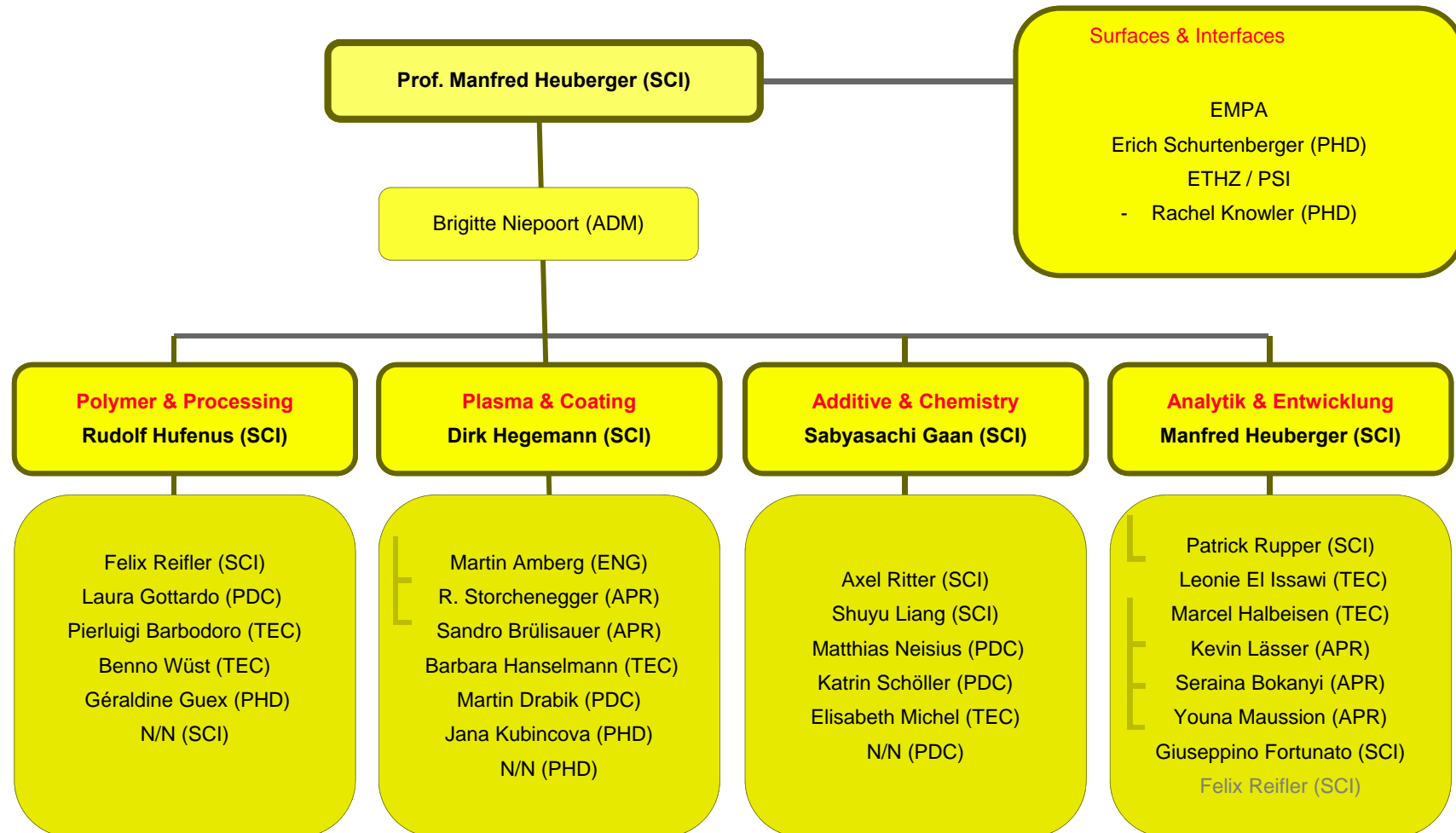


Protection



Materials Science & Technology

# Empa Laboratory *Advanced Fibers*

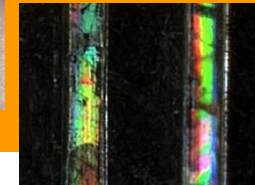


Legend: SCI Scientist, ENG Engineer, TEC Technical Staff, ADM Administration, PDC post-doc, PHD PhD student, PHY Physics, APR Apprentice



# Research Groups Advanced Fibers

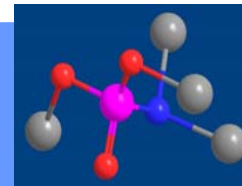
Polymers & Processing



Plasma & Coating



Additives & Chemistry



# Special Functionalities

- flame-retardant
- dirt-repellent, water-repellent
- electrical conductivity
- antibacterial
- anti-odor
- drug-release
- corrosion protection
- electrical insulation
- hydrophilic



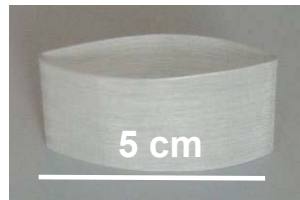


# Plasma & Coating – Ag Fiber

2007  
Transfer  
into industry



2008  
antistatic  
lattice apron



compact spinning

S E F A R  
■ ■ ■ ■



Paul Schlack Price  
awarded 2008

2009

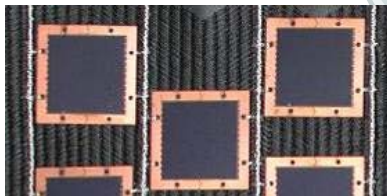
textile  
electrodes



electro  
stimulation

textile  
PV

electrical  
contacts



2010



Tech-  
in-  
Tex

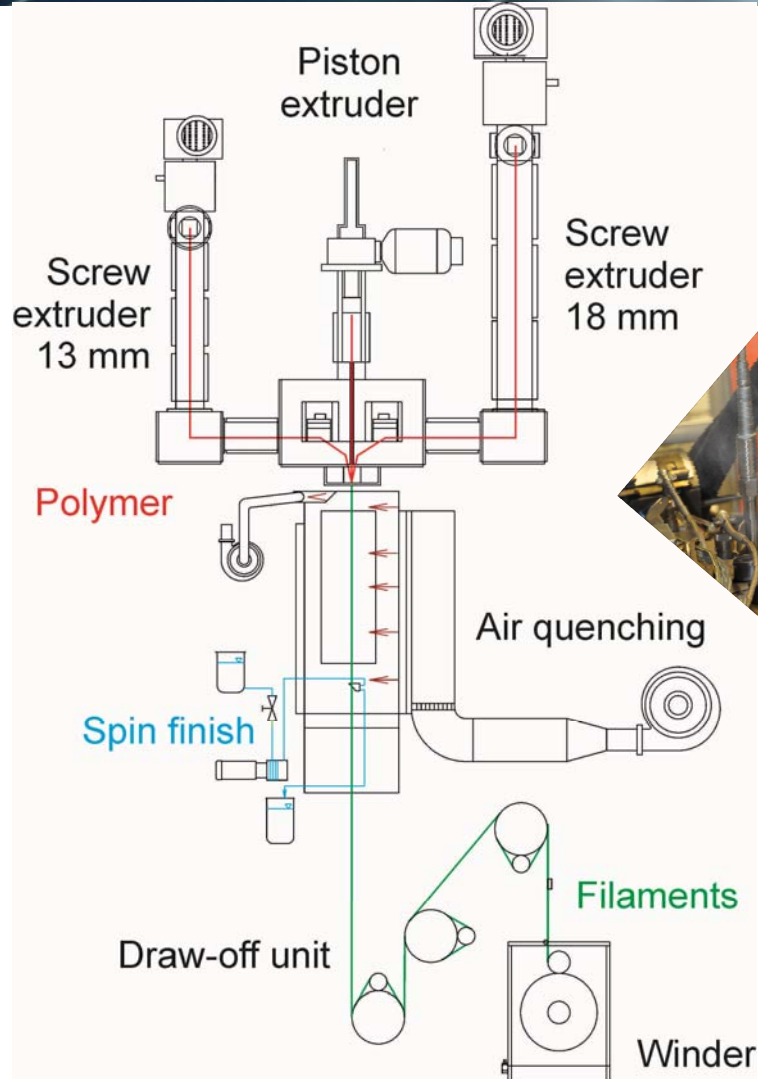
2009-2013

**Fibers**  
**Advanced**



# Pilot multicomponent melt-spinning plant

2004

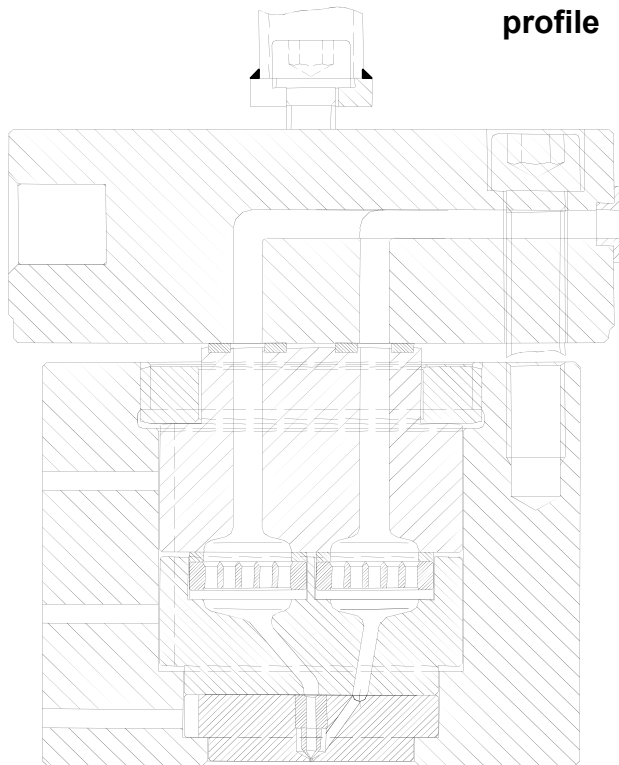
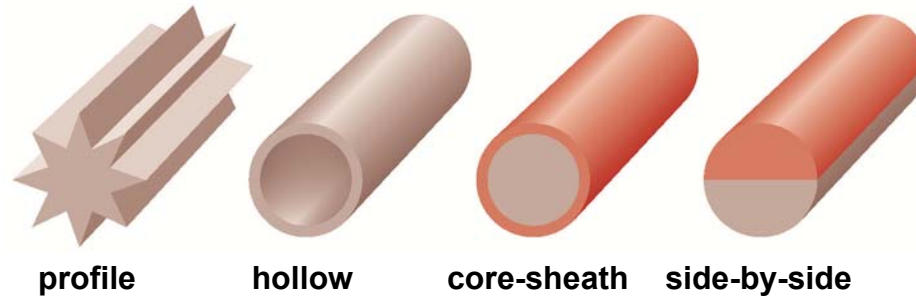


**Fibers**  
**Advanced**





# Mono- and bicomponent fibers

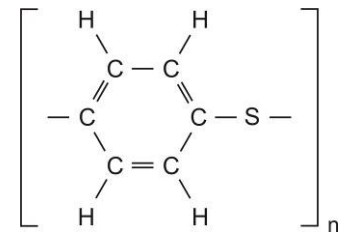


## Standard polymers

PET  
PA 6  
PA 6.6  
PA 6.12  
PA 12  
PP  
HDPE  
LDPE

## Special polymers

PPS      high performance polymers  
PEEK  
LCP      liquid crystal polymers  
PMMA  
PS      transparent polymers  
COC  
TPE      thermoplastic elastomeres  
PLA  
PHB      biopolymers  
PHBV  
PVA      water soluble polymers



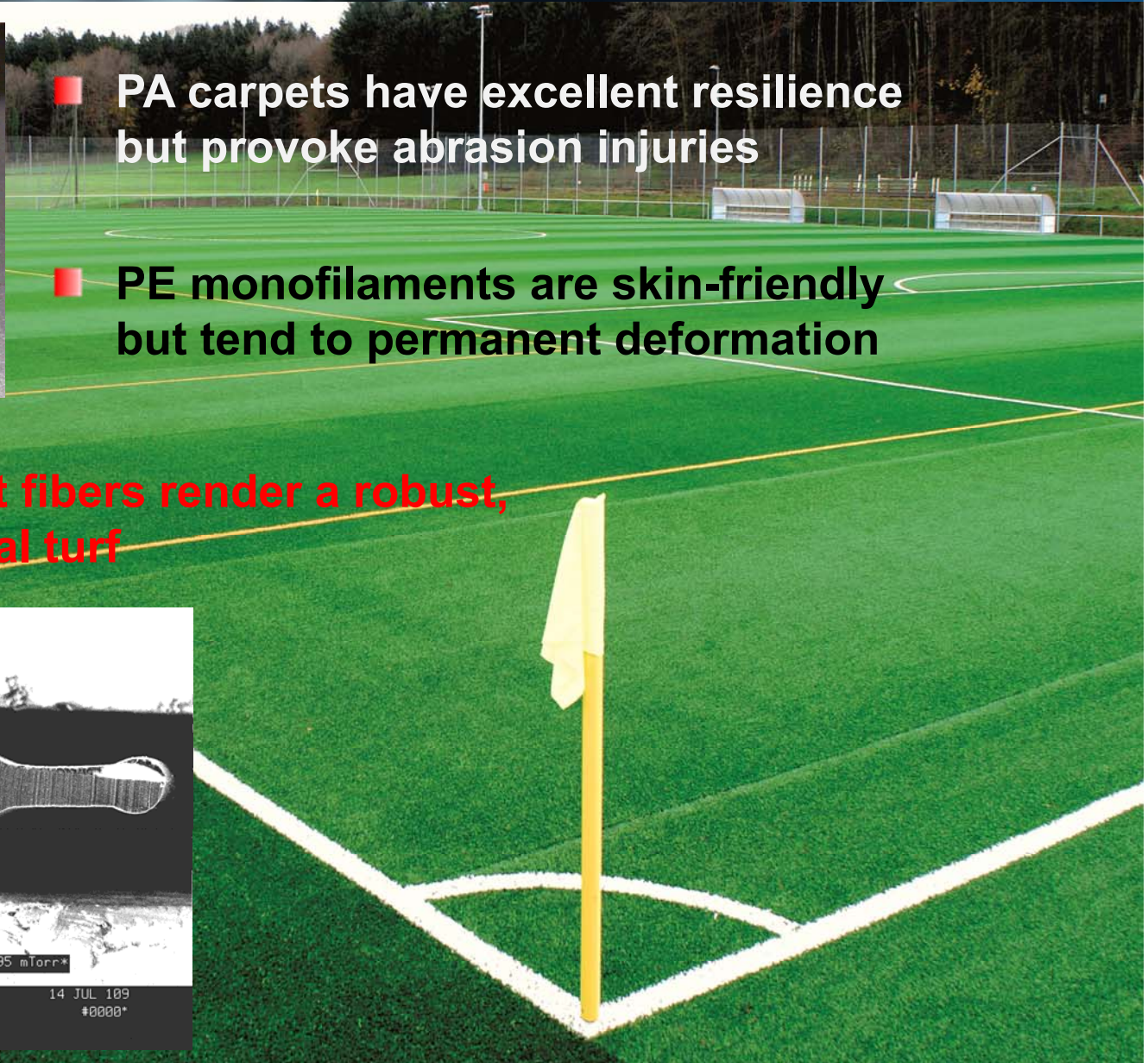
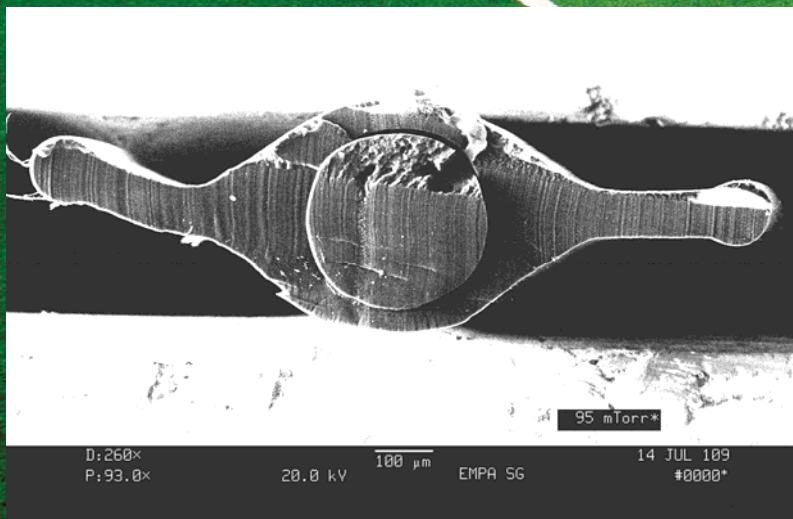
# Artificial turf fibers for future sports flooring



■ PA carpets have excellent resilience but provoke abrasion injuries

■ PE monofilaments are skin-friendly but tend to permanent deformation

■ PA-PE bicomponent fibers render a robust, skin-friendly artificial turf

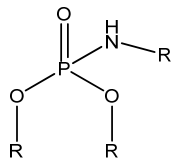




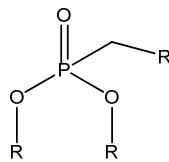
# FRs development in EMPA

## Organic Phosphorus Compounds

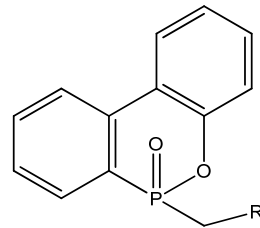
- **Phosphonates**
  - **Phosphoramidates**
  - **Phosphinates ( DOPO Derivatives)  
( Phosphoramidates)**
- Easy synthesis with high yeilds**



Phosphoramidate



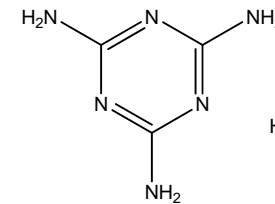
Phosphonate



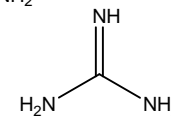
DOPO 9,10 Dihydro-9- oxa-10-  
phosphaphenanthrene-10- oxide  
derivative

## Inorganic Phosphorus Compounds

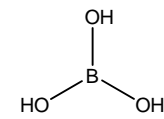
- **Salts of boron compounds**
  - **Salts of guanidine and melamine**
- Water based synthesis,  
Intumescent Characteristics**



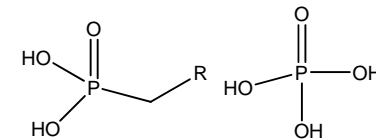
Melamine



Guanidine



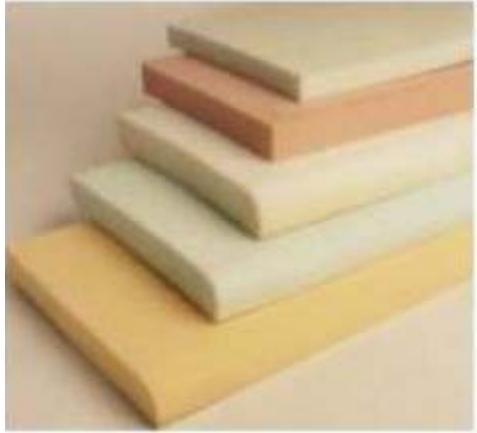
Boric acid



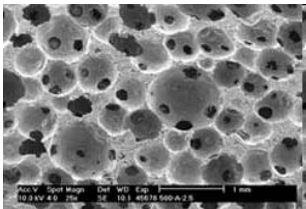
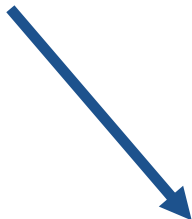
Phosphonic acid

Phosphoric acid

# Projects: Flexible PU FR



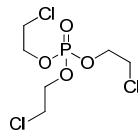
transportation, beddings, furniture



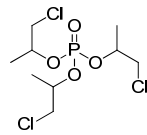
Open pores, O<sub>2</sub> can diffuse easily

**Fibers**  
**Advanced**

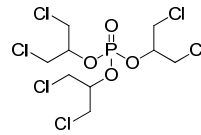
## Replacements for toxic Chlorophosphates



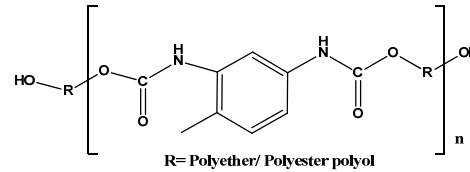
TCEP



TCPP



TDCPP



**Low concentration of aromatics**

- easily flammable and sustain the flame
- high heat release rate (400-500 W/g)
- formation of toxic gases like isocyanate, HCN, CO, CO<sub>2</sub>

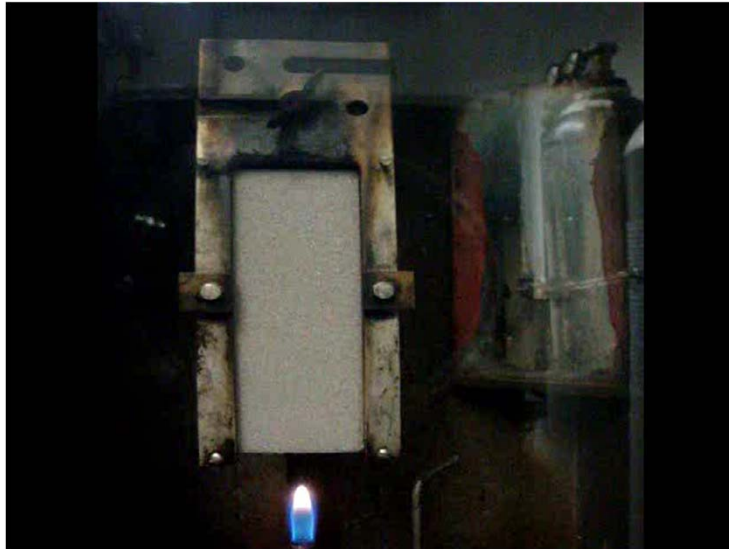


2010-2012- 2.5 yrs





# Projects: Flexible PU FR results



- virgin PU foam



PU foam with 5% of EMPA FR

**Outperforms any commercially available FR solution**  
**Plans to scale up the FR 100 Kg with FR manufacturer**

# Project: Coatings for E-Fiber



2009-2013



Tarnishing of Silver



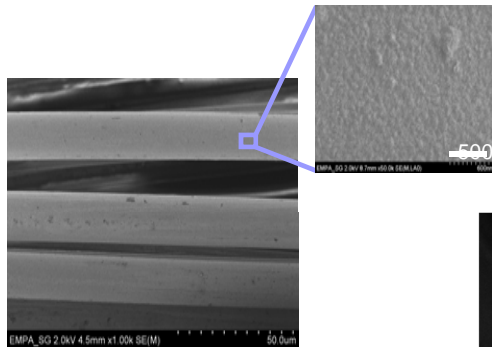
Solution Coatings of monomer or polymers



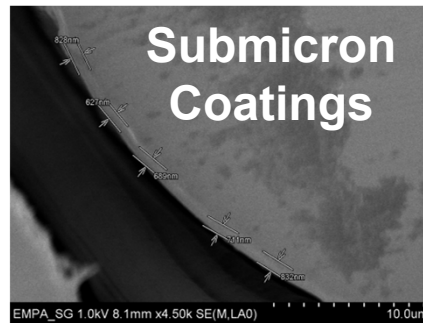
Melt Coating of polymer



Layer by layer assembly



Plasma Metallized Fibers  
Silver layer 200 nm



Submicron Coatings

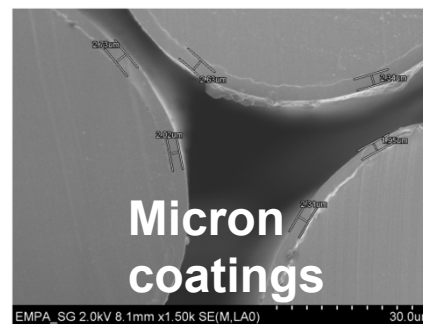


UV Curable PU Coatings

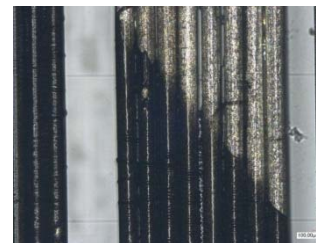
Features:

- Protection against H<sub>2</sub>S
- Insulation
- Transparent
- Selective strip-off ( UV )

Protective and Insulation Coatings



Micron coatings



Knowledge Transfer  
KTI Project with Industrial  
Partners under Preparation

**Fibers**  
**Advanced**

Manuscript to be submitted to ACS applied materials and surface

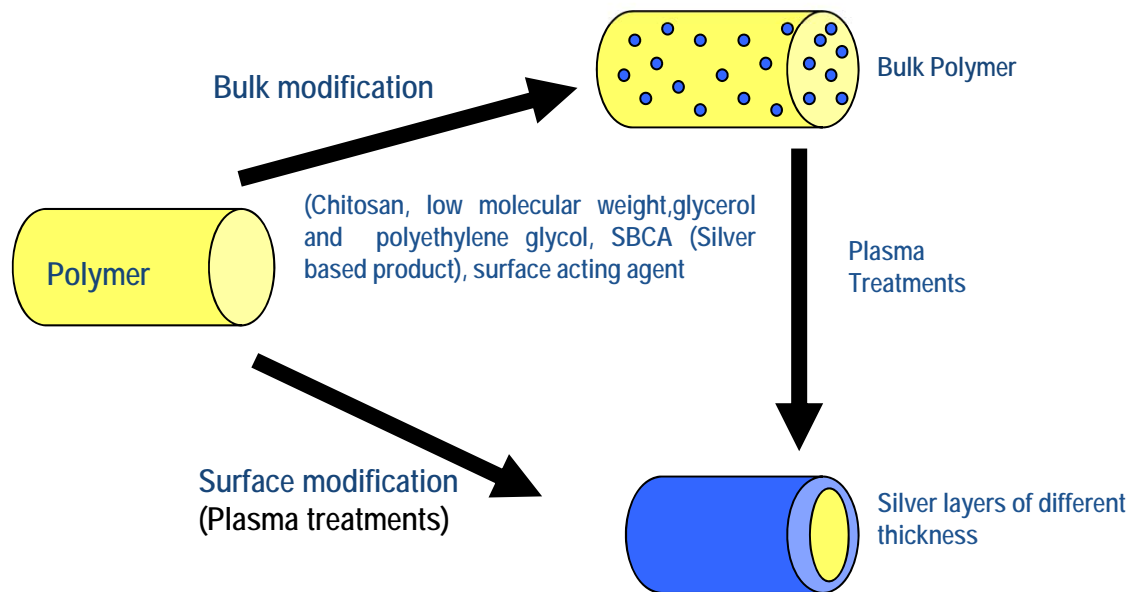




# Antimicrobial PLA



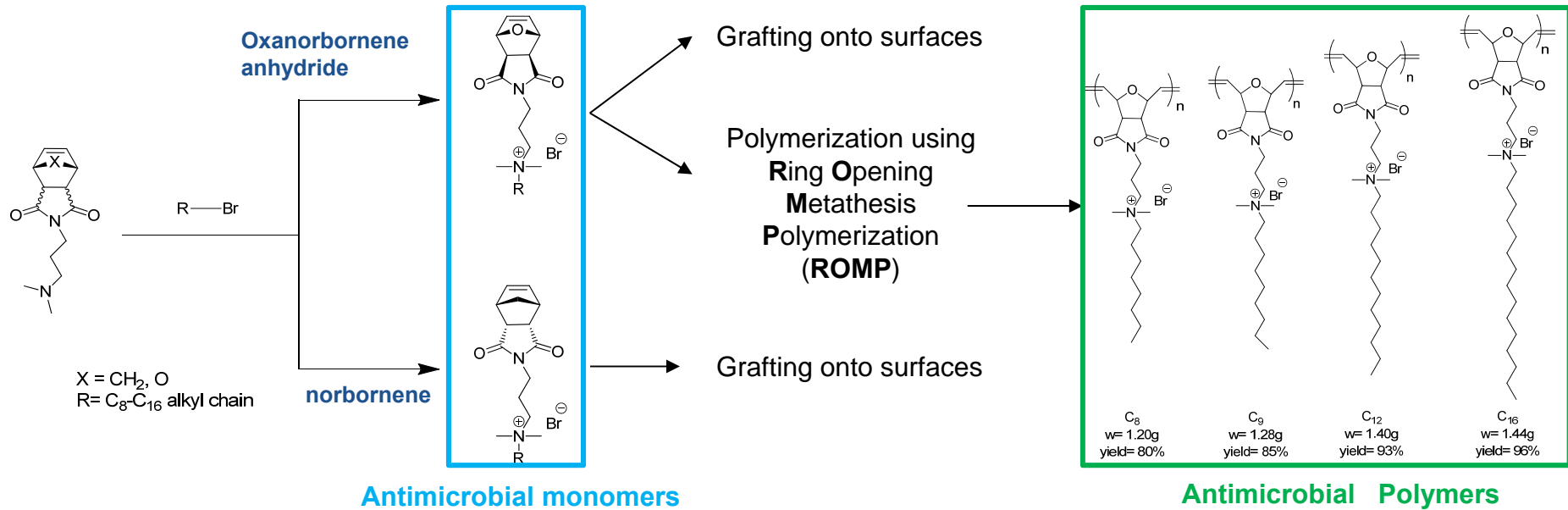
Joint PhD Study: Marina Turalija



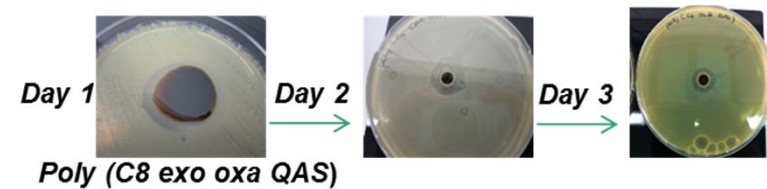
**The release of silver can be tuned by plasma based nanocomposites and bulk modification with coadditives**

**Main Application : Packaging materials**

# Research: Antimicrobial Polymer and Monomer



	MIC range (µg/mL)	MLC range (µg/mL)
Norbornene derivatives monomers	4-750	62-1000
Oxanorbornene derivatives monomers	16-250	125-750
Antibiotics	0.015-256	-



# Future Collaboration

- **Research Areas: Textile based functional coatings, additives , polymer processing, fiber spinning**
- **Exchange of Students and Scientific Personnel**
- **Joint EU project: Eurostar and FP7**
- **Use of infrastructure**
- **Possible industrial collaboration**



# Acknowledgements



Schweizerische Eidgenossenschaft  
Confédération suisse  
Confederazione Svizzera  
Confederaziun svizra

**CTI Switzerland**

**Industrial  
Partners**



[http://www.empa.ch/plugin/template/empa\\*/34822](http://www.empa.ch/plugin/template/empa*/34822)

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