Nanofibers in medical applications

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AGENDA

- **ABOUT ELMARCO**
- **A WORLD IN 10^{-9} m**
- **NANOSPIDER™ TECHNOLOGY**
- **NANOSPIDER™ PRODUCTS**
- **OPPORTUNITIES FOR NANOFIBERS IN MEDICAL APPLICATIONS**

ABOUT ELMARCO

Elmarco is the industry's first supplier of industrial scale nanofiber production equipment. Our partnerships with global industrial leaders and universities form the foundation for our success.

ELMARCO OFFICES

Liberec, Czech Republic –
Ladislav Mareš, CEO
Global headquarters, Technical Leadership Center, Corporate R&D, Sales and Equipment Production

Raleigh, NC, USA -
Ken Donahue, CEO
Sales, Service, Filtration product management

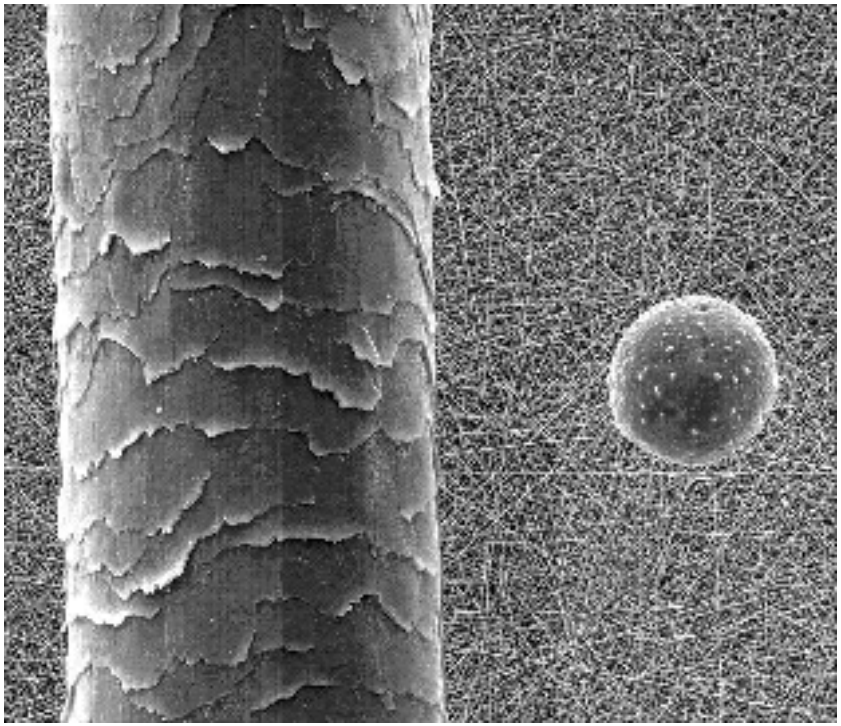
Tokyo, Japan -
Kaz Nomoto, CEO
Sales, Service, Asia-Pacific

In 2009 Elmarco opens new world-class Technology Center in Liberec and supporting offices in the US and Japan

KEY FEATURES OF NANOFIBERS

Nanofibers are a nanomaterial. Like all nanomaterials there are areas where the attributes are an incremental improvement to micromaterials; however there are areas where nanofibers provide truly disruptive innovation.

At least one dimension less than 100 nm
Industry accepts fiber diameters below 1,000 nm



- Large specific surface area
- Small pore size – good breathability
- Wide range of polymers capable of spinning
- The possibility to incorporate different additives
- High porosity
- These properties bring opportunities to create new unique materials in following application fields…

NANOSPIDER™ TECHNOLOGY THE ELMARCO WAY

Elmarco's Nanospider™ technology allows nanofibers to be produced on an industrial scale for a number of applications. Supported by a broad patent suite, Nanospider™ is a high voltage, free liquid surface electro-spinning process.

Feature: Rotating drum, partially submerged in a polymer solution

Benefit: Mechanically simple, allows lower equipment and operating costs

Feature: Nature defines the distance between Taylor cones

Benefit: Higher fiber packing density

Benefit: Higher fiber and web uniformity

High productivity
Easy maintenance
Economical operation
Top quality of nanofibers
High-level safety
Process flexibility

ELMARCO PRODUCTS – NANOSPIDER™ TECHNOLOGY

Elmarco's unique Nanospider™ technology is designed for ease of use, scalability, modularity and flexibility in producing the highest quality of nanofibers.

Upscaling of the technology

NS Lab → NS Pilot Line → NS Production Line

Laboratory unit – verification in samples – 10 m^2 per day

Upscale from the laboratory unit to production line – up to 1000 m^2 per day

Up to thousands m^2 per day for

WHY USE NANOSPIDER™ TECHNOLOGY FOR MEDICAL PRODUCTS MANUFACTURING

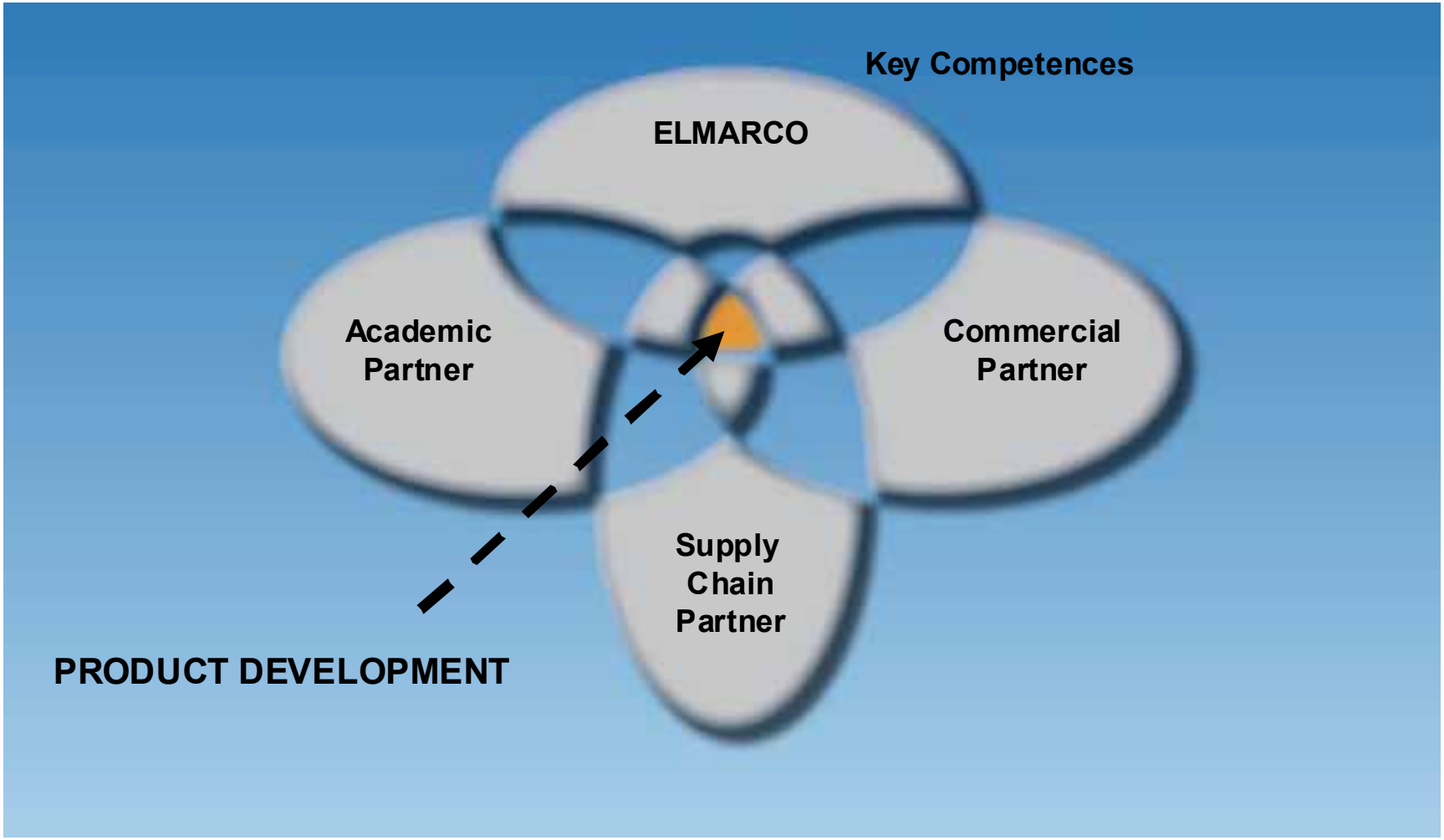
BENEFITS OF NANOSPIDER™ TECHNOLOGY

- combination of nanofiber layers from different polymer
- combination of nanofiber layer with different textile material
- different active materials can be incorporated into different layers
- less active materials is needed for the for obtaining of the same efficacy

NANOSPIDER™ TECHNOLOGY (Pilote line and Industriale line)

- was laid out, designed and operated in such way to minimise the risk of error and to permit effective cleaning and maintenance in order to avoid contamination, cross contamination and, in general, any adverse effect on the quality of the product
- may be operate in following purity classes:
  - according to GMP purity class D,C
  - according to ČSN EN ISO 14644-1 purity class 8,7

DEVELOPMENT PROCESS - WITH PARTNERS



OUR ACADEMIC PARTNERS

Elmarco has to this point entered into the following partnerships:
Technical University of Liberec (Czech Republic)
www.tul.cz
Massachusetts Institute of Technology (USA)
http://web.mit.edu/
North Carolina State University (USA)
http://www.ncsu.edu/
Nonwoven Cooperative Research Center (USA)
http://www.thenonwovensinstitute.com/ncrc/
National University of Singapore (Singapore)
http://www.nus.edu.sg/
Stellenbosch University (South Africa)
http://www.sun.ac.za/
Czech Academy of Sciences (Czech Republic)
http://www.cas.cz/
Charles University of Prague (Czech Republic)
http://www.cuni.cz/
Institute of Chemical Technology Prague (Czech Republic)
http://www.vscht.cz
Kyoto Institute of Technology (Japan)
http://www.kit.ac.jp/english/
Tokyo Institute of Technology (Japan)
http://www.titech.ac.jp/

Projects with Czech Academic Institutions

Project GA ČR: Biocompatible Nanofiber Scaffolds
Applications: Skin grafting, Corneal grafting
Partners: Institute of Experimental Medicine of the ASCR
Institute of Molecular Genetics of the ASCR
Institute of macromolecular Chemistry ASCR

Project AV ČR: Bioinspired Nanocomposite Structures for Bone Tissue Regeneration
Applications: Bone regeneration, Drug Delivery
Partners: Institute of Rock Structure and Mechanics of the ASCR
Institute of Macromolecular Chemistry of the ASCR
Institute of Physiology of the ASCR

Project AV ČR: Bioactive Biocompatible Surfaces and Novel Structures Cmposites
Applications: Medicine, Drug Delivery
Partners: Institute of Physics of the AS CR
University of Pardubice
Third faculty of Medicine, Charles University
Institute of Chemical Technology Praque

Project MPO: Nanofiber membranes utilization for controlled release of active compounds
Applications: Pharmacology
Partners: University of Pardubice

WHY USE NANOFIBERS…
…IN WOUND CARE

ADVANCED WOUND CARE

In contrast to traditional wound care, advanced wound care dressings operate in moist environments, require less frequent changing and help reduce the pain of dressing changes and lessen scarring.

Nanofibers may help in the improved care of:

- Acute wounds, including those caused by burns, surgical or traumatic wounds
- Chronic wounds, such as ulcers, not proceeding through the normal stages of healing

Nanofiber Wound Pad/ Hemcon Medical Technologies

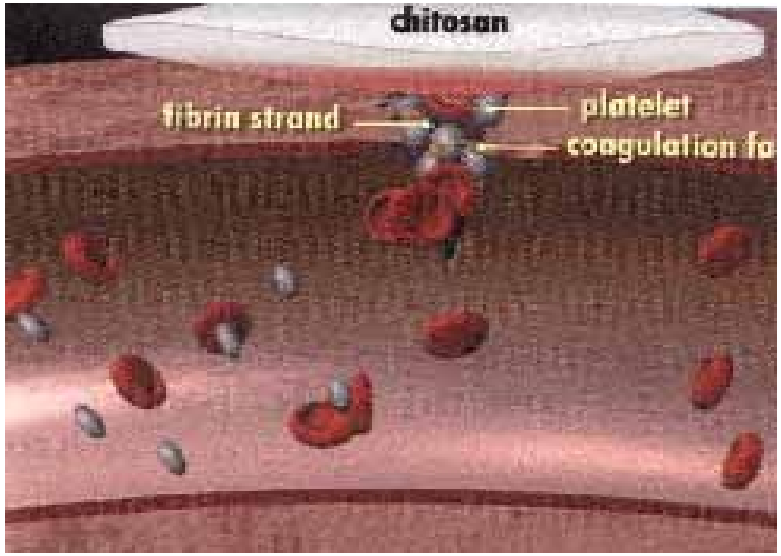
WHY USE NANOFIBERS…
…IN WOUND CARE

CONTRIBUTION OF NANOFIBERS IN ADVANCED WOUND CARE

- Permeability of gases and liquids
- High absorption capacity of liquids (exudate)
- High filtration efficiency for bacteria resulting in decreased infections
- Possibility to add drugs – haemostatic or antimicrobial dressing
- Swelling and gel forming capability to keep moist environs
- Anti adhesive effect to the derma - painless removal of the dressing without destroying newly formed tissue

Relevant polymers produced with Nanospider™ technology include

- Polyvinylalcohol,
- Chitosan,
- Carboxymethylcelulose,
- Gelatine, Collagen,
- Hyaluronic acid,
- Polyurethane and others.



WHY USE NANOFIBERS IN SURGERY …
…AS ANTI-ADHESION MATERIALS

TISSUE ADHESION – A SURGICAL PROBLEM

- Postoperative tissue adhesion of internal organs – a serious complication in modern medicine
- Tissue adhesion may result in numerous postoperative complications
- Pain, functional obstruction, and difficult re-operative surgery

A nanofiber membrane can be used as a tissue adhesion barrier.

CONTRIBUTION OF NANOFIBERS TO ANTI-ADHESION

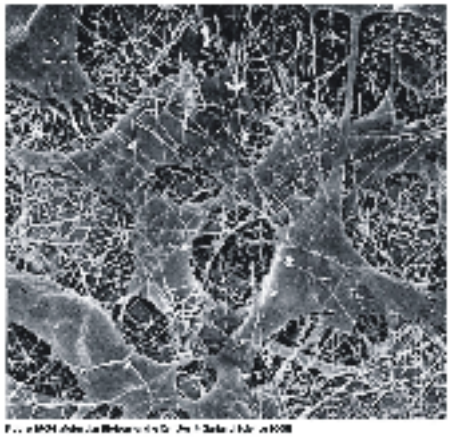
- Anti-adhesive effect – barrier between organs
- Bioresorbability – dissolves into body without toxicity
- Controlled life-time of nanofibers in to body
- Possible fast haemostasia and angiogenesis properties

Relevant polymers produced with Nanospider™ technology include:

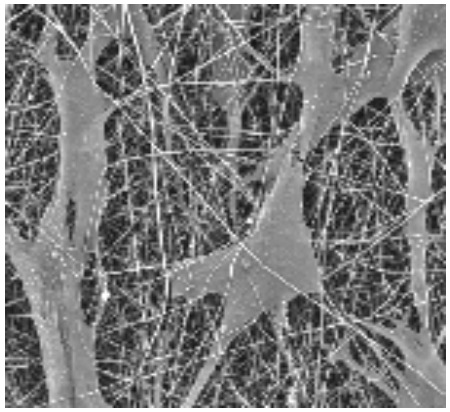
- PVA,
- Chitosan,
- Gelatine, collagen

WHY USE NANOFIBERS…
…IN TISSUE ENGINEERING

Almost of human tissues and organs are in nanofiber forms or structures.



Fibroblasts in the ECM of the corneal stroma



MSCs on gelatin nanofibers

NANOFIBERS AS SCAFFOLD FOR TISSUE ENGINEERING

Nanofibers + Cells → Tissue Repair

Nanofibers + Drug, Growth factor → Tissue Regeneration

WHY USE NANOFIBERS…
…IN TISSUE ENGINEERING

CONTRIBUTION OF NANOFIBERS IN TISSUE ENGINEERING

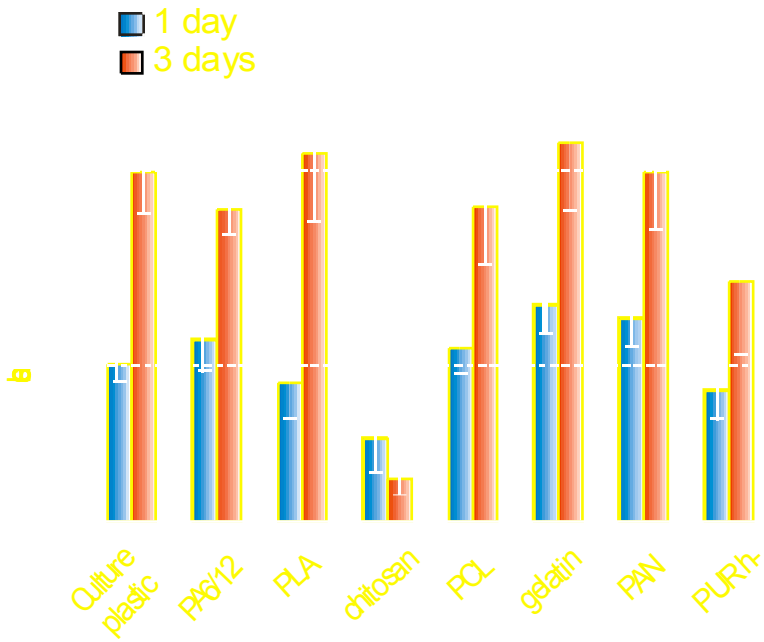
- **Mimic the 3D structure of ECM**
  - Structure similar to the targeted tissue
  - Proper environment for the cells attachment and growth
  - Porosity
  - Stiffness of surface

- **Biocompatibility**
  - Chemical, mechanical and biophysical properties suitable for in vivo implantation

- **Biodegradability**
  - Scaffold absorbed by the tissue

- **Easy to manufacture**
  by the technology Nanospider™

Viability and proliferetion of hMSCs on the polymeric nanofibers layers produced by Nanospider™ technology



WHY USE NANOFIBERS…
…IN DRUG DELIVERY SYSTEM

Improved and controlled delivery of drugs, therapeutics and special nutrition supplements via nanofibers through site-specificity and lower overall medicinal dosages can lead to a potentially industry altering approach to delivering therapeutics.

A nanofiber membrane can be used as a carrier for transdermal and transmucosal drug applications .

CONTRIBUTION OF NANOFIBERS TO DRUG RELEASE

- Controlled drug release
- Drug release over a longer period
- Reduction of the first pass effect
- Higher initial drug concentration
- Lower overall drug consumption

Relevant polymers produced with Nanospider™ technology include, PUR, Chitosan, PCL, PLA, PLAGA and others.

WHY USE NANOFIBERS…
…IN DRUG DELIVERY SYSTEM

Principles of products design

- Nanofibers layer doped by drugs

  Release of drug is controlled throught
  - the chemical or physical binding
  - system of polymeric nanofibers crosslinking

- Sandwich containing doped layer inside; outside are from both side NF layers used as membrane

  Release of drug is controlled throught
  - membrane structure (porosity),
  - thickness of membrane
  - membrane biodegradability (time)

THANK YOU FOR YOUR ATTENTION