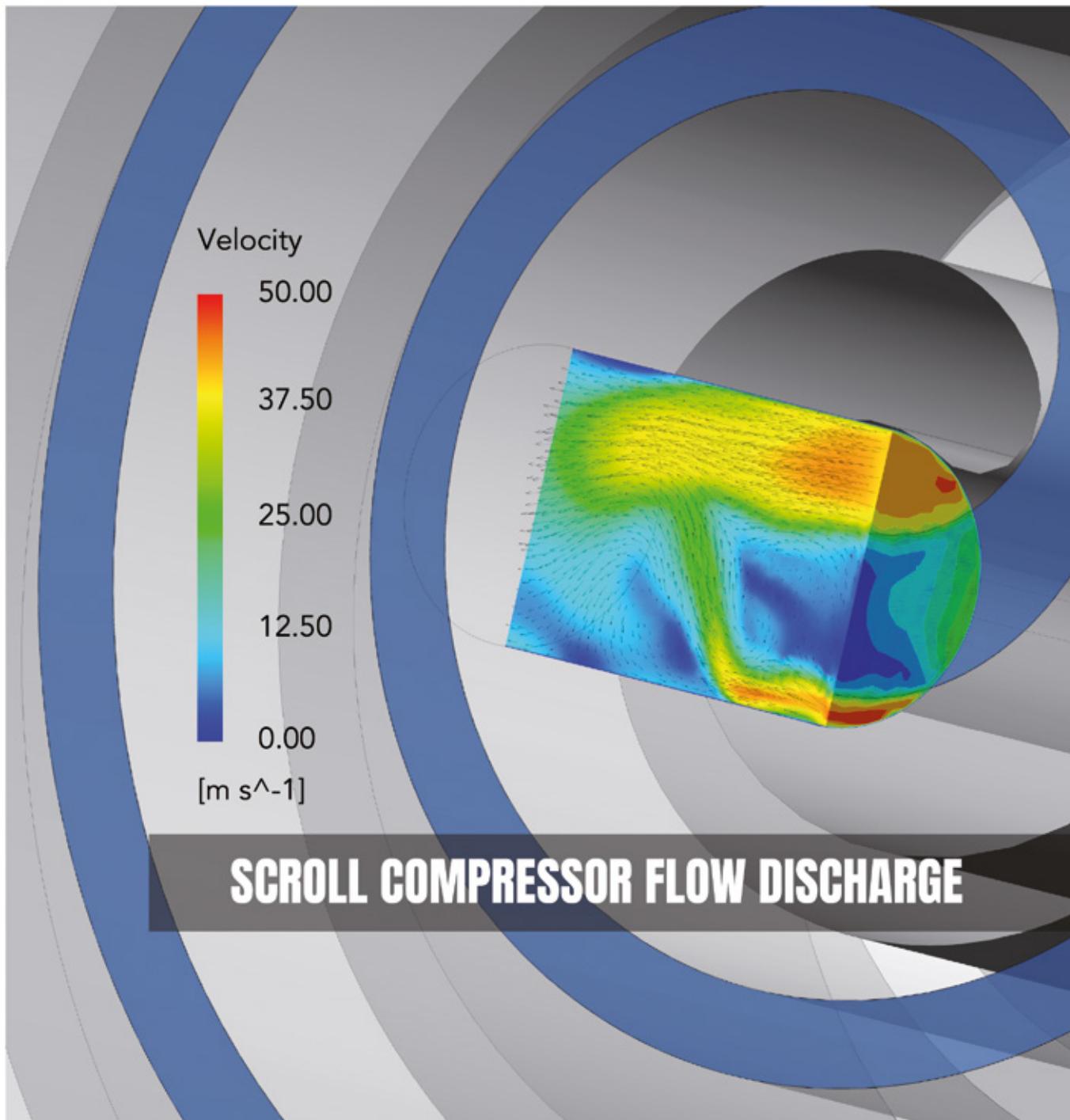
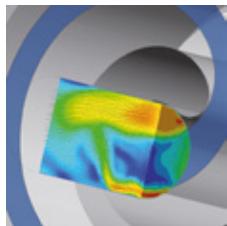


NEWSLETTER DEL DIPARTIMENTO DI INGEGNERIA INDUSTRIALE DELL'UNIVERSITÀ DEGLI STUDI DI PADOVA



## C O P E R T I N A

*Scarico di portata da un compressore scroll  
Scroll compressor flow discharge*



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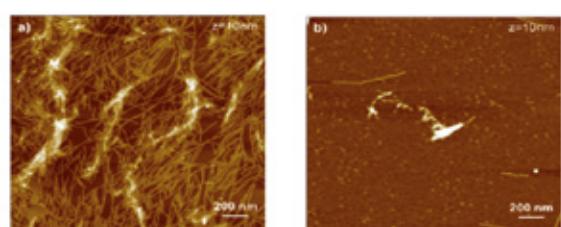
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**Cover story**

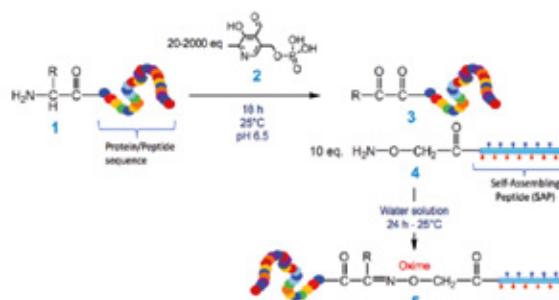
# 3D Synthetic peptide-based Architectures for the Engineering of the Enteric Nervous System

Damage of enteric neuronal projections and partial/total loss of selective neuronal populations are reported in intestinal disorders including inflammatory bowel diseases or short bowel syndrome. In order to develop a 3D “architecture” for enteric nerve cells, we propose the decoration of ionic-complementary self-assembling peptide (SAP) hydrogels (Figure 1) with adhesion/growth motives. SAPs (EAK or EAuK) were covalently conjugated to different bioactive molecules: RGD or (GRGDSP)4K (fibronectin), IKVAV (laminin), FRHRNRKGY (h-vitronectin, HVP) and Insulin-like Growth Factor-1 (IGF-1). Chemoselective ligation (Figure 2) was applied for the SAP conjugation with IGF-1 and the other long sequences. Freshly isolated murine enteric neurons attached and grew on SAPs: EAK reported 5-fold increase in adhesion of peripherin-positive neurons and 3-fold outgrowth of neurites compared with EAuK (Figure 3).

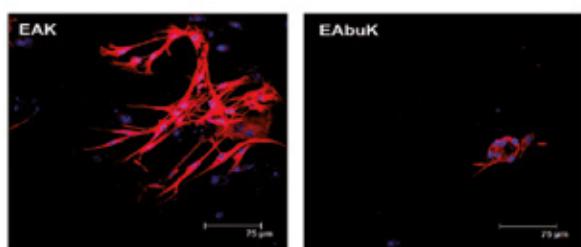
The enrichment of EAK with EAK-IGF-1 did not support neuronal growth whereas EAK+RGD-EAK significantly increased mRNA expression of neurotrophin-3 and nerve growth factor, two trophic factors supporting neuronal survival and differentiation. Cell-cell contact was evident on hydrogels enriched with EAK-(GRGDSP)4K and EAK-HVP. IKVAV decoration specifically increased mRNA expression of acetyl-cholinesterase and choline acetyltransferase, genes involved in synaptic communication between cholinergic neurons. Thus, decorated hydrogels are proposed as injectable scaffolds to support *in loco* survival of neurons, foster synaptic communication, or drive neuronal subtypes differentiation.



**Figure 1**  
AFM height images of: a) EAK, b) EAuK. The concentration for both samples was 0.15% (w/v). One hour of adsorption on mica surface.



**Figure 2.**  
Scheme of chemoselective ligation: step 1, the bio-transamination with PLP converts the N-terminal Gly in an  $\alpha$ -ketoaldehyde; and Step 2, the  $\alpha$ -ketoaldehyde reacts with an oxyamino group to produce an oxime.



**Figure 3.**  
Enteric neurons growth on EAK and EAuK. Immunofluorescence analysis of neurons cultured for 6 days and labeled with anti-peripherin antibody (red). Nuclei were stained with TOTO-3 iodide (blue).

Bioingegneria, biotecnologia  
e tecnologie per la salute

*Bioengineering*

DII research group

Chemical Bioengineering



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Main research topics:

- Biomaterials
- Hydrogels
- Chemoselective Ligation

## Materiali Avanzati

*Advanced Materials*

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Metallurgy



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## Portevin-Le Chatelier behaviour on 2017 - T4 aluminium alloy

In some materials, such as aluminium alloys, the plastic deformation shows an instability, called Portevin-Le Chatelier effect (PLC), which manifests itself as a serrated stress-strain curve and visible strain localizations in the form of inclined deformation bands. This effect is due to the interaction between solute atoms and mobile dislocations, which leads to repeating pinning and unpinning processes of the mobile dislocations during plastic deformation. In Al-Cu alloys, like 2017 alloy, the solid solutions constituted by aluminium and copper obtained after quenching, is unstable at room temperature and the microstructure evolves by the precipitation of  $\text{AlCu}_2$  phase. In this study the effect of aging time at room temperature (T4 treatment) of a solubilised 2017 Al alloy on the hardness and on the PLC effect is investigated. The alloy was solubilized at 530°C for 3 hours and after quenching in water, the tensile tests after different aging times at room temperature were made with a strain rate of 0.1 s<sup>-1</sup>. The hardness of the aged samples is reported in Figure 1. It can be seen the fast increase in hardness due to the formation of GP zones in the first 8 hours of aging. Longer aging produces the growth of GP zones to  $\text{AlCu}_2$  particles which are less effective in the increasing of hardness. The stress strain curves are reported in Figure 2. The PLC effect is well exhibited in the samples aged up to 8 hours. Because the PLC effect is due to the interaction between solute atoms and mobile dislocation, this effect is high when the solute atoms are well dispersed after quenching and when the secondary phases are coherent with the metal matrix as in the GP phases. The mobile dislocations during the plastic deformation can be pinned and unpinned by the solute atoms and by the small GP coherent zones. When the aging time produces a decrease of coherency of the GP particles, the pinned dislocations cannot break away from the obstacles to their movement and the PLC effect disappear.

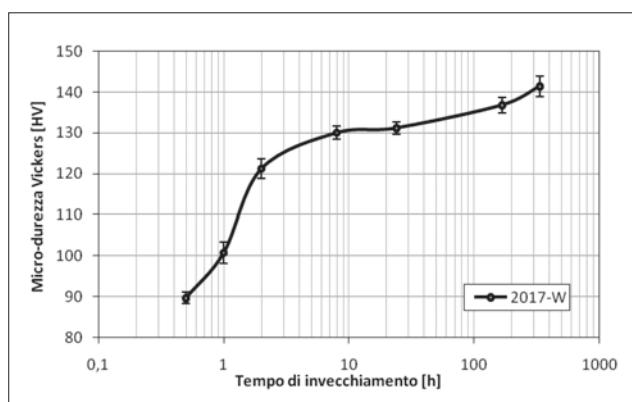


Fig.1  
Hardness evolution with increasing ageing time.

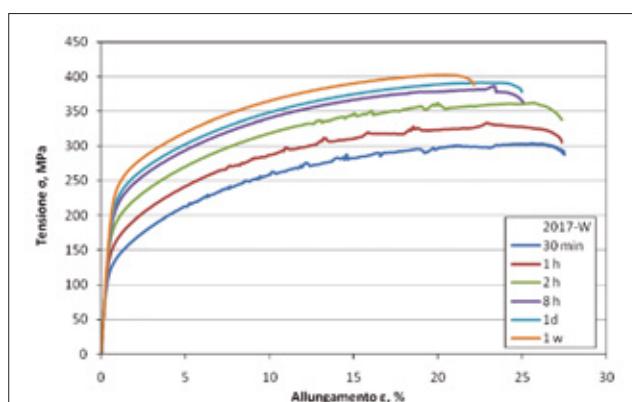


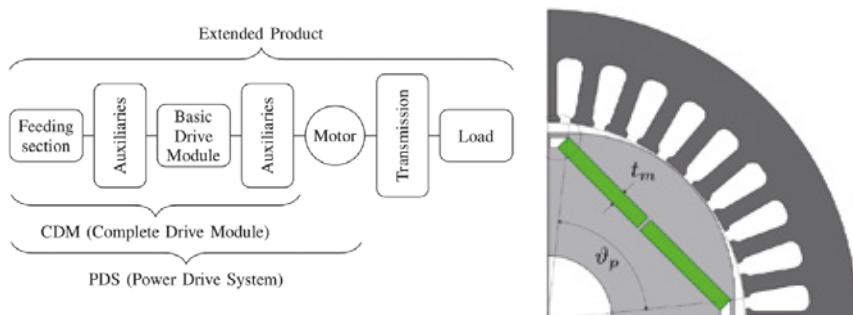
Fig.2  
Stress strain curves of aged samples.

# Design of electric motors and power drive systems according to efficiency standards

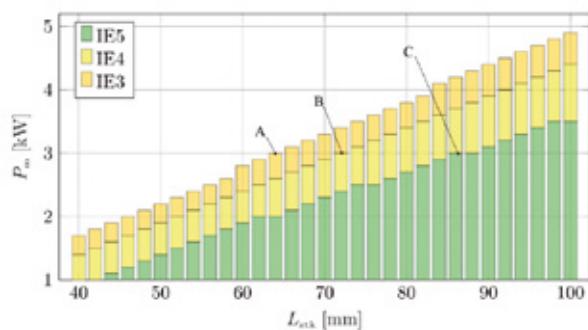
A great effort has been made in recent years to improve the energy efficiency of human activities and to reduce CO<sub>2</sub> emissions in the next future. Among the others, it is worth to mention the Kyoto Protocol which signature commit the European Union to achieve the so called target 20-20-20 by 2020. To realize such goals, one of the most important measures taken by the EU is the Energy related Products (ErP) Directive 2009/125/EC. The ErP Directive, also called the European Eco-Design Directive, establishes minimum energy efficiency requirements for products that are manufactured or imported into the European Union. Such a category includes also electric drives and many standards and regulations regarding efficiency requirement in electric motor (EM), complete drive modules (CDM) and power drive system (PDS) have been published.

In the prospective of moving up efficiency of electric motors, many different solutions have been proposed. Synchronous motors are the favourite candidates for higher efficiency class motor since they not suffer of rotor losses. Furthermore, other aspects complicate the replacing of existing motors with premium efficiency motors, the manufacturing of new motors could require a consistent amount of energy and materials, leading to a non-negligible environmental impact.

This research deals with the coordination of various mandatory standards in this application in the design of new motors and drives. The motor geometry is optimized for the nominal power rating and then it is investigated how the efficiency class of both the motor and the PDS (in which the motor is adopted) changes scaling the design to fit other power ratings with the same geometry, limiting thus the production cost of new motors.



*Extended product overview.*



*Motor efficiency class according to different stack lengths and mechanical powers.*

Ingegneria dei sistemi elettrici  
*Electric engineering systems*

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Electric Drive Laboratory



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This research is developed in cooperation with ORANGE1 Electric Motors



Main research topics:

- Design of electrical drives
- Design of electrical machines
- High efficiency power drive system
- Green power conversion

**Materiali****Materials**

DII research group  
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## Delamination in glass containers for pharmaceutical application: laboratory intercomparison looking for a predicting protocol procedure

*The formation of flakes in drug products due to specific and localized corrosion of glass vials, known as delamination, is a rare but very serious problem, and the FDA (U.S. Food and Drug Administration) put a warning to the pharma industry in 2011. The International Commission on Glass (ICG) activated a Technical Committee, TC12 "Pharma Packaging" with the aim to study this important problem. Since 2013 the TC12 members, coming from the most important glass producers, glass converters and users of pharma glasses, performed two main round robin tests with the aim of finding a testing protocol useful to predict the delamination propensity.*



<https://research.dii.unipd.it/nanoeng/>

### Delamination and the importance to predict it

After discovering glass flakes in different drug products in 2010 (with many parenteral drug recalls), the FDA (U.S. Food and Drug Administration) issued a warning to the pharmaceutical industry in 2011 on the so called delamination phenomenon. Delamination is observed mainly in tubular borosilicate containers (vials), and is attributed to the converting process which, especially in and near the regions where the working temperature is higher, causes a change in the composition of the surface layers. These regions corrode faster in aqueous solutions and, depending on several parameters, release ions while incorporating water and create a swelled and stressed hydrated layer. This layer can detach from the surface when the stress is high enough, creating the flakes typical of delamination. Fortunately, delamination is a rare phenomenon, but this means also that it is difficult to study. Therefore, the development of a shared protocol able to predict the propensity of a batch of vials to delaminate would be extremely important.

This has been the goal of the ICG Technical Committee TC12 during the last years.

### Testing protocol

The protocol tested by eleven labs and proposed by TC12 is based on the interaction of the inner glass surface of vials with methylene blue and the amount of silicon and boron, measured by ICP-OES (Inductively Coupled Plasma - Optical Emission Spectroscopy), present in autoclave extractions at 121 °C with a 0.9% KCl solution. This test is intentionally not much aggressive, but it could show significant differences among the tested vials. However, flakes were never observed. Therefore, a more aggressive protocol was associated to the first one with the only aim to demonstrate a direct correlation of the results given by the proposed protocol with the occurrence of delamination in severe conditions. A procedure aimed to accelerate the formation of lamellae was developed, based on the pre-treatment of the inner glass surface and the prolonged (up to one month) maintenance of vials at 50 °C. All vials were visually inspected every day after gently swirling the solution, to allow any particles or glass lamellae to become suspended and visible (as shown in the picture below).

### Main research topics:

- Nanoparticles and nanopowders for functional application
- Thin film for functional application
- Ceramic nanocomposites
- Nanostructured materials for gas sensors
- Biopolymer nanocomposites
- Optical characterization of thin films and nanocomposites

## Materiali

### *Materials*

DII research group  
Nanomaterials Engineering Group  
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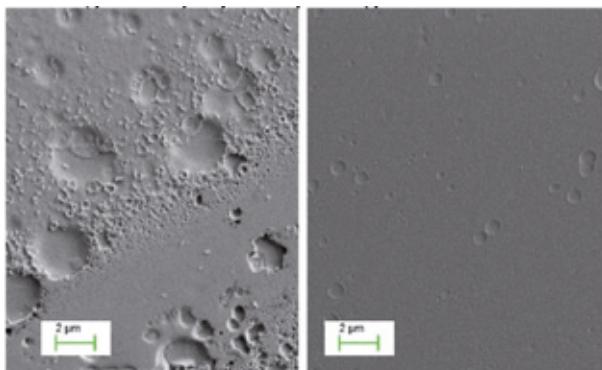


### Summary of results

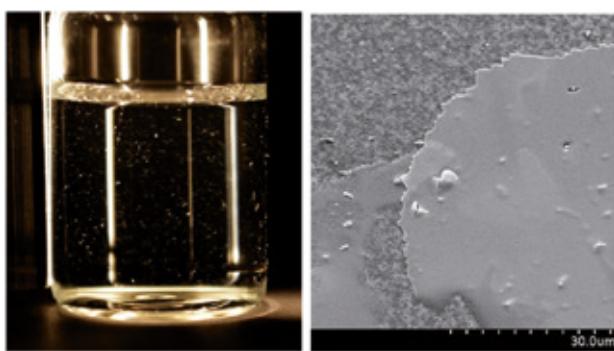
In the first part of the work it was demonstrated that the proposed protocol, mainly based on the ICP measurement of silica and boron oxide extracted during an autoclaving process at 121 °C, was able to predict a surface corrosion of the inner surface of vials. The results indicated that high values of silica were correlated with the corrosion of glass (see SEM picture), but no flake could be observed. In the second part of the work, using a more aggressive protocol it was possible to observe delamination in some of the tested vials.

The adopted multi-laboratory approach gave results with a good reproducibility, demonstrating the high level of reliability of measurements. The intercomparison results clearly showed a very good consistency between the results of the two testing protocols: high level of extracted silica were found in vials which exhibited the occurrence of strong delamination, while in the vials where delamination was minimal or not observed at all, the level of extracted silica was much lower.

Delamination is strictly depending on the drug product and the storage conditions, therefore the proposed test cannot give indications on the full compatibility between a drug product and a glass container, but it is an easy and sufficiently fast method to assess the general propensity of a glass vial to delaminate.



*SEM image of the inner glass surface at the bottom of a vial with high (left) and low (right) silica release in solution.*



*Glass flakes in suspension in the solution (left), and a flake observed at the scanning electron microscope (right).*

Study on 10 R vials with low delamination propensity provided by:

**Nuova Ompli (Stevanato Group),  
Schott, Nipro, Corning and Bormioli Rocco**



**CORNING**



## Energia

## Energy

DII research group

Trasmissione del calore  
in microgeometrie

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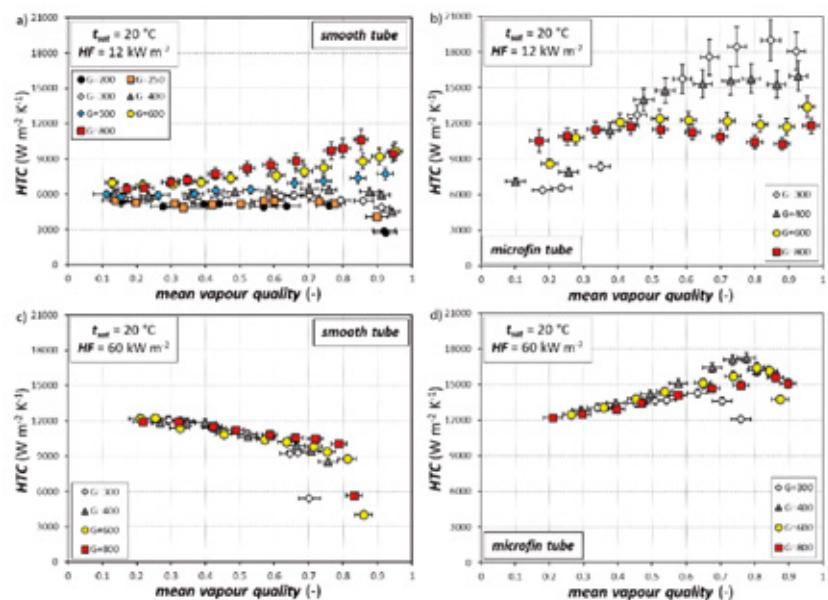
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The research in the field has been started and successfully carried out by  
Andrea Diani, Luisa Rossetto.

## Evaporation heat transfer inside small-diameter smooth and microfin tubes

The air conditioning and refrigeration industry is working for the replacement of common refrigerants, such as HFC 134a and 410A, having high Global Warming Potentials (GWP), in order to accomplish the new environmental regulations. However, the implementation of more eco-friendly refrigerants is not enough in order to develop new smart equipment: low refrigerant charge equipment, i.e. equipment which involves small-sized tubes, should be designed.

The research investigates the characteristics of R513A, R1234ze(E), R1234yf during flow boiling. R513A is an azeotropic mixture made of R1234yf and R134a (0.56/0.44 by mass), and it has been proposed as a direct drop in of the common R134a. R1234ze(E), R1234yf show almost null GWP. Experimental tests have been run in a wide range of operative conditions: mass velocity in the range 100-800 kg m<sup>-2</sup> s<sup>-1</sup>, heat flux in the range 12-60 kW m<sup>-2</sup>, for saturation temperatures of 15, 20 and 25 °C. Four different mini tubes are tested: two smooth tubes with an inner diameter of 2.5 and 3.5 mm, and two microfin tubes with an inner diameter at the fin tip of 2.4 mm and 3.4 mm respectively. Heat transfer coefficients and frictional pressure drops are evaluated from the experimental measurements. The effect of the microfins on the thermal and hydraulic behavior during flow boiling are highlighted. Finally, experimental heat transfer coefficients and frictional pressure drops are compared against values predicted by correlations available in the literature, in order to validate computation methods, useful to design compact heat exchangers.



## Main research topics:

- Flow boiling
- Heat transfer coefficient
- Pressure drop

Figure 1.

R513a flow boiling heat transfer coefficient (HTC) against vapour quality at different values of mass velocity  $G$  (expressed in  $\text{kg m}^{-2}\text{s}^{-1}$ ), at saturation temperature 20 °C, in a smooth tube with inner diameter 2.4 mm and in microfin tube with an inner diameter at the fin tip of 2.4 mm

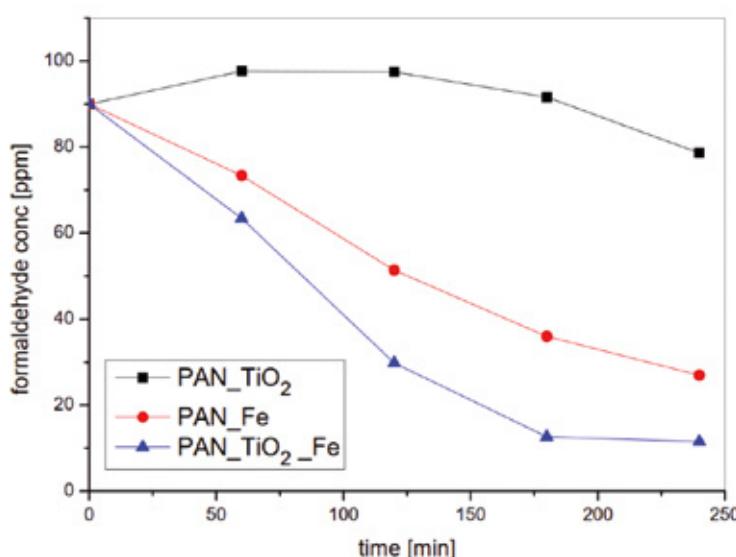
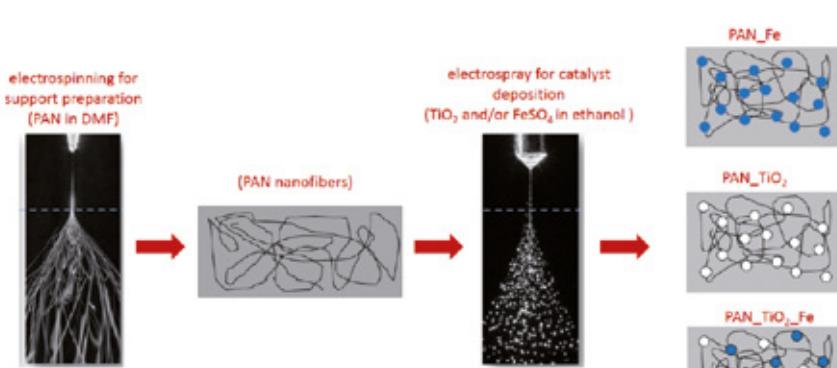
# Combined AOPs for Formaldehyde Degradation Using Heterogeneous Nanostructured Catalysts

Fire scenarios may pose serious risks and induce severe damages to anthropic structures, activities and business. These can be represented by typical fires in industrial facilities or also atypical scenarios involving differentiated targets as in the case of interface fires.

Risk assessment of atypical scenarios requires improved approaches since a multi-risk framework can arise including the interactions between the fire and surrounding domains (figure 1). An effective hazard investigation and management should therefore include estimations of consequences based on the results of models' simulation.

The present study deals with a preliminary risk assessment methodology applied to fires interacting with an existing urban area (WUI fires). The fire spread is approached through a dedicated tool and a GIS (Geographic Information System) -based system is used to spatially map expected consequences. Starting from these data, a preliminary risk estimation is proposed with the aim of mapping hazardous areas. In this sense, a combined approach based on fire simulation tools and exposure functions is employed.

Major risk areas for specific targets are identified in terms of risk contours (figure 2), and expected results can be used to support land planning and emergency-related operations.



## Sicurezza ambientale e industriale *Environmental and industrial safety*

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PEG, NANOENG,  
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Research output from the project  
NANOSENATOX (NANOstructured membranes for SENsing and Abatement of TOXic and harmful compounds - R. Bonora, A. Lorenzetti, A. Martucci, M. Roso). Department of Industrial Engineering (University of Padova), under the Twinning program

### Main research topics:

@PEG

- Nanostructured membranes
- Mechanical and chemical recycling of polymeric materials
- Fire behavior of polymeric materials
- Development and processing of high performance polymers and biopolymers

### @NANOENG

- Nanoparticles and nanopowders for functional application
- Thin film for functional application
- Ceramic nanocomposites
- Nanostructured materials for gas sensors
- Biopolymer nanocomposites
- Optical characterization of thin films and nanocomposites

### @ DECON/DEMIL

- Protection against CBRNE events, reducing individual and collective exposures.
- Demilitarization and disposal of waste military munitions and explosives.
- Environmental Remediation and Recovery.

## Ingegneria dei sistemi elettrici

*Electric systems engineering*

DII research group

Power Systems



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The research activity is carried out as part of the project NEBULE, financed by the Interdepartmental Centre "Giorgio Levi Cases" for Energy Economics and Technology, involving research groups of the departments of Economics and Management (DSEA), Information Engineering (DEI) and Management and Engineering (DTG).



## Main research topics

- Management and control of distribution networks with high penetration of Distributed Energy Resources
- Ancillary services market evolution due to energy transition and its impact on power system's efficiency
- Flexible planning and management of micro-grids with generation, storage and demand control as support for sustainable and efficient electrical systems
- Enabling technologies for consumption electrification and E-Mobility: development and smartization of the MV power grid

## Participation of Small-scale Variable Distributed Renewable Energy Sources to the Balancing Services Market

According to the latest indications from EU Directives, demand response and distributed generation flexibility are encouraged, in form of aggregated virtual power plants, in order to meet network balancing needs, stressed by the steady growth of non-programmable renewable energy sources. Along with energy policy updates at European level, Italy recently opened its ancillary service market to distributed energy resources (DER) connected at distribution level. For practical reasons, as of today, the ancillary services market has maintained its original structure, just extending the participation to smaller units (also in aggregated form), however this approach leads to management issues for the Distribution System Operators (DSOs), with potential sub-optimal usage of the available resources. This research focuses on comparing the potential costs associated to different market frameworks (Fig. 1), taking into account the technical constraints in the distribution network. The framework (a) is based on a purely commercial approach, meaning that the aggregator gathers the energy provided by DER without caring about the actual connection point, but just for economic convenience, maintaining the DSO in its current role of technical operator. In framework (b) a purely technical approach is considered, letting the DSO be responsible of the imbalances that may arise in the distribution grid and taking on both the commercial and technical roles by physically aggregating the units to comply with the technical constraints. A Monte-carlo analysis conducted assuming different generation mixes and uncertainty scenarios in a reference distribution network indicates that the social cost for balancing may vary significantly under the two approaches, especially when uncorrelated imbalances occur (as for wind generation) (Fig. 2). In addition, involving the DSO in the selection of balancing offers would allow cost reduction, exploiting the lower costs for upward reserve rather than maintaining the costs originated by technical issues. Future research will focus on investigating the interactions among agents and their characteristics in terms of resources portfolio.

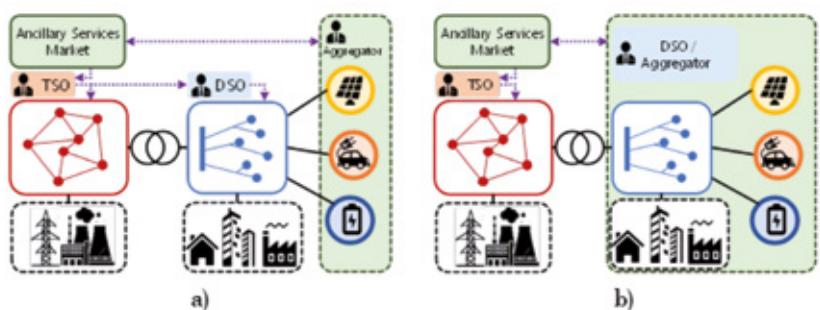


Figure 1: Balancing service aggregation approaches: commercial (a) and technical (b)

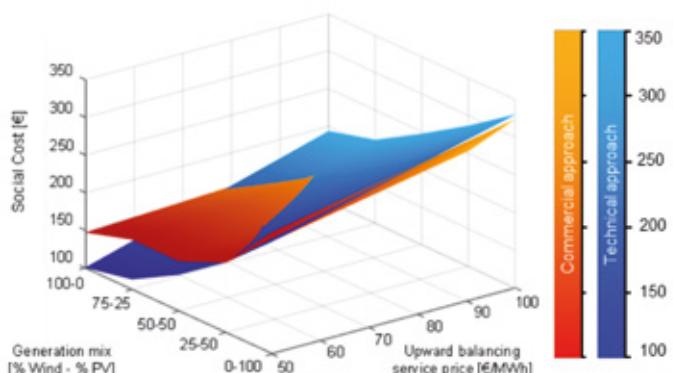
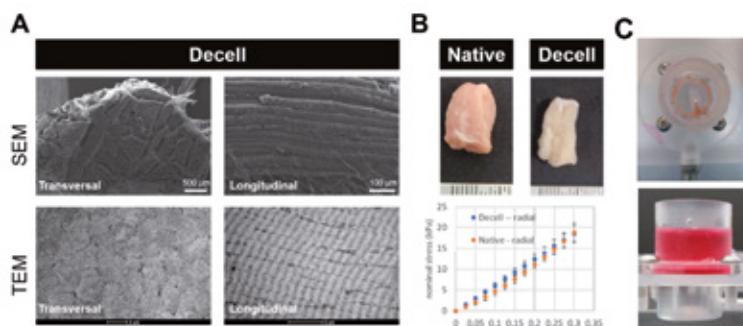


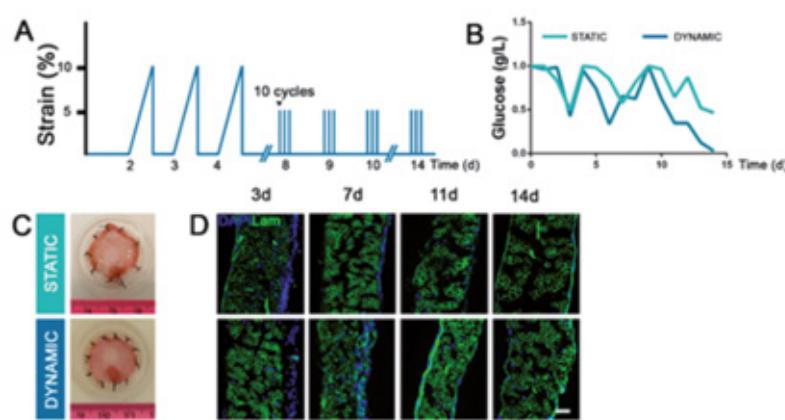
Figure 2: Resulting social cost for balancing for varying generation mixes and upward reserve price

# Development of extracellular matrix scaffolds for skeletal muscle tissue engineering in congenital diaphragmatic hernia repair

Congenital diaphragmatic hernia (CDH) is a severe malformation of the developing diaphragm, affecting 1 every 2,500 - 3,000 live birth. The common use of synthetic patches to repair CDH leads to side effects as lack of elasticity and growth with the child, causing subsequent re-herniation. An innovative solution for the repair of this congenital defect is the use of tissue engineering approach, thanks also to a bioreactor specifically developed to the purpose. Our group has shown that the use of a biological patch obtained directly from the decellularization of the diaphragmatic muscle considerably improves the treatment of CDH in an animal model, reducing the formation of scar tissues on the diaphragm. After decellularization, the scaffold is cultivated with human muscle cells and matured within bioreactor under mechanical stimulation, to obtain a diaphragm as much as possible similar to the original tissue. This innovative approach is aimed at producing scaffolds that will be repopulated with the cells obtained directly from each single patient, pursuing the goal of an advanced personalized regenerative medicine in a fast, automated and on demand way.



*Figure 1. Morphological and mechanical characterization of decellularized patches: A. SEM and TEM transversal and longitudinal section of diaphragmatic patch; B. Macroscopic view of native and decellularized samples used to test the mechanical properties and nominal stress vs strain. C. Top and lateral view of the bioreactor with a decellularized patch immersed in culture medium*



*Figure 2. A. Mechanical stimulation protocol applied to the dynamic cultures. B. Glucose consumption monitored in real time during the culture. C. Macroscopic appearance of static and dynamic re-cellularized samples at 14 days. D. Immunofluorescence of Laminin (green) and nuclei (DAPI) to evaluate cell distribution during time.*

Bioingegneria, biotecnologia  
e tecnologie per la salute

## Bioengineering

DII research group  
Biomechanics  
Mechanics of biological materials



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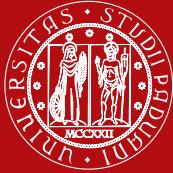
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The research activity has been carried out in collaboration with Dr. Martina Piccoli (Tissue Engineering Laboratory, Fondazione Istituto di Ricerca Pediatrica Città della Speranza)

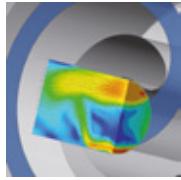
[www.irpcds.org/it/lab/tissue-engineering/](http://www.irpcds.org/it/lab/tissue-engineering/)

## Main research topics:

- Mechanical characterization of biomedical polymers
- Mechanical behavior of tissues from human/animal models
- Development and characterization of scaffolds for tissue engineering
- Constitutive modelling of biomedical materials and tissues
- Computational biomechanics



## Cover story



L'immagine riguarda lo studio di approcci numerici adeguati per la simulazione fluidodinamica di compressori/espansori volumetrici di tipo scroll. In particolare si sono condotte analisi finalizzate ad evidenziare l'influenza dei giochi assiali sulle prestazioni di questa tipologia di macchine. La figura evidenzia i passaggi di portata che intervengono tra diverse camere operative a causa di questi giochi assiali, nonché la forte non-stazionarietà del campo di moto allo scarico del compressore con conseguente influenza delle dimensioni e del posizionamento della porta di scarico.

### Francesco Giacometi



Ha conseguito la laurea in Ingegneria Energetica nel 2018 presso l'Università di Padova, dove ha ottenuto un assegno di ricerca FSE nell'ambito di configurazioni innovative di pompe. È ora dottorando presso il Dipartimento di Ingegneria Industriale sotto la supervisione della prof.ssa G. Cavazzini all'interno del gruppo di ricerca TES (Turbomachinery and Energy System). La sua ricerca riguarda lo sviluppo di modelli numerici per l'ottimizzazione fluidodinamica di impianti idraulici con particolare riferimento ad aspetti di efficienza e di affidabilità.

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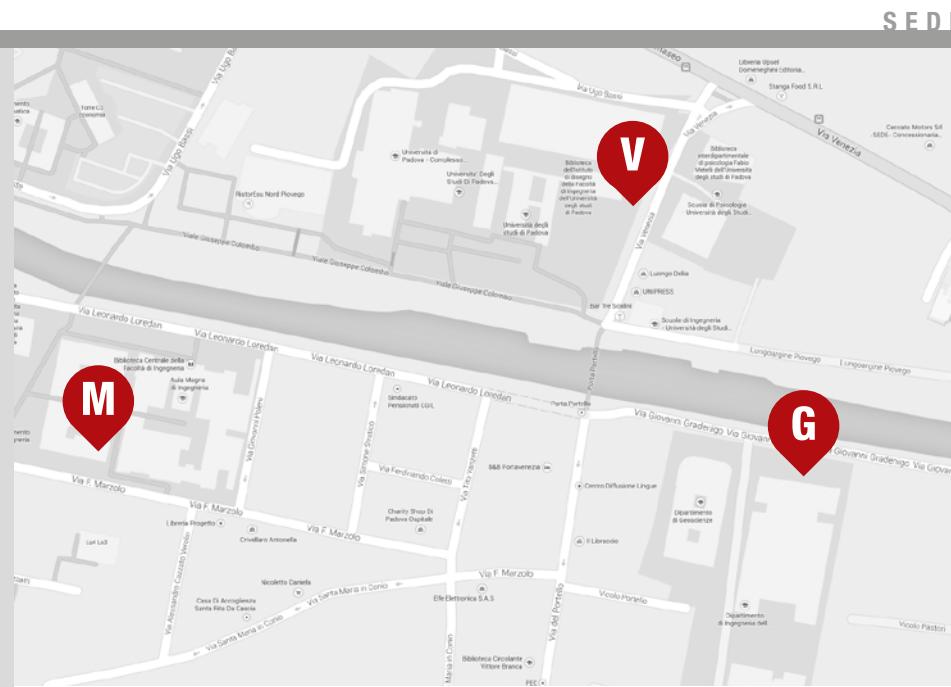
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