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DELL'UNIVERSITÀ DEGLI STUDI DI PADOVA

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DIPARTIMENTO
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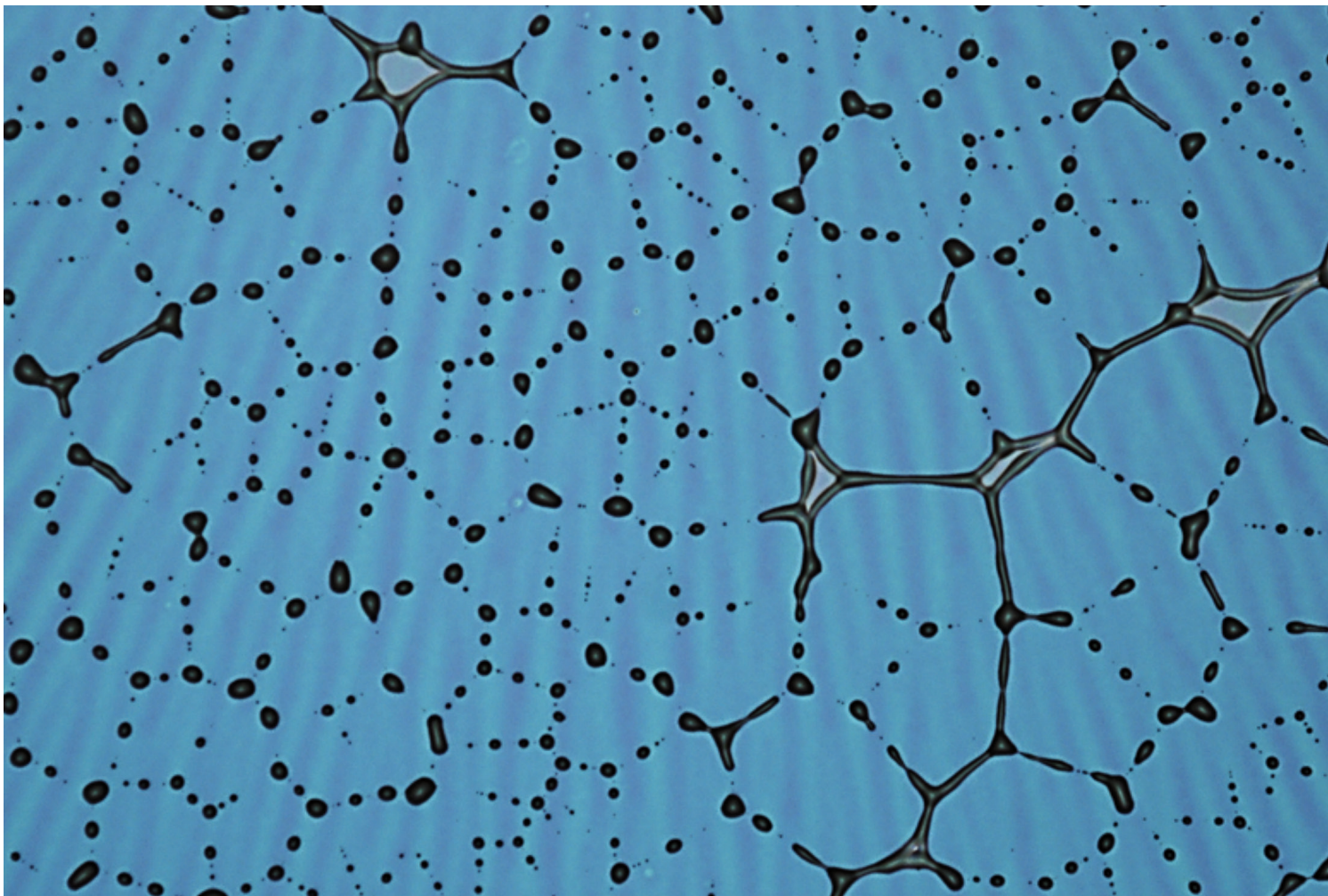
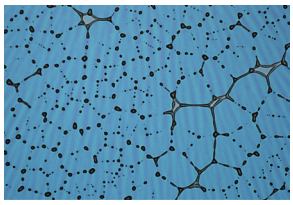
INDUSTRIALE





COPERTINA

Dewetting di film sol-gel

PAGINA

DIPARTIMENTO DI INGEGNERIA INDUSTRIALE

Removal of phenolic compounds using powdered activated carbons from spent coffee grounds

Emerging pollutants pose a severe risk for the ecosystems and the human health, since they are continuously released into the environment. Among them, phenolic compounds play an important role being widely used in industrial applications.

In the framework of circular economy, Spent Coffee Grounds (SCGs) were converted into Powdered Activated Carbon (PAC) by means of pyrolysis, using KOH as activating agent.

Figure 1. Powdered activated carbon obtained from spent coffee grounds.

Their adsorption capacity on a panel of phenolic compounds was compared with those of two commercial PACs, after preliminary studies on organic dyes with different ionic properties, to assess the affinity between adsorbates and adsorbents.

Pseudo-first-order and pseudo-second-order kinetic models were carried out, together with Freundlich and Langmuir isotherms. Results show a reduction of 100% for Methylene Blue (MB), 71.5% for Phenol (Ph), 97.0% for Chlorophenol (CP), and 34.4% for Bisphenol-A (BPA) with the PAC from SCGs.

Figure 2. Methylene blue discoloration after PAC treatment.

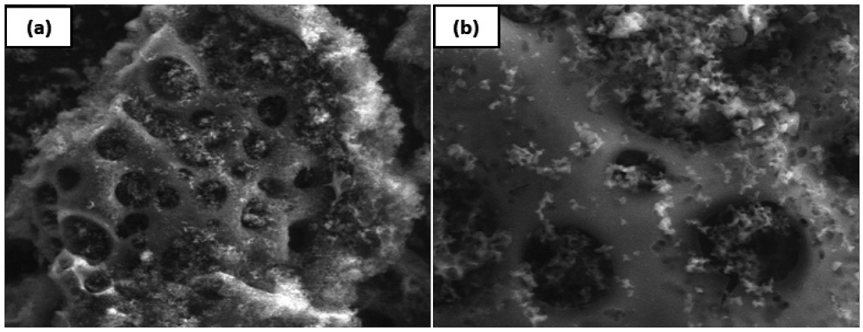


Figure 3. ESEM images of PAC obtained from SCGs at 400X (a) and 1600X (b).

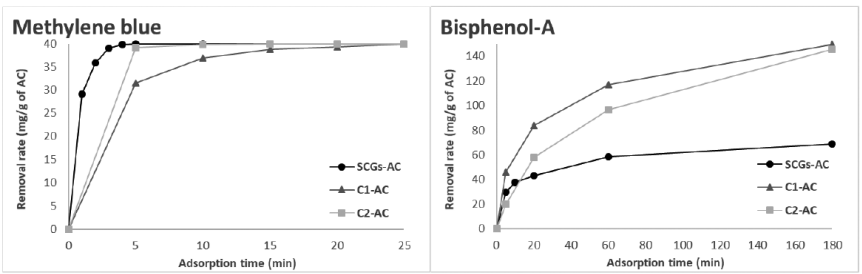


Figure 4. Removal rate (mg/g of AC) for methylene blue and bisphenol-A.

Research topic:
Materials

DII research group

CHEMTEC

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The research was carried out mainly by Rosson Egle (DII, University of Padova) within her PhD thesis work, with the collaboration of Dr Giovanni Marangoni (DII, University of Padova)

Acknowledgements:
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Main research topics:
- Wastewater treatment
- Activated carbon
- Adsorption
- Micropollutants removal

Research topic:
Materials

DII research group
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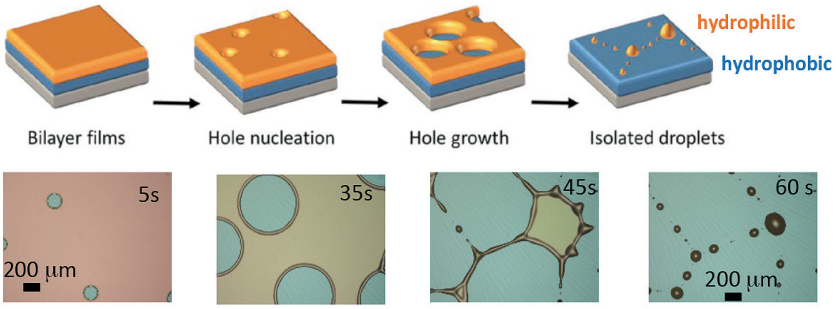
The presented research activity is carried out in collaboration with the Sustainable Thermal Energy Technologies research group: http://stet.dii.unipd.it/ and the Neto research group of University of Sydney.

Main research topics:

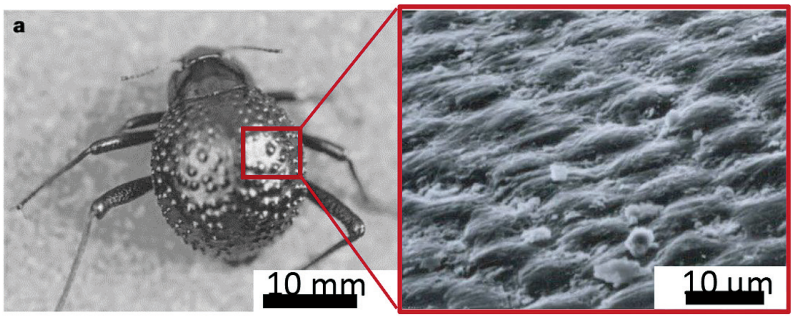
- Nanoparticles and nanopowders for functional application
- Thin film for functional application
- Ceramic nanocomposites
- Nanostructured materials for gas sensors
- Biopolymer nanocomposites
- Optical characterization of thin films and nanocomposites

Biomimetic Patterned Surfaces from Sol-Gel Dewetting

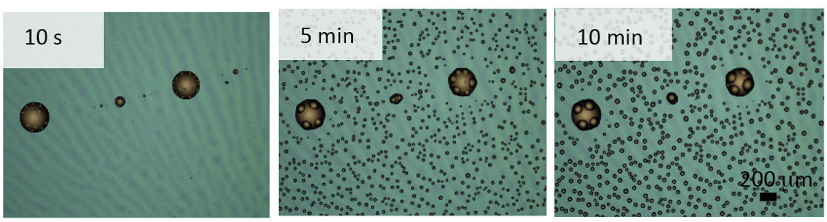
The realization of patterned surfaces with features in the micro- and nanoscale is of interest in many technological fields, such as for example photonics, microfluidics, cell culture. Common methods used to produce these features include photolithography, electrodeposition, focused ion beam milling, colloidal templating, and two-photon polymerizations. While these approaches offer a precise control of the size and spatial distribution of the features, the techniques are often complex and not suitable to upscaling. Recently, research in material science engineering has focused on biomimetic approaches based on integrating physical and chemical methods that combine soft matter structures and processes to yield materials with a variety of textures and shapes at different length scales. Among these, film dewetting is an attractive patterning approach, which combines low cost and straightforward procedures with the possibility of control over large pattern areas. In our group we developed a controlled dewetting of sol-gel thin films induced by solvent annealing. The key factors that control the dewetting process are identified and patterns with tunable diameter between 5 and 80 μm and tunable height between 1 and 10 μm are fabricated on a large scale. By changing the chemistry of the sol-gel system, we realized patterns with wetting contrast, consisting of hydrophilic bumps on a hydrophobic layer.



They are inspired by the exoskeleton of the Namib desert beetle.



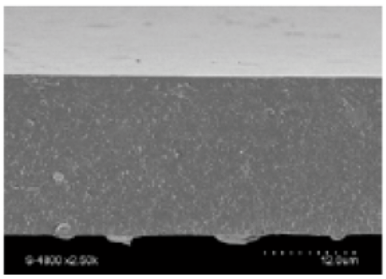
They are amenable to application in atmospheric water capture and dehumidification systems,as they facilitate condensation and allow for water droplets to roll-off at low critical volumes (6-8 μl).



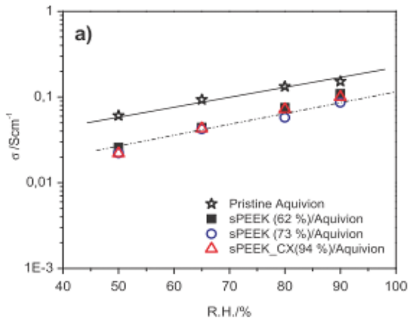
Condensation of 70%RH for ΔT= 3°C

Mechanically stable nanofibrous sPEEK/Aquivion composite membranes for fuel cell applications

In the continuous advances of proton exchange membrane fuel cells (PEMFCs), the development of the ionomer membrane is crucial for their reliability and high volume commercialization. An ideal membrane must attain a high proton conductivity and a low gas-permeability by maintaining at the same time a high mechanical, chemical and thermal stability, a low deformation due to water absorption and low cost of production. Maximizing the proton conduction, while keeping sufficient mechanical strength and reduced dimensional swelling is a key challenge for the development of PEMFC membranes. Much research in this domain has been devoted to the use of perfluorosulfonic acid (PFSA) ionomers, including composite/blend membranes and alternative functionalized polyaromatic systems. In this last approach, sulfonated polyether ether ketone (sPEEK) exhibits lower cost, lower fuel permeability and easier availability than PFSA but, at high levels of sulfonation, presents poor dimensional stability. A promising strategy is the development of composite nanostructured systems comprising electrospun nonwoven mats to stabilize proton exchange membranes and improve their properties for fuel cell application. Indeed, the incorporation of nanofibers provides a means to enhance overall membrane durability by increasing mechanical, dimensional, oxidative and hydrolytic stability, as well as proton conductivity in comparison to their conventional cast or extruded counterparts. In the present work we prepared nanocomposite proton exchange membranes based on fibrous sulfonated poly(ether ether ketone) (sPEEK) and Aquivion® using a two-step procedure involving electrospinning and impregnation. In all cases, the composite membranes demonstrated a diminution in proton conductivity compared to the non-reinforced membrane, but enhanced mechanical properties and dimensional stability. In particular, the system comprising crosslinked sPEEK presented the best mechanical and swelling behaviors with a lower conductivity loss.



Cross-section of composite membrane



In-plane proton conductivity measurements

Comparison of mechanical properties

Sample	Young modulus [MPa]	Yield stress [MPa]	Elongation at break [%]
Aquivion®	184 ± 4	9.7 ± 0.2	167.1 ± 8.0
sPEEK (62%)/Aquivion®	280 ± 5	10.3 ± 0.1	7.8 ± 1.1
sPEEK (73%)/Aquivion®	268 ± 1	10.7 ± 0.1	10.4 ± 2.9
sPEEK_CX (94%)/ Aquivion®	440 ± 20	15.5 ± 0.5	18.6 ± 0.3

Comparison of water uptake and dimensional stability

Membrane	Water uptake [%]	Area swelling [%]	Thickness swelling [%]	Volume swelling [%]
Aquivion®	74	80	19	114
sPEEK (62%)/Aquivion®	96	85	18	118
sPEEK (73%)/Aquivion®	–	–	–	–
sPEEK_CX (94%)/ Aquivion®	76	21	40	70

Research topic:
Materials

DII research group
Polymer Engineering Group (PEG)

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This research activity on composite PEMFCs has been carried out in collaboration with the Institut Charles Gerhardt of Montpellier University.
In particular the following people were involved in the project:
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Dr. Sara Cavaliere
Dr. Rakhi Sood
Dr. Stefano Giancola
Dr. Anna Donnadio
Dr. Stefano Pasquini

Polymer Engineering Group

Main research topics:

- Nanostructured membranes based on nanofibers
- High performance polymeric nanocomposites
- Thermal stability and fire behavior of polymeric materials and foams
- Design and processing of polymeric materials
- Physical and chemical recycling of plastic materials

Research topic:

Materials

DII research group
Advanced Ceramics and Glasses
CERAMGLASS

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Collaboration with Dr. J. Kraxner, Dr. M. Michalek, Prof. D. Galusek (FunGlass, Alexander Dubcek University of Trencin, Slovakia) and with Prof. A.R. Boccaccini (University of Erlangen - Nuremberg, Erlangen, Germany)

This contribution is a part of dissemination activities of the project FunGlass. This project has received funding from the European Union´s Horizon 2020 research and innovation programme under grant agreement No 739566 [https://www.funglass.eu/].

More information on glass and glass-ceramic foams available at https://www.sciencedirect.com/science/article/abs/pii/S0167577X19312492

Main research topics:

- Nanostructured ceramic composites from preceramic polymers and fillers.
- Advanced porous ceramic components.
- Bioceramics from novel formulations and processes.
- Monolithic and cellular glasses and ceramics.
- Novel building materials from inorganic waste
- Additive manufacturing of porous and dense ceramic components

Porous bioactive glass microspheres prepared by alkali activation/flame synthesis process

A scaleable, low cost preparation procedure for porous bioglass microspheres was developed by combining alkali activation of glasses (partial dissolution and formation of surface compounds) and flame synthesis. Irregularly shaped glass powder were first obtained by melting an oxide batch with chemical composition based on the 45S5 Bioglass®. The melt was poured onto a stainless steel plate, obtaining glass fragments, later crushed and passed through a 45 µm sieve. The powders were cast in an alkaline aqueous solution (1 M NaOH, for a solid loading of 65 wt%) and left for1 h under mechanical stirring (500 rpm). Finally, glass suspensions were dried and hardened at 75°C; the consolidated material was crushed and sieved in the range 45-75 µm. The hardening was due to the formation of Na- and Ca-based carbonate and silicate hydrated compounds (Fig. 1-2) subsequently exploited for high temperature foaming. In fact, activated powders were fed into an oxygen-methane torch (by means of a vacuum powder feeder at a rate of 1.4 g/min using oxygen carrier gas), which realized a fast softening of glass with concurrent gas evolution from activation compounds, interrupted by spraying distilled water. The process yielded porous glass microspheres (Fig. 3) to be used in tissue engineering applications (also as drug carriers). The intake of sodium ions from the activating solution nearly compensated the Na_2O loss from high temperature processing. In addition, the fast thermal cycle prevented extensive crystallization (see Fig. 2), which could decrease the bioactivity of 45S5 Bioglass®.

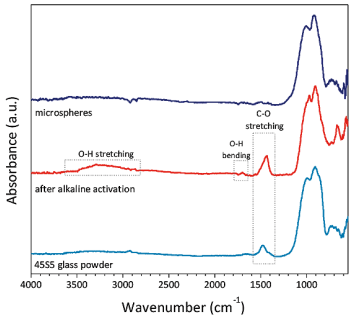

Fig. 1 (left) - FTIR spectra of 45S5 bioglass before activation, after activation and after flame synthesis; the activated material exhibits typical bands corresponding to the formation of hydrated compounds

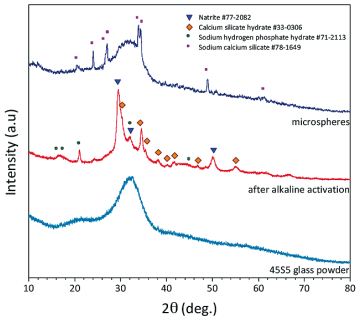

Fig. 2 (right) - Diffraction of 45S5 bioglass before activation, after activation and after flame synthesis; the activated material includes hydrated compounds and natrite (Na_2CO_3)

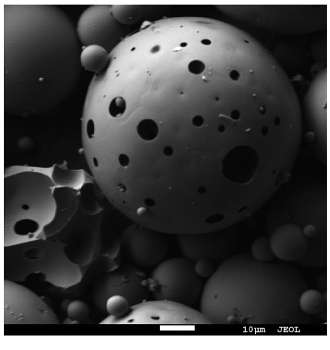

Fig. 3 (left) - Example of hollow bioglass microsphere after flame synthesis; the preliminary activation provides an intimate mixing of glass and foaming compounds (carbonate and hydrated compounds)

Integrated Thermal Electricity Storage System: Energetic and Cost Performance

A large penetration into the electric grid of variable, intermittent and unpredictable renewable sources like wind and solar is stressing the need of installing large-scale energy storage to compensate their power fluctuations. Pumped Hydro Storage (PHS), Compressed Air Energy Storage (CAES) and Flow Batteries (FB) are the commercially available technologies but suffer of geographical constrains or require fossil fuel streams or are characterized by low cycle life. With the aim of overcoming these issues, the TES group researchers developed and patented the "Integrated Thermal Electricity Storage System" (IT-ESS).

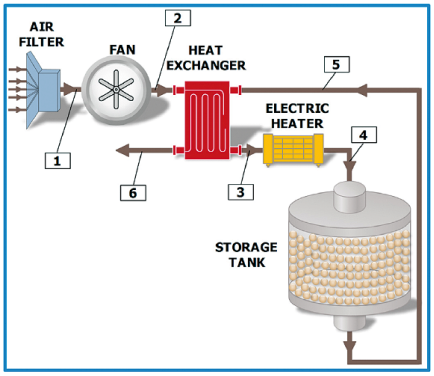

Figure 1. The IT-ESS charging scheme.

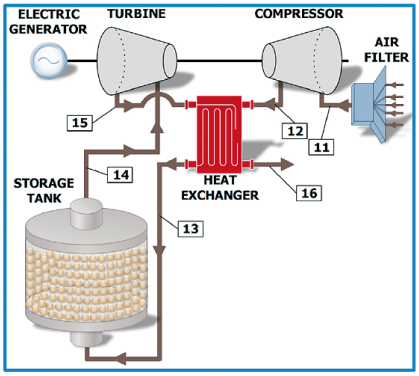

Figure 2. The IT-ESS discharging layout.

When the IT-ESS is managed in storing mode, ambient air is filtered and sucked by a fan (1-2), which boosts it into a regenerative heat exchanger (2-3) and, then, into the electric heater where it is heated up: the latter component acts as a conversion device where the excess electricity is converted into heat (3-4). The hot air exiting the electric heater (point 4), enters the storage tank, heats up the storage material contained into the reservoir and exits (point 5) at a lower temperature. The air at condition 5 flows across the heat exchanger (5-6) and is thrown out into the environment.

During the discharge phase, ambient air is sucked, filtered and, then, compressed by a compressor (11-12). The compressed air flows throughout the heat exchanger (12-13), enters the storage tank and, being the reservoir's storage material at high temperature, it is heated up. Then, hot and pressurized air enters the air turbine and expands. Being the turbine mechanically coupled with the electric generator, the air expansion generates mechanical power which is partially converted into electrical energy by means of the electric generator. In this manner, the excess electricity stored during low demand hours in the form of sensible heat in the IT-ESS, is reconverted again into electricity during peak demand hours.

Numerical investigations showed that IT-ESS energy density and price per energy unit stored is equal to 120÷180 kWh/m³ and 100÷180 $/kWh, respectively. Considering that PHS and CAES are characterized by an energy density of 0.5÷1.5 kWh/m³ and 3÷6 kWh/m³, and a price per energy unit stored of 10÷70 $/kWh and 2÷140 $/kWh, the IT-ESS can absolutely compete with both of them despite its lower energetic performance. In addition, IT-ESS does not suffer of geographical constraints like CAES and PHS, low cycle life like FBs and does not require fossil fuel like CAES.

Research topic:
Energy

DII research group
Turbomachinery and Energy System Group (TES)

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The research activity is carried out in collaboration with the Turbomachinery and Energy System Research Group (TES).

https://research.dii.unipd.it/tes/

Main research topics:

- Design and Optimization of New Large-Scale Thermal Energy Storage System
- Fossil Fuel Based Power Generation Unit Flexibilization
- Power Generation Units Dynamic Analysis
- Waste Heat Recovery Units Design and Optimization
- Hybrid Power Generation System Optimization
- Life Cycle Assessment
- Biogas Engine Emissions Characterization

Research topic:

Energy

DII research group

BETA_Lab: Building Energy Technology Assessment

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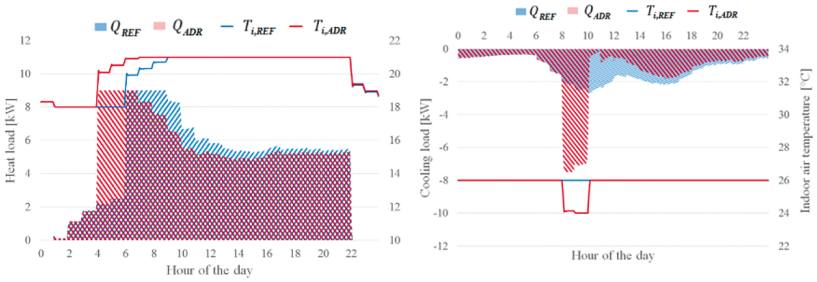
Main research topics

- Modeling and Field Measurements of Radiant Systems
- Ground Source Heat Pumps
- Solar Systems Design for Heating and Cooling
- Double Skin Facades
- Energy Analysis and Temperature Distributions in Large Spaces
- Simulations and Measurements in Buildings
- Energy Efficiency of Building Plant System
- Nearly Zero Energy Buildings (nZEB)
- Low Exergy Systems in Buildings
- Thermally Activated Building Systems
- District Heating and Cooling Networks
- Thermal Comfort
- Modelling and Development

HVAC control strategies to exploit the energy flexibility of buildings structures

The 2015 Paris Agreement on Climate Change following the COP21 Conference boosted the European Union's efforts to decarbonize its building stock. As a result, the European Commission presented in November 2016 the Clean Energy Package for All Europeans, a set of measures aimed at regulating the transition towards a sustainable energy system. The first document to be approved was the new Energy Performance of Buildings Directive (EPBD) 2018/844.
Among other novelties, the Directive 2018/844 introduces a framework to assess the smart readiness of buildings, which rates their ability to adapt their operation to the needs of the occupant and the grid and to improve their energy efficiency and overall performance. This capability is strongly related to the so-called energy flexibility of the building, i.e. to its "… ability to manage its demand and generation according to local climate conditions, user needs and grid requirements", as defined by the research group of the IEA EBC Annex 67.

For the first time, the EPBD does not only look at the performance of single buildings, but also on their ability to interact and provide additional services to the energy system. This regulatory step marks the advent of the digital age in the world of buildings.
The energy flexibility of smart-ready buildings can be exploited, for instance, by Active Demand Response (ADR) programs, i.e. changes in electric energy use of HVAC devices from their normal consumption patterns as function of certain signals. The thermal capacitance of buildings and thermal energy storage (TES) systems to shift the load of electrically driven HVAC devices -such as heat pumps.



In a recent simulation-based study, we showed that the potential for energy flexibility of buildings is mainly related to the level of insulation of the envelope during the heating season, and to the time of the event during the cooling season. The combination of these variables and the climatic conditions during the event determine the amount of energy that can be shifted over time. Some recurring trends and exceptions due to different user habits have been highlighted. Moreover, we showed that the cost associated with flexibility is an increase in consumption for upward modulation events and a reduction in thermal comfort conditions for downward modulation events. The greater the flexibility potential of the buildings, the higher the costs, both in heating and cooling modes.

In a parallel work, we wanted to exploit the energy flexibility of a residential dwelling equipped with an air-source heat pump and a PV solar system.
To this end, a model predictive control algorithm was developed with the aim of minimizing the heating cost. The proposed control strategy was able to significantly reduce the user's cost for electricity with respect to a conventional thermostat controller thanks to an increased share of self-produced electricity, approximately from 5% to 16%.
The energy bill for the final user is then reduced from 8% to 12% without affecting the thermal comfort in the indoor environment. Note that the controller exploits the thermal mass of the building to shift the heat load pattern with no need of additional thermal energy storage systems.

SafeUAV: a controlled parafoil system for drones

SAFEUAV project is focused on the design and testing of an unmanned controlled parafoil system, to be used as emergency landing device for UAVs in case of critical failure.

The system has successfully completed prototype development and a scale model has undergone initial flight testing with airdrop campaigns from an octocopter drone. The model, comprising a reduced dimension parafoil and electronics is carried at test altitude (100 m) under the octocopter drone using a dedicated flight chain and then released using a custom designed release mechanism. Parafoil is afterwards controlled by pulling down the left or right trailing edge of the canopy with two custom designed actuators, activated by the flight control system. The parafoil flight control system is implemented on off the shelf components using a Beaglebone control and command unit, commercial IMU and GPS sensors for attitude and trajectory data and brushless motors for actuation of parafoil's control lines. The system will include in its final configuration an on board NXP S32V234 vision processor for trajectory eleboration.

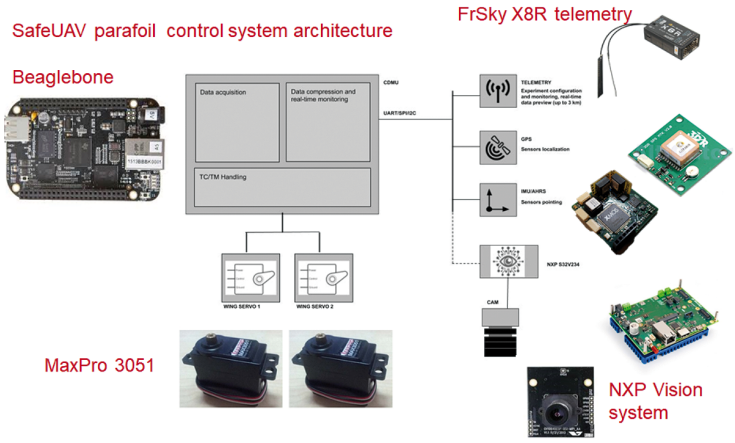


Figure 1. SafeUAV parafoil control system architecture

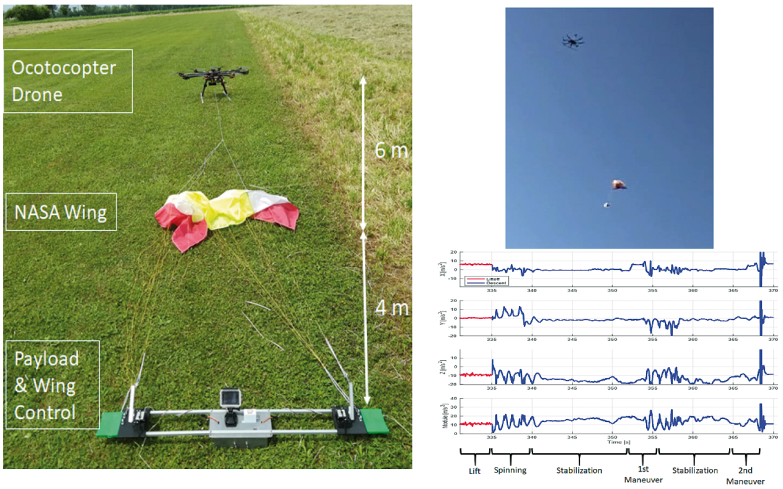


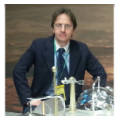
Figure 2. Flight chain (left) and test data of controlled descent (right)

Research topic:

Mechanical systems engineering

DII research group

Flight dynamics and space systems



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Main research topics

- UAV design
- Flight dynamics
- Parafoil trajectory control

SafeUAV is developed under coordination and funding by Department of Industrial Engineering as part of the SID research program of the University of Padova.

Research topic:

Mechanical systems engineering

DII research group

MMSA/Vehicle Dynamics

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Wearable airbags for motorcycle riders

Wearable airbags are relatively recent for the motorcycle-garments industry, and their development still relies mainly on trial and error through experimental testing. The application of numerical simulation is still in its infancy.

The research carried out at DII aims at assessing the performance of wearable airbags for motorcycle riders through numerical simulations. Comparison against experimental tests is also employed for validation purposes. The model of existing airbags have been built and simulated on a number of relevant test scenarios.

The first scenario is derived from the drop test used for certifications according to EN 1621. The results are used to calibrate the virtual models and to estimate the bag material properties by comparison of numerical and simulated anvil peak force.

In the second scenario the airbag is fitted on a Hybrid III 50th dummy model and validated in a thorax impact test, according to 49CFR572. The focus is mainly on the dummy's chest deflection. A low speed variant of 49 CFR 572 has also been also considered (SAEJ2779).

In the third scenario a shoulder impact test is considered. In this scenario the Hybrid III dummy cannot be used, indeed it has been developed for frontal impacts - a human body model has been used instead.

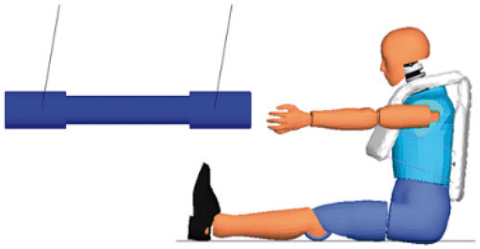
The models have also been used to investigate a number of design parameters, in order to maximize the protection performance of the airbag, namely the inflation pressure, the shape of the bag, its thickness as well as the position of welded joints and stiches.

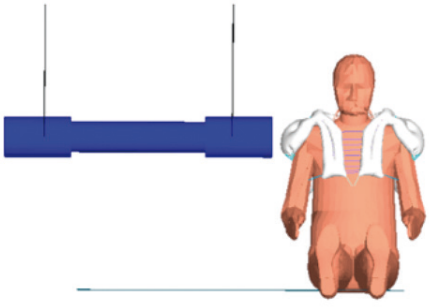
The simulation have been carried out using the Madymo simulation environment.

The research has been supported by FSE 2014/2020, projects 2105-118-2121-2015 and 2105-86-2216-2016. Additional details can be found in the following references.

E. Marconi, F. Gatto, M. Massaro, "Numerical and Experimental Assessment of the Performance of Wearable Airbags for Motorcycle Riders", Proceedings of the World Congress on Engineering, July 4-6, 2018, London, UK.

D. Girardi, E. Marconi, M. Massaro, "Assessment of shoulder and chest protection of wearable motorcycle airbags", Proceedings of the ASME 2019 International Design Technical Conference, August 18-21, 2019, Anaheim, CA, USA.





The impact of Enterprise Social Networking on Performance Measurement and Management

Literature describes the transformation process of employees' individual competences into firm-specific competences as a great challenge in the performance measurement and management (PMM) field.
Recently, to favour the transformation of competences, some companies have adopted enterprise social networking (ESN). However, not enough studies support the understanding of its role in performance measurement and management and scant attention is given to the inclusion of competences in holistic performance measurement and management system.
To help close this gap, using a qualitative meta-analysis, the use of the ESN is investigated 32 multinational companies (see for instance Marriott Hotel, Mc Donald's, Microsoft, Novartis, Oracle, Pfizer, Procter and Gamble, Royal Dutch Shell etc.).
The findings highlight the key role of ESN in supporting the transformation process of knowledge, skills and abilities (KSAs) based on the opportunities of social relations between employees who share interests, hobbies or activities.
ESN is largely used by employees to manage their competences, create their own profiles, connect themselves with other workers, communicate messages and post files in real time. Moreover, using ESN people can host forums on their own favourite topics concerning work questions and informal talk. The use of ESN improves the learning and knowledge of everyone and generates numerous benefits for organizations. ESN creates the opportunity to improve knowledge sharing in the workplace; an intermittent, centralized knowledge management process is transformed into continuous online knowledge. This online knowledge circulates very quickly as it could easily be shared in vertical and horizontal communications; it is transferable and managed by the whole network, i.e., knowledge of "who knows what" and "who knows whom".
As summarized in Table I, the meta-analysis highlights some ESN characteristics that typify the process of measurement and management of competences and that may support the transformation of knowledge, skills and abilities of employees.

Table I. Measurement and management of competences by ESN.

KSA management	Provide continuous feedback, suggestions and support Facilitate relationship, knowledge sharing and discussions Allow to open project on favourite topics Encourage self-management of own KSAs Impact on emotions and behaviours
KSA measurement	Provide real time data collection, analysis and reports Allows self-monitoring of activity reports Encourage the use of KPIs Favour a self-performance measurement

Research topic:

Management and Entrepreneurship

DII research group

Management e imprenditorialità

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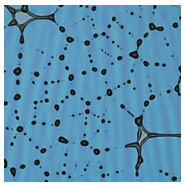
Main research topics:

- Performance measurement and management
- Social networking
- Knowledge, skills and abilities (KSAs)

Cover story



Dewetting di film sol-gel: l'immagine, ottenuta con un miscroscopio ottico, mostra un timelapse di un processo controllato di dewetting ("debagnamento") di un film sol-gel di silice. Tale processo è stato utilizzato per creare micropattern costituiti da isole idrofiliche su uno strato idrofobico ispirate all'esoscheletro di uno scarabeo del deserto del Namib. Grazie alla diversa bagnabilità, questi rivestimenti facilitano la condensazione dell'acqua in condizioni di basse umidità e possono trovare applicazione in sistemi di deumidificazione. Tale ricerca è stata svolta in collaborazione col gruppo della professoressa Neto, Università di Sidney.

Dott. Ing. Elena Colusso

Nata a Treviso, il 28/10/1990. Ha conseguito la laurea magistrale in Ingegneria dei Materiali nel 2014 presso l'ateneo patavino, dove ha poi proseguito gli studi ottenendo nel 2018 il Dottorato in Scienza e Ingegneria dei Materiali e delle Nanostrutture sotto la supervisione del prof. Alessandro Martucci. Durante il dottorato ha svolto un periodo di ricerca presso Tufts University, collaborando col gruppo del Prof. Omenetto allo studio dei nanocompositi a base di fibroina di seta. Dopo un breve periodo di ricerca presso l'Università di Sidney, è rientrata a Padova come ricercatrice post-doc presso il gruppo NanoEng del DII. I suoi interessi di ricerca riguardano principalmente lo sviluppo di materiali nanostrutturati biomimetici per applicazioni in campo ottico e ambientale.

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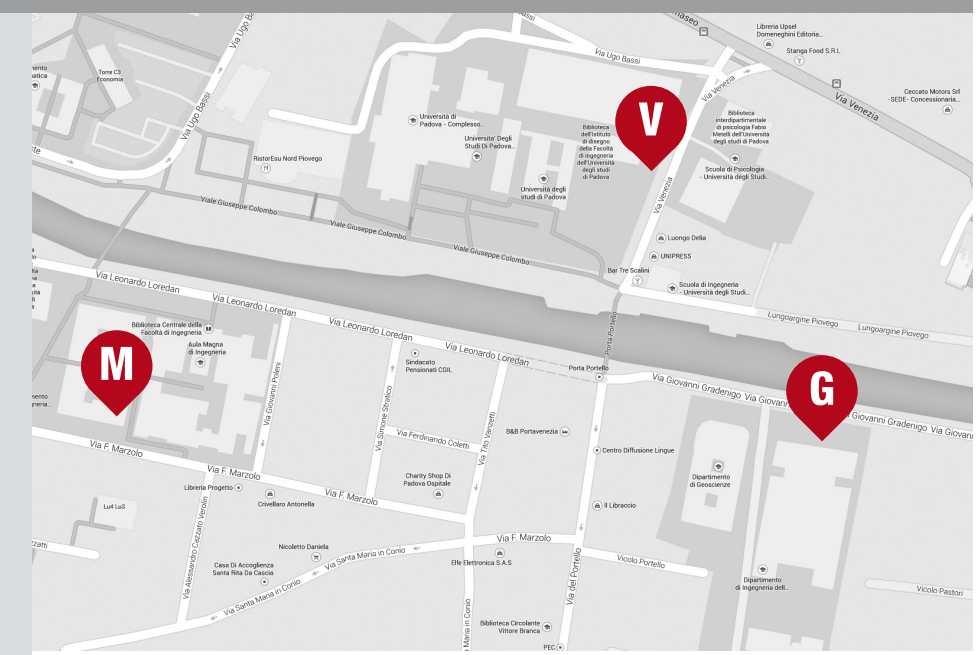

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