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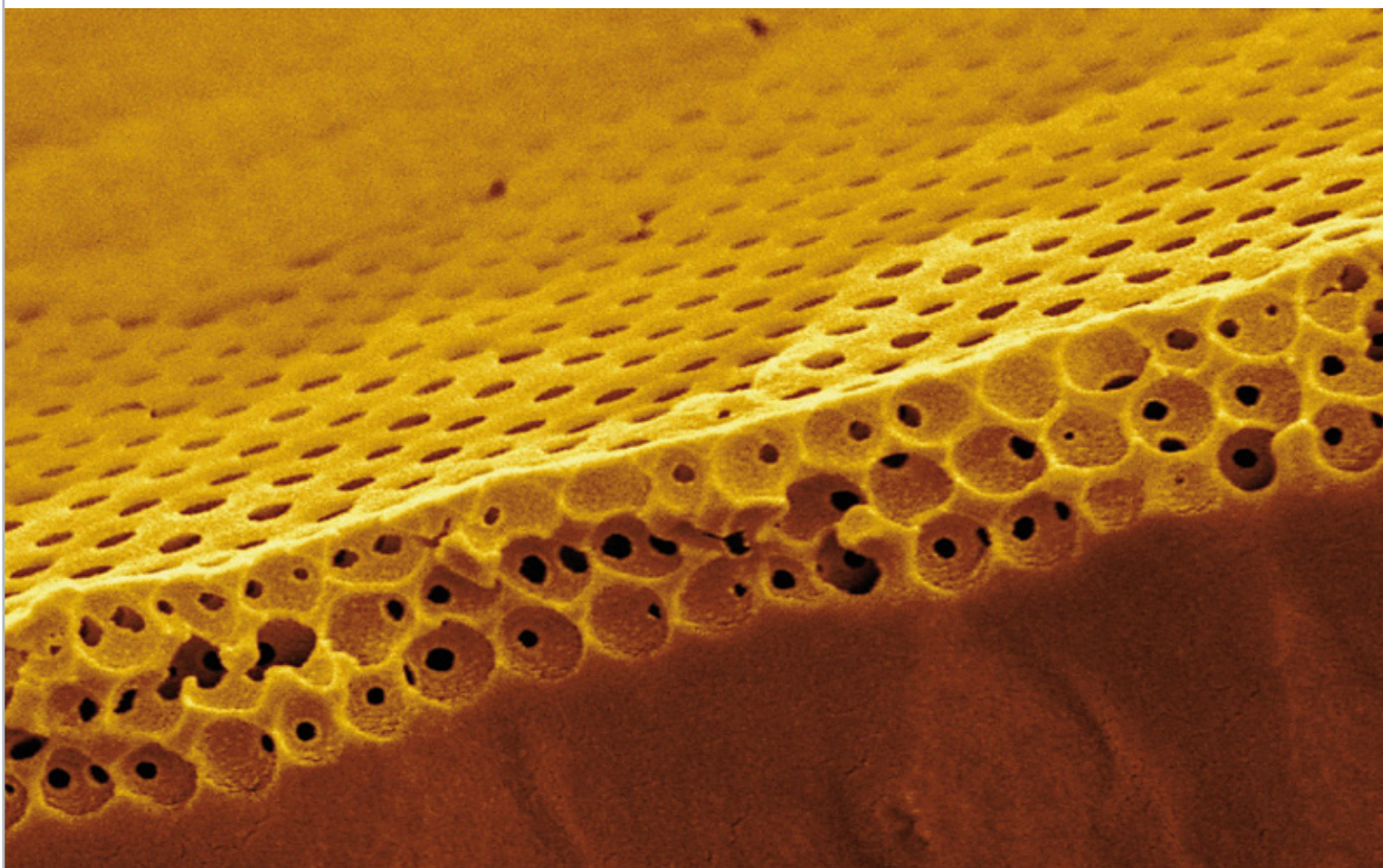
NEWSLETTER DEL DIPARTIMENTO DI INGEGNERIA INDUSTRIALE DELL'UNIVERSITÀ DEGLI STUDI DI PADOVA

UNIVERSITÀ DEGLI STUDI DI PADOVA

DIPARTIMENTO DI INGEGNERIA INDUSTRIALE



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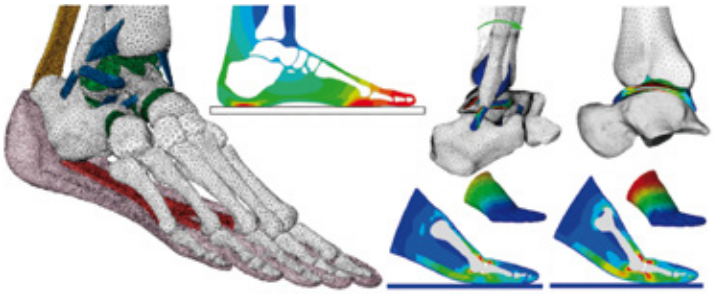
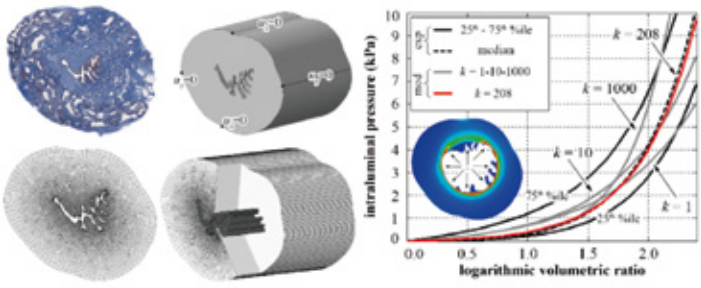
DIPARTIMENTO DI INGEGNERIA INDUSTRIALE

Mechanics of Biological Tissues and Structures

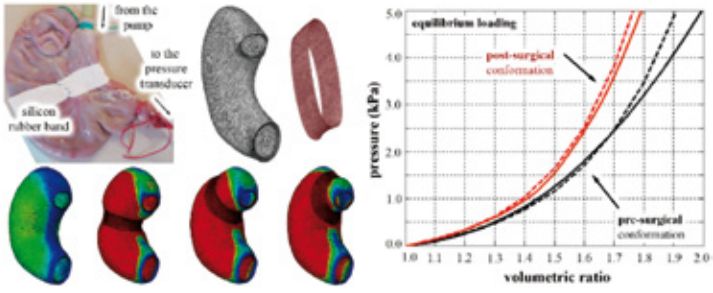
The activity is reported with reference to the Center for Mechanics of Biological Materials established at University of Padova (www.cmbm.unipd.it). Integrated research and advanced education is performed within different departments that belong to engineering and medical area, with an interdisciplinary approach in treating the problems of biological tissues, biomaterials and biological structures mechanics. Experimental and numerical investigations are performed with regard to both hard and soft tissues. Computational mechanics approach is addressed to material and geometric non linear problems, by defining advanced constitutive formulations and procedures for parameters identification. Visco-hyperelastic, plastic, damage and multiphase models are developed with regard to different tissues, according to their histo-morphometric configuration and phenomenological functional response. Healthy and degenerated conditions are considered, investigating the evolutionary behavior caused by ageing, pathology and trauma. Modelling of complex biological structures is performed with regard to dental, foot, urological, gastroenterological, etc. mechanics. The mechanics of biological tissues is studied also with regard to phenomena occurring by the adoption of prosthetic devices, in particular evaluating the interaction phenomena occurring at tissue-implant interface, on the evolutionary healing trend or degeneration. The analysis of the mechanical response of biomaterials represents a fundamental part of the investigation, in direct correlation with the industrial design and manufacturing of biomedical devices, for evaluation of biomechanical compatibility. Extended relationships are maintained with European and North American Universities, research centers and industries, aiming at the development of international research projects.



foot biomechanics



urological biomechanics



gastrointestinal biomechanics

Bioingegneria, biotecnologia e tecnologie per la salute
Bioengineering

DII research group
Mechanics of Biological Tissues and Structures

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Centre for Mechanics of Biological Materials

Main research topics:

- Integrated experimental and computational investigation of the mechanical behavior of biological tissues and structures
- Computational methods for the analysis of biomechanical functionality in healthy and degenerative conditions
- Computational tools for the design and the assessment of surgical/diagnostic procedures in correlation with medical practice
- Design and reliability investigation of biomedical devices

Energia
Energy

DII research group
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Photometry and Light Engineering

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This study was carried out in collaboration with ing. Elena Pedrotti and ing. Alessandro Scroccaro.

The research topics are realised also in collaboration with:

Agenzia regionale per la Prevenzione e Protezione Ambientale del Veneto

Università degli Studi di Padova

Università degli Studi di Padova — Dipartimento Di Psicologia Generale

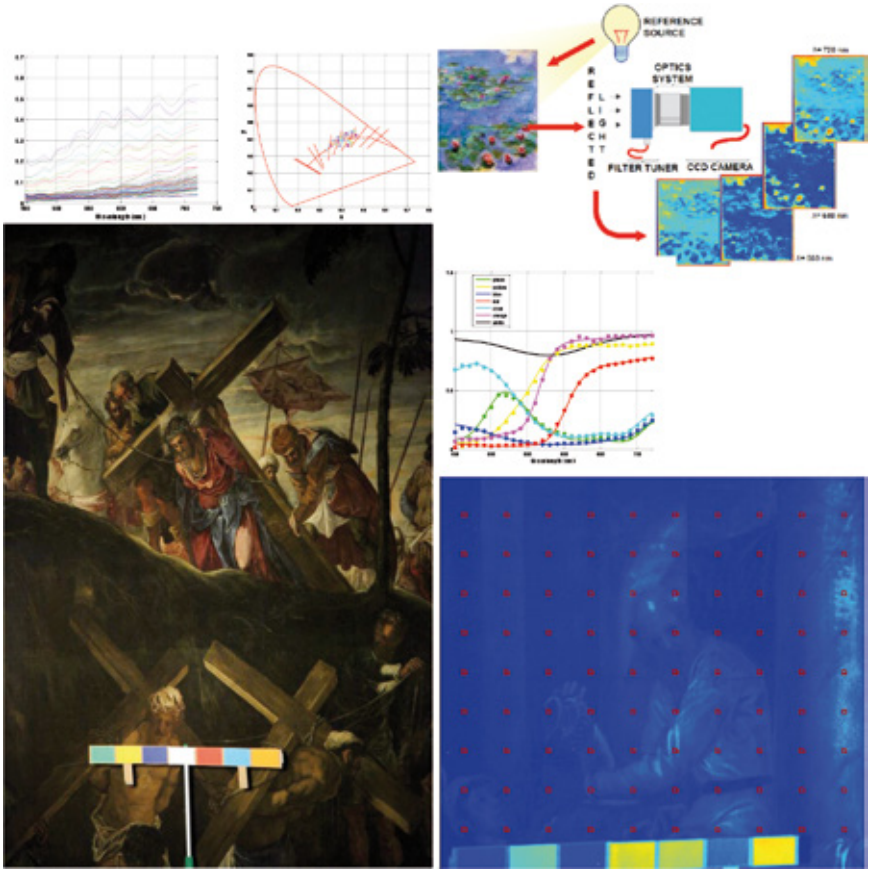
OSRAM

Main research topics:

- Measurement and calibration of light sources and radiant sources
- Analysis of reflecting properties of surfaces
- Study of colour rendering of light sources and applications to the lighting of works of art
- Use of ultraviolet source in water purification

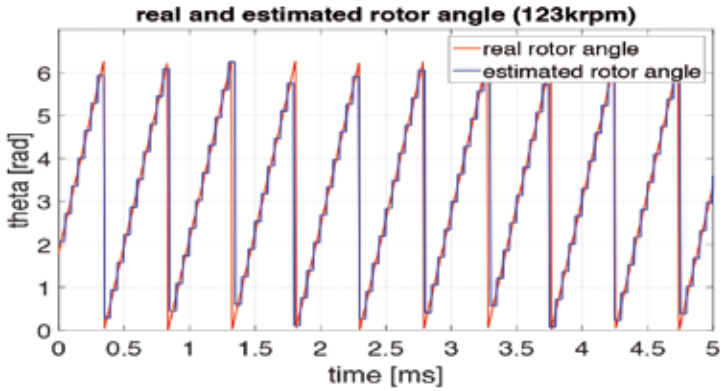
Analysis of Tintoretto's paintings in the Scuola Grande di San Rocco by an Image Spectrometer

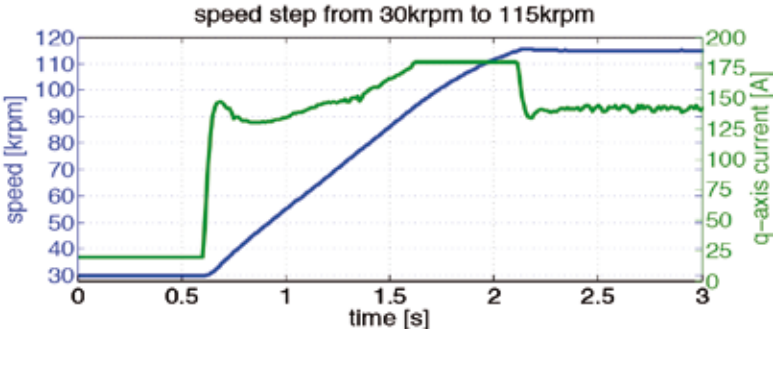
The Scuola di San Rocco is a confraternity established in Venice in 1478 by a group of wealthy Venetian citizens. The walls of their seat are covered by Tintoretto's painting. The lighting systems consisted of halogen spot lights which allow a very low lighting of the painting and of the halls themselves and do not take into consideration the colorimetric characteristics of the surface to be lit.
A new lighting system was required and should be based on the analysis of the colorimetric characteristic of the paintings.
As colours are a perception which depends on the impinging light and on the object ability of reflecting light , to define the light source, we need to measure the spectral reflectance function of the paintings, in many points. We have to characterize wide areas without touching the precious works.
An image spectrometer was ad hoc composed by a scientific CCD camera and a lens; tunable filters to identify different wavelengths in the visible range were applied, a source emitting radiation in all visible range lit the paintings; a set of various chromatic samples was inserted into the scene as a reference; an acquisition system allowed the managing of a huge amount of recorded data.
The shapes of most of the reflectance functions are similar, this confirms the visual appearance of the paintings which present mainly red, yellowish, and brownish nuances.
The estimate of the overall measurement uncertainty suggests a value about 7% of the measured value plus a bias of 1% caused by the acquisition noise.
The measurements is the basis for the new lighting system for the Tintoretto painting in the "Scuola Grande di San Rocco", it allows the appearance of the painting is as close as possible to the one under the ideal light source, reducing the risk of deterioration of the painting due to the radiation, as it uses the less power.



Design and control of super high-speed electrical machine for a fuel-cell compressor for automotive applications

High-speed electric drives are gaining popularity in various applications: pumps, compressors, blowers, hybrid-electric vehicles and micro gas turbines. This is thanks to the advantages of such drive solutions, among the others the increase of the power per kilogram ratio of the machine.
This advantage, is particularly well suited in mobile applications such as electric vehicles where space and weight saving is a mandatory target in order to improve the system's consumption and emissions. Another important advantage is the reduction/removal of intermediate speed-up gearbox thanks to the adoption of a high speed motor: this yields an immediate improvement of the system reliability and a reduction of its maintenance cost.
Nevertheless, the operation of the motor at high speed requires a particular system design. Traditional bearings are normally avoided for high speed machines and a bearing-less solution or air bearing configurations are adopted. The latter is particularly advantageous in high speed compressors, where the air bearing can be fed directly by the compressor outlet. Such solutions introduce additional requirements on the drive, e.g. when it comes to the design of the start-up procedure. Further, the mechanical constraints in the use of position resolvers for high speed permanent magnet synchronous motors call for efficient sensor-less control algorithms based on speed estimators. The electrical peculiarities of such high speed machines (such as low stator inductance and resistance) can cause a series of problems with the stability of the control, if the position and speed of the rotor are not known with high precision.
EDLab conducted a research in cooperation with Alpitronic and BMW to develop and implement an electric drive for a super-high speed compressor for fuel cells (i.e. 130,000 rpm) designed for an electric vehicle. A control scheme, based on a sensorless Extended Kalman filter algorithm, has been implemented and successfully tested in a real drive system with three different compressor prototypes. Experimental measurements at full speed and in dynamic response have been successfully performed.





Ingegneria dei sistemi elettrici
Electric systems

DII research group

EDLab
Electric Drive Laboratory

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Research in cooperation with:

Main research topics:

- EDLab is mainly devoted to the study, design and experimental validation of advanced issues related to the design and the control of electrical motors for variable speed drives for any industrial, commercial and home application.

- A distinctive recognized feature of EDLab is the development of researches in tight synergy between the motor designers and the control designers.

Ingegneria dei sistemi meccanici
Mechanical systems

DII research group
Applied Mechanics

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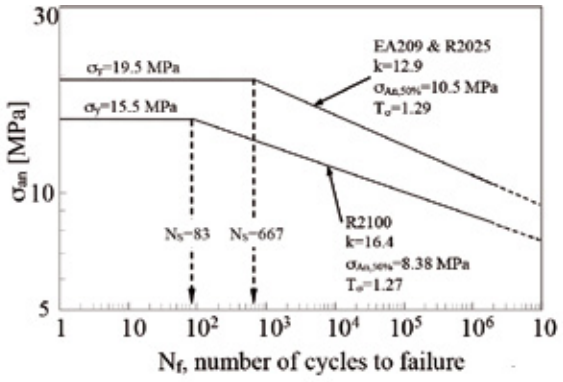
Lavoro realizzato in collaborazione con Electrolux S.p.A.

Main research topics:
- Structural Integrity
- Fatigue behaviour of Metallic Materials and Structures
- Fracture Mechanics of Metallic Materials
- Fatigue and Fracture design methods of Metallic and Polymer materials

Fatigue design curves of virgin and recycled polypropylene compounds

Nowadays recycling is one of possible strategies to achieve reduction of product-costs as well as environmental impact. In this context, thermoplastics are very efficient materials for their recycling feasibility. In last months, the static and fatigue behavior of different calcium-carbonate ($CaCO_3$) filled polypropylene (PP) compounds, containing different fraction of recycled PP, was analysed. Static and fatigue notch sensitivity and damage mechanism were investigated as well. Tensile static and fully reversed fatigue tests were carried out on three different compounds, namely a 42 wt% $CaCO_3$ filled PP (EA209), a 42 wt% $CaCO_3$ filled PP containing 25% recycled polypropylene (R2025) and a 42 wt% $CaCO_3$ filled 100% recycled PP (R2100). The notch sensitivity was investigated as well, considering double-edge notched specimens, having 10 mm circular notch radius, 2 mm U-notch radius and 0.5 mm V-notch radius. Concerning their fatigue behavior, it was found that all tested materials are notch insensitive from extremely low to high cycle fatigue regime. Moreover, at least from an engineering point of view, it was noted that the presence of 25% recycled PP did not influence the material fatigue strength, compared to that of specimens made of virgin PP. Therefore, a single design stress-life curve was proposed for both materials, based on the net-stress-amplitude . Conversely, a down-graded design stress-life was proposed for R2100 compound (see Fig.1). During the static and fatigue tests, the damage evolution was investigated by using an on-board travelling microscope. It was found that under static and fatigue loads, damage mechanisms and their evolution were independent on the type of material and notch radius and consisted of void formation and coalescence. As an example, Fig. 2 shows the damage evolution observed from "lateral view" (see Fig. 2a) in a R2100 specimen having a notch radius of 10 mm, fatigued by a net-stress amplitude sa= 10 MPa that failed at 281980 cycles.

Fig. 1. Fatigue design curves for EA209 & R2025 compounds and for R2100 material.



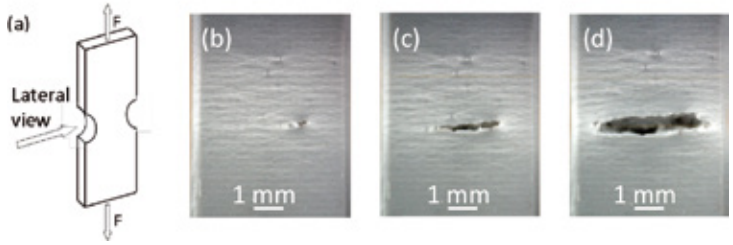


Fig. 2. Fatigue damage evolution observed at the notch tip from "lateral view" (a) at N=278983 (b), 280636(R2100_R10, σ_{an}=10 MPa; N_f=281980).

Novel 'inorganic' gel casting process for the manufacturing of glass foams

A new technique, based on gel casting, has been developed for the production of highly porous soda-lime glass foams (porosity >85 vol%). The new process is less expensive and more environmentally friendly than the current procedures, based on the sintering of glass powders mixed with foaming agents, which decompose and release gases at temperature well exceeding the glass softening point (850-950 °C).

The alkali activation of soda-lime waste glass allows the obtainment of well-dispersed concentrated suspensions, undergoing progressive gelification by treatment at low temperature (80 °C), owing to the formation of calcium-rich silicate hydrates. An extensive direct foaming is achieved by mechanical stirring of partially gelified suspensions, exhibiting a marked pseudoplastic rheological behavior (see Fig. 1), comprising also a surfactant.

The final microstructure (total amount of porosity, cell size) can be directly correlated with the degree of gelification (Fig. 2). A sintering treatment, at only 700 °C, is finally applied to stabilize the structures, particularly for limiting the leaching of alkaline ions (Fig. 3a).

The specific strength ($\sigma f/\rho$) of the newly developed foams approaches 10 MPa cm³/g, in good agreement with the data for commercial foams.

The process can be easily extended to many types of glasses, Ca-rich (e.g. bioglasses, Fig. 3b) or not (e.g. nearly Ca-free alumino-boro-silicate glass from the recycling of pharmaceutical vials., Fig. 3c)

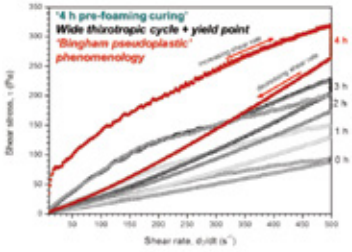


Fig.1 (left) – Flow curves of soda-lime glass suspended (65 wt% solid content) in alkali activated aqueous solution (2.5 M KOH) after different gelation times, before mechanical stirring

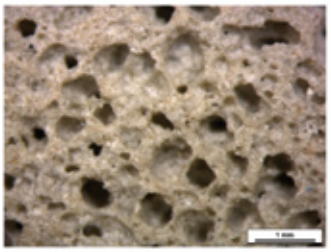
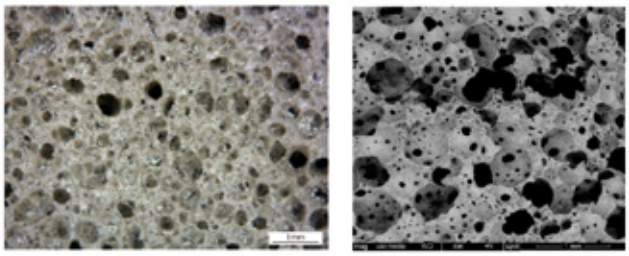


Fig.2 (right) – 'Green' soda-lime glass foam, after mechanical stirring and drying (24 h at 75 °C)



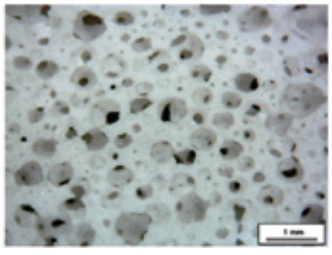


Fig.3 – Examples of glass and glass-ceramic foams from gel casting (followed by sintering)
a) soda-lime glass foam after firing at 700 °C
b) bioactive wollastonite-diopside glass-ceramic foam, after sinter-crystallization at 900 °C
c) Glass foam from pharmaceutical glass, sintered at 700 °C

Materiali avanzati
Advanced Materials

DII research group

ACG - Advanced Ceramics and Glasses

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This study was carried out in collaboration with Prof. Marco Pasetto and Dr. Giovanni Giacomello (Department of Civil, Environmental and Architectural Engineering (ICEA), University of Padova)

The research leading to these results has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No 642557 (CoACH, www.coach-etn.eu)

More information on glass and glass-ceramic foams available at http://www.sciencedirect.com/science/article/pii/S0955221917300262 (open access) and http://www.mdpi.com/1996-1944/10/2/171 (open access)

Main research topics:

- Novel construction materials from inorganic waste and/or recycled glasses
- Monolithic and cellular glasses and glass-ceramics
- Nanostructured ceramic composites from preceramic polymers and fillers
- Advanced porous ceramic components
- 3D printing of ceramics
- Bioceramics from novel formulations and novel processing
- Porous geopolymers

Management
Management

GREEN Gruppo di Ricerca
in Economia dell'Energia

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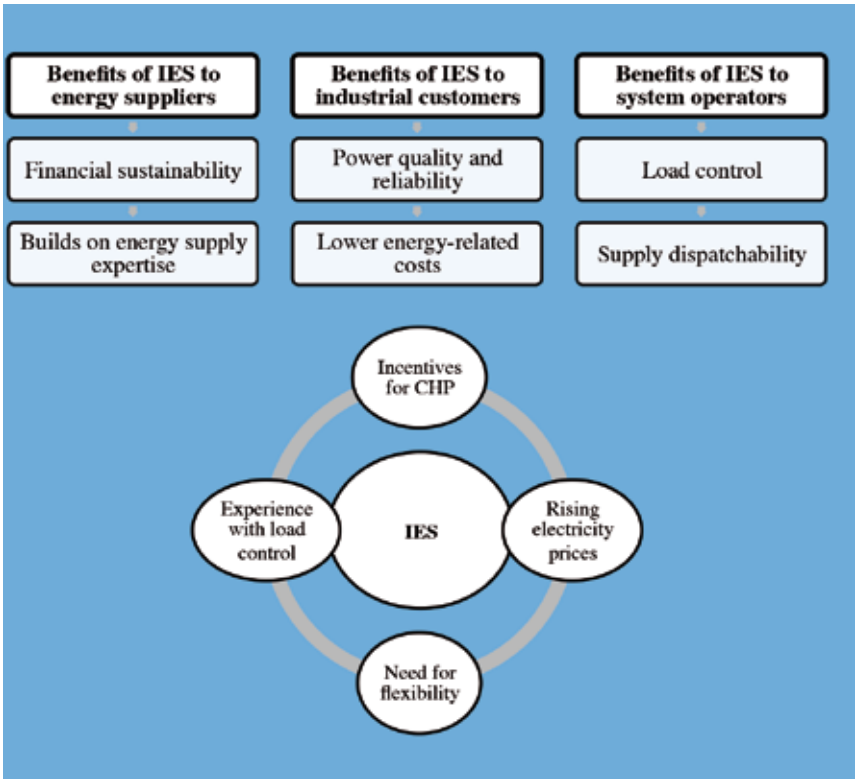
The research area of the Energy Economics Group is focused on Energy markets, Renewable energy and energy efficiency economics and policy, Energy and climate policies.
We work in the field of regulation for various bodies at the international level and are consultants for companies and public administrations.

Main research topics
- Conversion of solar energy
- Energy markets and regulations
- Energy scenarios and energy/environment policies
- Technologies for energy saving
- Economic evaluation of environmental and energy resources

New business models for electricity supply

Liberalization policies, the challenges of integrating distributed generation resources, and the recent flattening of electricity demand due to the economic crisis and technological change have led to lower returns for European electricity suppliers. Innovative and sustainable business models are needed to serve electricity customers while reflecting the operational needs of the system and maintaining supplier financial viability. Our research describes a novel model of Integrated Energy Services that encompasses distributed generation (DG) and demand response (DR) resources for industrial customers. We further worked on some of the market opportunities and regulatory drivers for the development of similar schemes across Europe.
The traditional business of European Utilities is shrinking and their market value has been dramatically reduced in the last decade. This is due to the low margins in electricity supply, with a flat demand since the crisis of 2008 and the fast technological change that is making the digital control of electricity grid affordable and reliable. In this framework a new role is given to grid operators and utilities are looking for higher margins in supplying new services with higher returns. Our work is focused on understanding the value for the system of these services and on addressing the regulation for an efficient evolution of the sector.



Prediction of powder segregation in mass and funnel flow silos

Every process involving the handling of particulate materials with different physical properties (e.g. particle size, density, shape or surface roughness) can lead to a spatially non-uniform state of the bulk. This phenomenon is called segregation. The British Materials Handling Board asserts that "segregation is the most influential common factor that adversely affects the uniformity of bulk materials"; segregation, in several case, creates granular products out of specification. Broad size distributions seem to be the major factor determining the segregation of granular materials. Typically during bulk deformation, the smaller particles fall down into the voids existing between the larger ones with the result that some regions are enriched of fines while other of coarse material. This specific mechanism of segregation is called percolation.

The prediction of segregation in order to control and minimize the phenomenon is an important industrial challenge. APTLab has developed and implemented a numerical model for prediction of segregation in binary mixtures of granular materials differing in size. Bulk composition variations due to percolation can be predicted for example during the discharge of silos operating in different flow regimes: mass [Fig.1] and funnel [Fig.2] flow regime. This model is sensitive to the local mixture composition and to the local shear rate. The flow of granular material is simulated through an ad hoc rheology and numerically coupled with the segregation model. Numerical simulations have been compared with published experimental data to validate the model. The model correctly predicts three different stages during the discharge both the flow regimes (mass and funnel flow in [Fig.3] and [Fig.4] respectively): 1) an initial transient, with an enrichment of fines at the outlet; 2) a pseudo-steady state in which no segregation is observed and 3) a final transient characterized by a large segregation of fines, particularly in the funnel flow regime.

Fig. 1

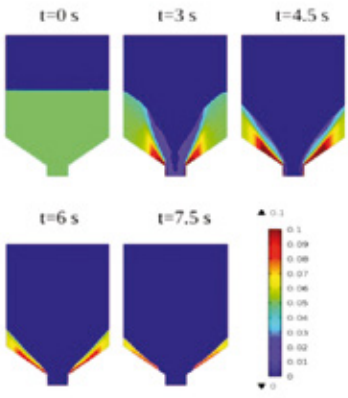


Fig. 2

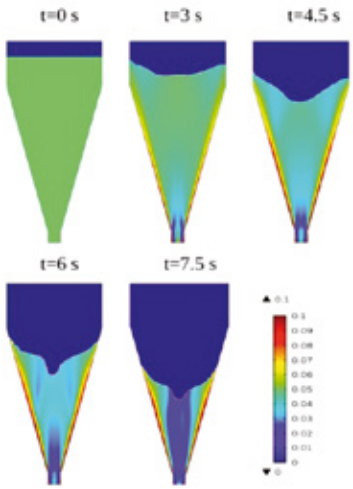


Fig. 3

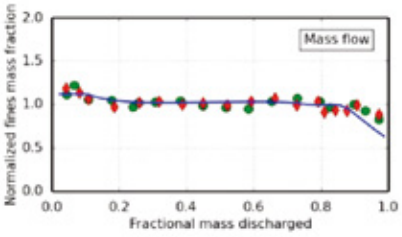
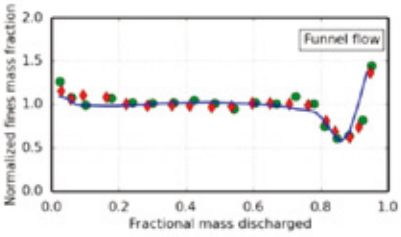


Fig. 4



Management e imprenditorialità
Management and entrepreneurship

DII research group
APTLab – Advanced Particle Technology Laboratory

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Main research topics:

- Mechanics of particulate materials
- Multiphase flows
  (gas-solid flows, wet granular materials)
- Mixing and segregation of powders
- High shear wet granulation
- Powder wettability and flowability
- FEM and DEM modelling of powder behavior

Ambiente
Environment

DII research group
Analisi del Rischio
nell'Industria di Processo

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Research collaboration:
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Prof. B. Fabiano Università di Genova
Prof. M.F. Milazzo Università di Messina
Prof. C. Pellegrino DICEA
Università di Padova
Prof. R. Nomen IQS Barcellona (E)
Prof. A. Jovanovic,
University of Stoccarda (D)
Prof. S. Macchietto,
Imperial College London (UK)

Industrial collaboration:
ANTEA s.r.l. Padova (I)
UNISAFE, Spin Off Venezia
Corpo Nazionale Vigili del Fuoco
Honeywell Co. New York (USA)

Main research topics:
- Development and Application of Risk Analysis Procedures in the Process Industries.
- Reliability and Safety Engineering.
- Analysis and Mitigation of Emerging Risks Concerning Energy Supply Critical Infrastructures.
- Risk Analysis in Transport of Dangerous Goods
- Development of Early Warning Detection Systems in Runaway Reactive Systems.
- Innovative Hazard Identification and Evaluation Techniques in the Green Chemistry and Biorefineries.
- Interaction between Seismic and Natural Risks and Consequences on Facilities subjected to Risk of a Major Accident.

Risk Assessment of CO_2 Pipeline Network for CCS – A UK Case Study

The Carbon Capture and Storage (CCS) in geological reservoirs is considered to be on the most promising solutions to control greenhouse gas emissions during the 2020s. The CCS chain involves three stages: the capture of the CO2 from large stationary sources, its transmission to the storage site and finally the injection into the geological reservoir. CO2 can be transported using one or a combination of transport media: truck, train, ship or pipeline. Transport by pipeline is considered the preferred option for large quantities of CO2 over long distances, and is the subject of this paper. In general, it is therefore necessary to identify a suitable CCS infrastructure routing that must be safe, environmental acceptable, economical and practical. From a safety perspective, the route must provide a safe and secure environment for the pipeline during construction and over its operational life and ideally be routed away from populated areas.
This study focuses on a CO2 pipeline network located in the UK starting from the previous work, based on technical and economic drivers. The aim of work is mainly consisting on the application of a quantitative risk assessment (QRA) method to the case study with the analysis of actions and workable alternative design options aimed at mitigating risks connected to accidental CO2 releases. Figure 1 describe the QRA approach. Accidental events in a CO2 pipeline can produce a spray release followed by a dense gas dispersion, and the high concentration of CO2 can cause fatalities. To determine possible health effects it is important to quantify not only the CO2 concentration but also the duration of the exposure, as the gas cloud evolves. For the calculation of risk, the consequences are associated to the Probit function, which calculates the percentage of the death of the individual.
The result of mitigation risk and the analysis of the costs arising from alternative pipeline pathways are shown by means of a specific example, Figure 2.

Figure 1 QRA methodology

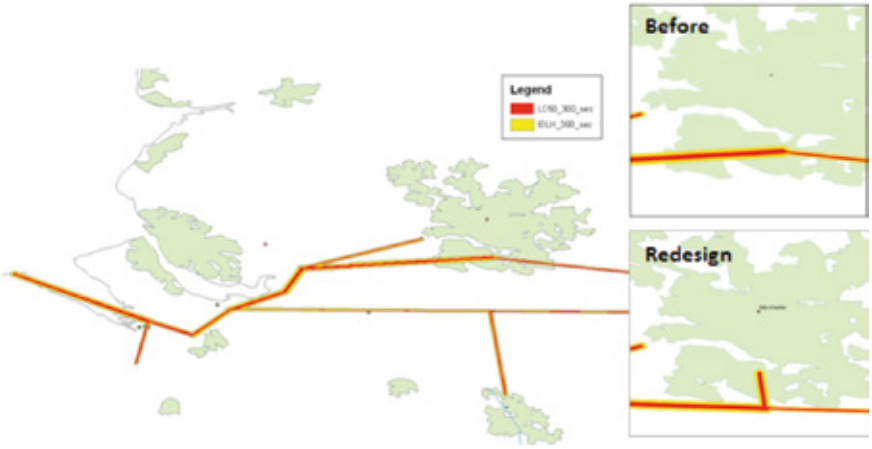

Figure 2 Pipeline network near Manchester city: CO2 consequences due to full bore rupture and redesign network to improvement the safety near center of city.

Achievements

È del Dipartimento di Ingegneria Industriale una delle 100 più belle 'E-mobility Stories'

"100 Italian e-mobility stories", promosso da Enel e Fondazione Symbola, è il rapporto dedicato alla filiera italiana della mobilità elettrica, che raccoglie esperienze eccellenti dalla realizzazione e costruzione dei veicoli alle batterie, dalla componentistica al design, dalle ricariche alle app dedicate ai servizi tradizionali. Tra le cento storie narrate vi è anche quella nata al Dipartimento di Ingegneria Industriale in cui si è ha progettata una nuova tipologia di ricarica wireless. Le ricerche sono quelle sviluppate dal team patavino giudato dal prof. Giuseppe Buja (in foto, a sinistra) in collaborazione con il prof. Manuele Bertoluzzo. L'impegno del dipartimento di Ingegneria Industriale a favore della mobilità elettrica era già stato premiato nel 2015 dall'autorevole rivista IEEE Transactions on Industrial Electronics, che aveva giudicato lo studio firmato da Giuseppe Buja, Manuele Bertoluzzo e Ritesh Kumar Keshri «il migliore nel settore dell'elettronica industriale».

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Il Dipartimento di Ingegneria Industriale partecipa al progetto europeo FunGLASS

La creazione di un centro di ricerca a Trenčín (Slovacchia) riconosciuto a livello internazionale e specializzato in vetri per diverse funzionalità, è l'obiettivo del progetto FunGLASS (http://funglass.eu/), finanziato dal programma dell'Unione Europea Horizon 2020 con 15 milioni di euro per il periodo 2017-2023. L'iniziativa è stata presentata il 16 febbraio a Bruxelles (foto a sinistra, in alto) con gli altri nove progetti selezionati tra più di 160 che hanno partecipato al bando Teaming (Teaming - Spreading Excellence and Widening Participation - https://ec.europa.eu/programmes/horizon2020/en/h2020-section/spreading-excellence-and-widening-participation). Il kick-off meeting inizio ufficiale delle attività del progetto) ha avuto luogo a Trenčín dal 7 al 9 marzo (foto a sinistra, in basso).
Coordinato dall'Università Alexander Dubček di Trenčín (Prof. Dusan Galusek), FunGLASS vede la partecipazione delle Università tedesche Friedrich-Alexander di Norimberga-Erlangen e Friedrich-Stiller di Jena, del Consejo Superior de Investigaciones Científicas (CSIC) di Madrid - attraverso l'Instituto de Cerámica y Vidrio -, e dell'Università degli Studi di Padova (Italia) - attraverso il Dipartimento di Ingegneria Industriale (riferimento: Prof. Enrico Bernardo). Il Dipartimento di Ingegneria Industriale è l'unico istituto italiano coinvolto in progetti Teaming finanziati.
Tutti i partner saranno coinvolti direttamente nella realizzazione e gestione del nuovo centro, le cui attività saranno orientate allo studio di vetri con proprietà funzionali speciali (ad es. luminescenza, conduzione di energia elettrica) e alla funzionalizzazione di vetri convenzionali al fine di modificarne le proprietà. Altre linee di ricerca includono la realizzazione materiali a base vetrosa per applicazioni biomedicali o al fine di riutilizzare e valorizzare rifiuti industriali, per applicazioni nell'edilizia, oppure lo sviluppo di rivestimenti utilizzati in macchinari industriali e nel settore automotive.
I progetti Teaming supportano la collaborazione tra istituzioni di ricerca europee per la creazione di centri di eccellenza, o di un significativo miglioramento di quelli esistenti, in paesi o regioni con basso rendimento in ricerca e sviluppo. In particolare, il progetto FunGLASS trasformerà l'attuale "Centre of Excellence for Ceramics, Glass and Silicate Materials" in "Centre for Functional and Surface Functionalized Glasses".

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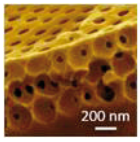
EU Horizon 2020 H2020-WIDESPREAD 2014
Project FunGLASS
http://funglass.eu/
http://cordis.europa.eu/projects [Teaming phase 2]

UNIVERSITÀ DEGLI STUDI DI PADOVA

DIPARTIMENTO DI INGEGNERIA INDUSTRIALE

Cover story



Cristallo fotonico 3D con nanostruttura di opale inverso.

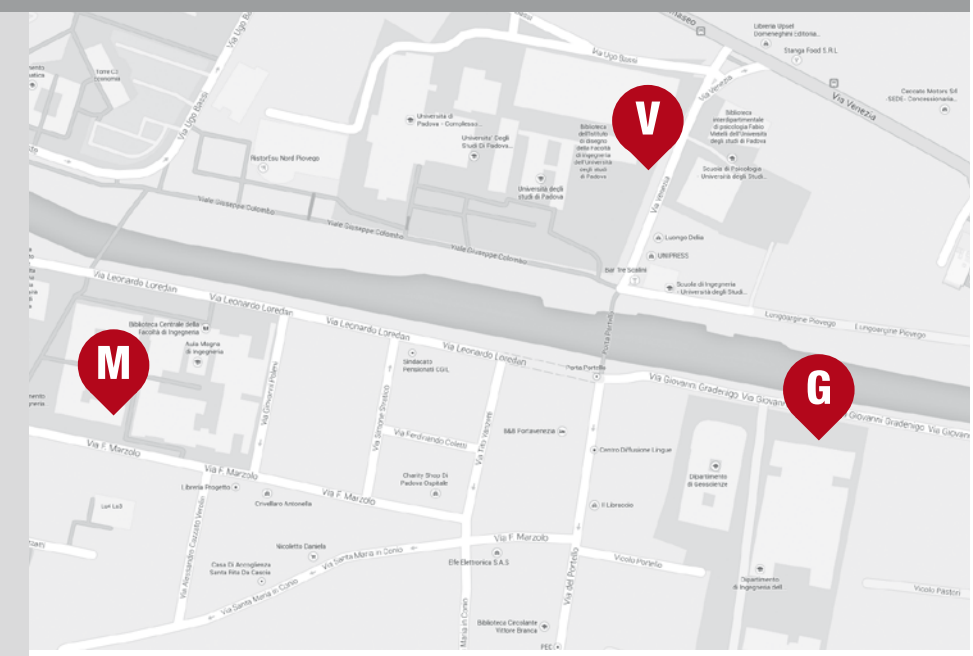
L'immagine mostra un particolare di una nanostruttura di opale inverso realizzata in fibroina di seta e nanoparticelle di ossido di titanio. Gli opali inversi sono particolari cristalli fotonici 3D caratterizzati da una modulazione periodica dell'indice di rifrazione all'interno del reticolo, che influenza la propagazione della luce impartendo loro particolari proprietà ottiche. L'utilizzo della fibroina di seta, un biopolimero naturale biodegradabile e biocompatibile, apre la possibilità di utilizzare tali strutture per la realizzazione di biosensori e device impiantabili. La struttura è stata realizzata nell'ambito di una collaborazione con il Prof. Omenetto della Tufts University, pioniere nell'utilizzo della fibroina di seta per applicazioni bio-fotoniche.

Ing. Elena Colusso

Nata a Treviso, il 28/10/1990. Dottoranda in Scienza e Ingegneria dei materiali e delle Nanostrutture XXX ciclo, supervisore prof. Alessandro Martucci. Dopo aver conseguito la laurea magistrale in Ingegneria dei Materiali nell'ottobre 2014 presso l'Università di Padova, ha iniziato la sua attività di ricerca come dottoranda presso il gruppo NanoEng del DII. I suoi interessi di ricerca riguardano principalmente lo sviluppo di materiali nanocompositi a matrice polimerica per la realizzazione di dispositivi ottici e bio-fotonici, con particolare riferimento alla fibroina di seta

www.dii.unipd.it

SEDI



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