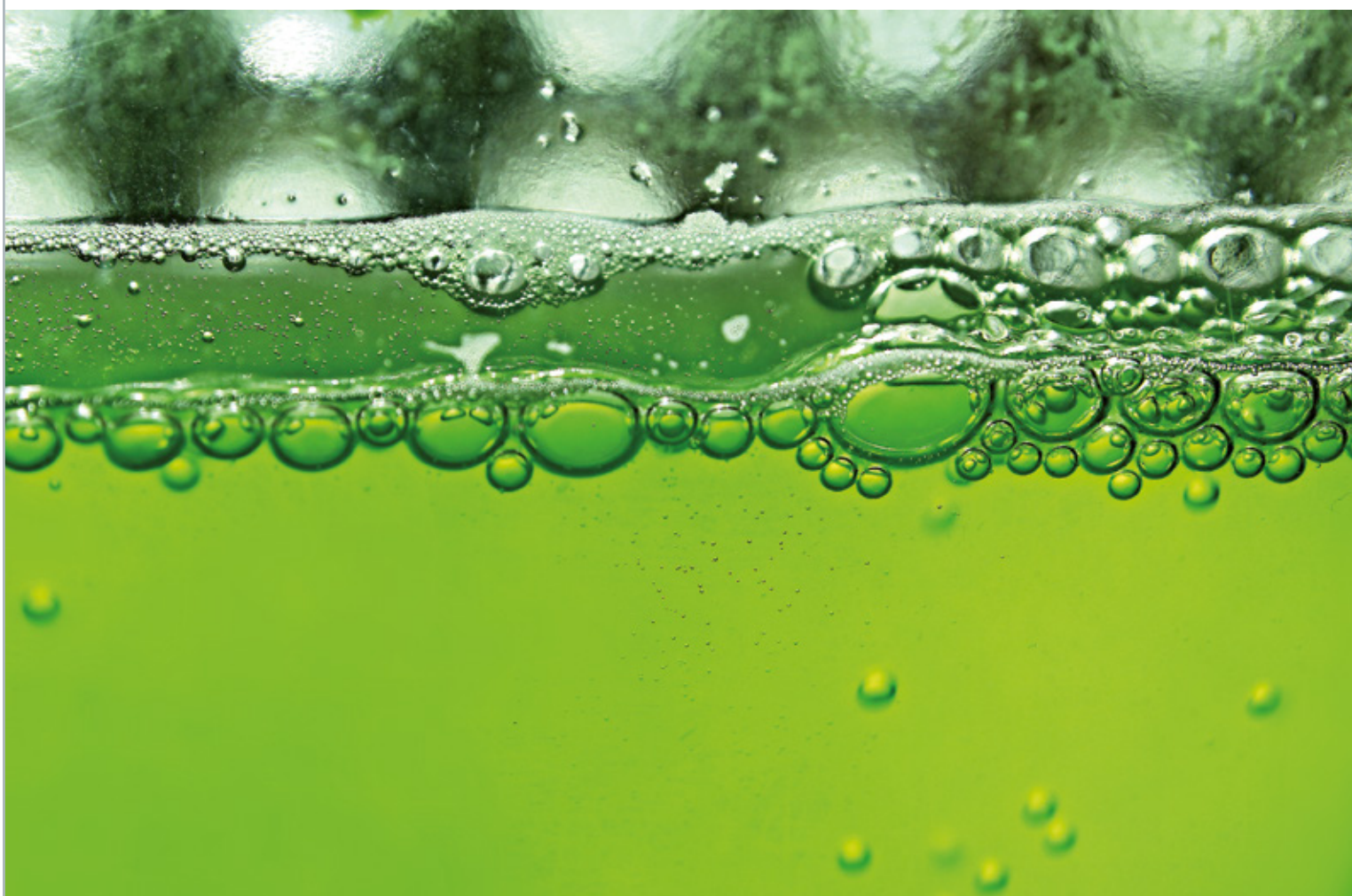
# DIINFORMA

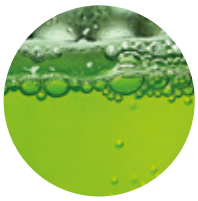
01
APRILE 2016
ANNO 2

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

UNIVERSITÀ DEGLI STUDI DI PADOVA

DIPARTIMENTO DI INGEGNERIA INDUSTRIALE





## COPERTINA

*Coltura di Scenedesums obliquus, in un reattore flat panel.*

PAGINA



DIPARTIMENTO DI INGEGNERIA INDUSTRIALE

Massimo Guglielmi

Direttore del DII

Siamo al quinto numero della Newsletter del Dipartimento di Ingegneria Industriale, grazie all'impegno di coloro che si sono prodigati e continuano a impegnarsi per rappresentare efficacemente le molte sfaccettature dell'attività di questo grande dipartimento.

La multidisciplinarietà delle attività di ricerca condotte presso il DII emerge con chiarezza dagli articoli di questo numero: dall'uso della $CO_2$ supercritica per la conservazione dei materiali biodegradabili ai sensori analogici e digitali per lo studio di Marte; dai sistemi integrati fotovoltaico-fotobioreattore per la coltivazione di microalghe al miglioramento delle caratteristiche superficiali mediante lavorazione criogenica; dall'ingegnerizzazione di strutture 2D e 3D per applicazioni biologiche allo studio della contaminazione di materiali da costruzione da parte di agenti chimici per uso bellico, alle tecnologie per il recupero del silicio perso nella produzione dei wafers di silicio.

In questo numero vengono presentati inoltre: una sintetica analisi delle startup innovative in Italia e le iniziative del DII per l'Anno della Luce, il corso di laurea triennale in Ingegneria Meccanica ed il corso di laurea magistrale in Ingegneria dei Materiali.

Per dare spazio alle giovani generazioni di ricercatori, di cui l'Università italiana ha sempre più bisogno, uno spazio è dedicato alle ricerche di Roberto Benato e la Cover story è dedicata al dottore di ricerca Eleonora Sforza, attualmente assegnista di ricerca senior.

DIPARTIMENTO DI INGEGNERIA INDUSTRIALE

UNIVERSITÀ DEGLI STUDI DI PADOVA

DIPARTIMENTO DI INGEGNERIA INDUSTRIALE

## DII Perspective Lecture

Costruire sistemi regionali a supporto dell'innovazione imprenditoriale

Prof. Jonathan Levie (Strathclyde University - UK)

**3 maggio 2016 ore 15.00 - Aula Magna del Bo**

Bioingegneria, biotecnologia e tecnologie per la salute
*Bioengineering*

**DII research group**
**Chemical Bioengineering**

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European project “Future Food”, Horizon 2020, Call H2020-SFS-2014-2.

European project “Processing Raw Materials into Excellent and Sustainable End Products while Remaining Fresh (PRESERF)” - SEVENTH FRAMEWORK PROGRAMME THEME KBBE-2009-2-2-03-Sustainable food and feed processing.

Research project "Supercritical decellularization of engineered tissues for clinical application" funded by Cassa di Risparmio di Trento e Rovereto (CaRiTRo), biomedical science section.

Consultant agreement “High pressure CO2 pasteurization of melon: feasibility study”, Committent: Sealed Air S.p.A

Main research topics:

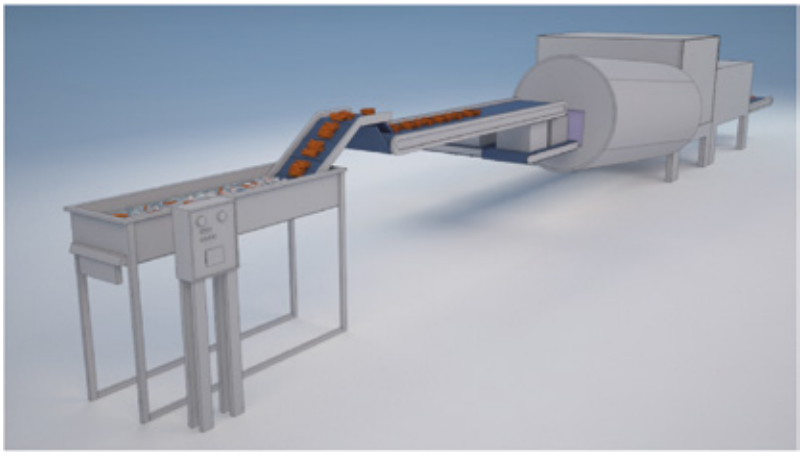
- Optimization of high pressure $CO_2$ process for low temperature food pasteurzation
- High pressure $CO_2$ process for food drying
- Batch and continuous pasteurization/drying of solid food products
- Investigation of $CO_2$ microbial inactivation mechanism
- In situ and on-line analysis of food quality under $CO_2$ pressure
- Microbial analysis of food products after pasteurization treatment
- Supercritical $CO_2$ drying of decellularized biological matrices

# Supercritical $CO_2$ processes: new frontiers for the maintenance of food and natural biomaterials

In the Supercritical Lab we study the potential of supercritical $CO_2$ as alternative technology for the preservation of biodegradable materials. Pasteurization and drying are two of the most common techniques used in the food industry for the long term maintenance of food characteristics and safety in terms of microbial contents. Usually these techniques require high temperature conditions, which degrade physical-chemical characteristics, modify the sensorial aspects and deplete the nutritional contents of the treated products. Recently, our group has been investigating the potential of supercritical fluids, in particular $CO_2$, as a mean of bactericidal agent at supercritical state, both for liquid and solid foodstuffs. It has been proved that it induces microbial inactivation at low temperature (<40° C) showing great benefits for the maintenance of organoleptic properties and the nutritional content, without altering the physical and mechanical characteristics of the products. Additionally, supercritical $CO_2$ has been also applied as innovative technique for food drying, showing great potential for different fruits and vegetables.

Recently our group has been also involved in the conservation of natural scaffold for biomedical applications. The use of acellular matrices in tissue engineering has become extremely significant as tissue substitute for organ/tissue reconstruction. Nowadays these scaffolds must be used within few weeks from their preparation and they can’t be stored in advanced for patients with emergency needs. In this scenario we are investigating the effect of supercritical $CO_2$ drying as preservation techniques for decellularized scaffolds in order to create a process that will allow the long-term maintenance and banking of these scaffolds.

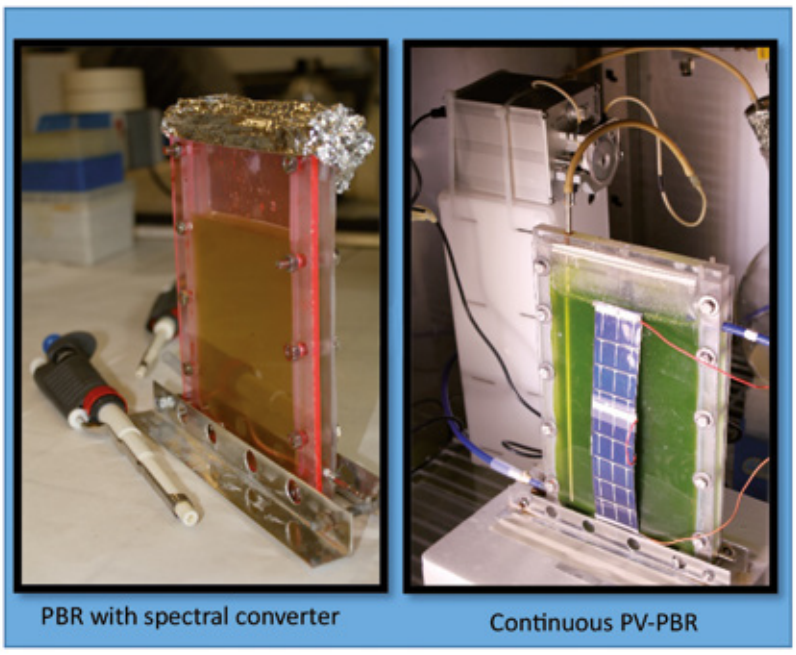
We are developing and set-up plants that allow the continuous recirculation of $CO_2$ at high pressure, with a direct effect in reducing timing and running costs, thus increasing the efficiency of these promising high pressure processes.



*High pressure $CO_2$ pasteurization continuous plant for solid products*

# Improving the photoconversion efficiency in industrial photosynthesis: an integrated photovoltaic-photobioreactor system for microalgal cultivation

One of the main limitations to large-scale production of biofuels is the lower efficiency of sunlight conversion by photosynthesis of terrestrial plants. Microalgae show a faster growth, but also in this case, the maximum theoretical value for photosynthetic efficiency is hardly achieved in real outdoor cultivation systems, mainly due to inefficient light utilization, in addition to photosaturation and photoinhibition phenomena that take place at high irradiances. This work is focused on testing different possibilities aimed at improving the overall photo-conversion efficiency (PE) of microalgal production in photobioreactors (PBR). Two strategies were followed: the first one increases the portion of spectrum available for photosynthesis employing luminescent spectral-converter filters, the second one integrates microalgae reactors with photovoltaic panels, producing electrical energy together with biomass. Experiments were carried out both in batch and continuous laboratory scale flat-plate PBRs, at different light intensities and regimes, with two different species (N. salina and S. obliquus).
According to the first strategy, a commercially available spectral converter was applied to the surface of a flat panel reactor increasing the portion of spectrum available for photosynthesis. Even though the filter is able to efficiently absorb the green wavelengths and shifts this radiation to the red range, no significant effect was observed on algal growth, even under low irradiances.
On the other hand, integrating microalgae PBR with a photovoltaic (PV) panel, remarkably increased the overall PE of the system, by producing directly available electrical energy together with microalgal biomass. Moreover, under higher irradiances, a partial cover of the reactor surface resulted in reduced photosaturation and photoinhibition phenomena. Most importantly, under certain conditions, integrating microalgae cultivation in PBRs with PV allows to reach overall energy conversion values that exceed the theoretical maximum set by photosynthesis itself.




Energia
*Energy*

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Biomass Research Laboratory
Old Dominion University - Norfolk, VA 23529

Main research topics:

- Effect of light and operating variables on continuous cultivation of microalgae in Photobioreactors
- Optimization of sustainable nutrient and $CO_2$ supply for industrial autotrophic cultivation
- Exploitation of microalgae for Wastewater treatment and $CO_2$ capture
- Modelling of microalgae growth for process design and optimization
- Process simulation and techno-economic analysis of algal biomass production

Ingegneria dei sistemi elettrici
*Electric systems*

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Space Measurement and Instrumentation

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The research project has been funded by Italian Space Agency. It has been selected by in 2011 by an ESA International Peer Review Board.
The project has been carried out in collaboration with INAF- OaCapodimonte, INAF- OaArcetri, Latmos, Oxford University, INTA, FMI, Temis SrL, ABSL, Aviotec, Unavia

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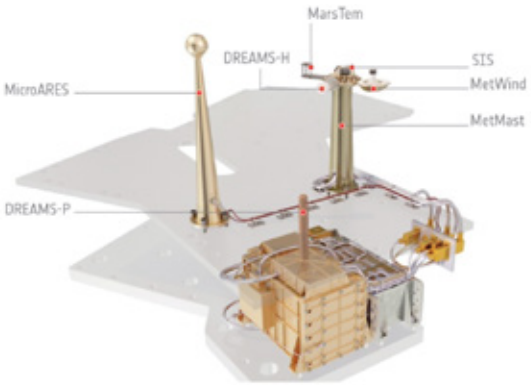
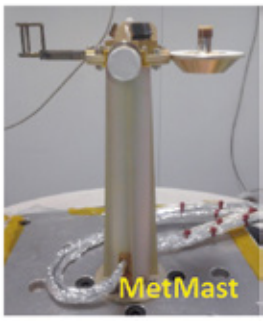
Assistant Researcher: Dr. Michele Cesaro, Dr. Francesca Cucciarre, Ing. Eugenio Di Iorio, Dr. Elisa Segato
External Collaborators: Dr. G.P. Guizzo, Dr. Enrico Friso, Ing. Matteo Poli
Lab. Technician: Mr. Filippo Donà, Mr. Luca Tasinato

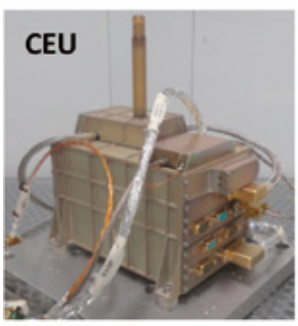
Main research topics:
- Metrology and measurement
- Sensors and instrumentation
- Instrumentation for planetary exploration
- Space technologies
- Design of Experiments

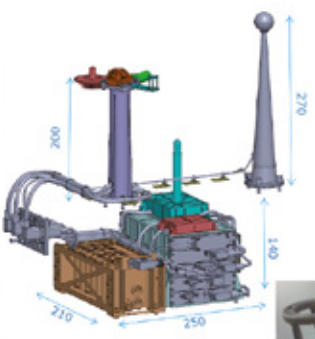
# The DREAMS experiment on the ExoMars 2016 mission for the study of Mars environment during dust storm season

DREAMS is a completely autonomous sensor suite constituted by: power unit (a rechargeable battery) , Central Electronic Unit (CEU) comprising all electronic boards for sensor data acquisition and communication with EDM, the Metmast and uAres masts which host most of the external sensors. Since DREAMS comprises both analog and digital sensors, proximity electronic units are provided for handling digital units. A dedicated harness guarantees the connection of DREAMS hardware in the internal Schiaparelli bay with the external sensing units and the EDM control unit. DREAMS Electronics through its application SW manage the acquisition, pre-elaboration compression and storage of the following sensors: MarsTEM (thermometer), DREAMS-P (pressure sensors), DREAMSH (humidity sensor), MetWind (2-D wind sensor), MicroARES (electric field sensor), SIS (Solar Irradiance Sensor) with contributions coming from all over Europe: Italy (system, CEU, Battery and MarsTEM), Finland (DREAMS-P&H), UK (MetWind), France (MicroARES), and Spain (SIS). Starting from the scientific objectives, the CISAS team derived the scientific requirement end the requirement specifications, for all the engineering aspect: thermal, mechanical, electrical, SW design modeling and testing; electronics functional design and testing while the electronics boards manufacturing has been subcontracted to industry. Reliability is the mandatory key word, while measurement and metrology is the one assuring all the performance, experimentally verified on ground in facilities developed on purpose, reproducing the harsh Martian environment. All the DREAMS suite has been tested and qualified by the research team.



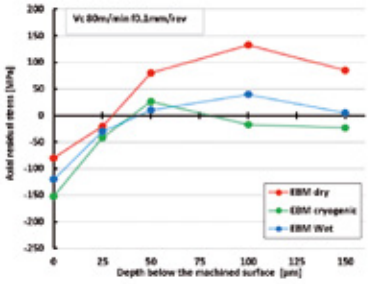



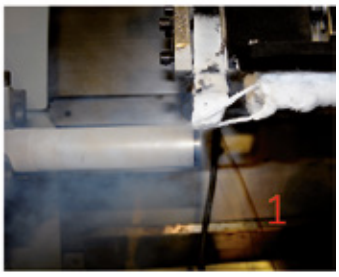



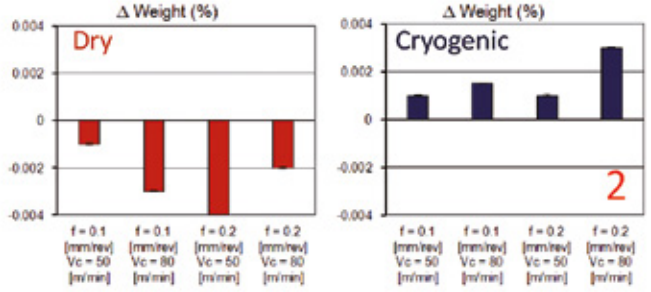




# Cryogenic machining for enhancing surface characteristics

Metal cutting operations are traditionally realised applying lubricoolants made by mixing small volumes of synthetic or natural oil with water, to limit high cutting temperatures and forces arising during machining. These emulsions are hazardous for the human body, causing serious skin and breathe health problems due to long exposures of machine operators; furthermore they are environmental contaminants damaging waters and soils if wrongly handled. With regard to the biomedical field, these problems are even amplified because chemical residuals and pollutants left on the machined surgical replacements raise the costs for cleaning and sterilizing operations. On these bases, cryogenic machining appears to be the ideal answer to all these issues, consisting in machining by applying a high pressure, clean and non-toxic cryogenic fluid such as liquid nitrogen to the cutting zone. In this context, the main contribution of this research consists in evaluating the effects of applying liquid nitrogen to machine the biomedical alloy Ti6Al4V produced by Additive Manufacturing techniques, focusing on the induced surface integrity and its applicability in the biomedical industry. Turning tests are performed comparing cryogenic cooling with standard dry and wet cooling strategies. The surface integrity generally improves under cryogenic machining, finding lower values of surface roughness, higher values of surface compressive residual stresses (see Figure 1) and of surface hardness compared to dry cutting. These enhanced surface material properties induce higher wear resistance under loads and chemical conditions typical of the human body. Worn pins machined under cryogenic cooling manifest an increment of the final weight due to a prevalent adhesion wear mechanism, rather than a final weight loss observed on dry machined pins due to a release of metallic particles (see Figure 2), therefore provoking less release of hazardous metal ions that can cause adverse tissue reactions.




Ingegneria dei sistemi meccanici
*Mechanical systems*

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The research was conducted in collaboration with the Italian company Eurocoating S.p.a in the ambit of the national research project NEMO, mainly aimed at investigating the machinability of biomedical alloys produced by Additive Manufacturing and optimizing machining operations for biomedical applications.

Main research topics:

- Manufacturing systems and processes
- Micro-technologies and precision technologies
- Shaping of metallic materials
- Processing of polymeric materials
- Geometric metrology

Materiali avanzati
*Advanced Materials*

DII research group
HyMat Laboratory

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Prof. P. Bariani and G. Lucchetta, DII UNIPD
Prof. M.T. Conconi, DSFARM UNIPD
Prof. M. Fagnoni, UNIPV
Dr. L. Lorenzelli, CMM-FBK
Prof. E. Di Fabrizio, UMG and KAUST

Projects:
CARIPLO "Development and characterization of materials for EUV Lithography"
CARITRO "Detection of residual antibiotics in milk based on plasmonic sensors integrated with microfluidic platforms"

Main research topics:
- Design and development of micro and nano-structured electrochemical and optical biosensors
- Materials engineering for 2D and 3D structures micro and nano fabrication
- Microfabrication for cell culture and stem cells applications

# Engineered 2D and 3D structures for biological applications

HyMat are engineered hybrid, nanocomposite or polymer materials offering innovative solutions for the development of functional structures from the nano to the mesocale, through the application of the most advanced lithographic techniques.
A highly versatile synthesis platform is built up by a bottom-up approach at low processing temperatures. The key building blocks are functional organic molecules, natural or synthetic polymers and hydrogels, inorganic oxide networks or nanoparticles. Developed HyMat formulations allow to obtain combinations of properties inaccessible with traditional routes.
Synthesized materials enable the fabrication of: optical micro and nano-structures; biocompatible substrates; miniaturized sensors; directly patternable resists for UV, EUV, X-ray, e-beam lithography and nanoimprint technologies; films of variable inorganic and organic compositions, and controlled porosity; 2D and 3D polymers and hydrogel structures are engineered for different biological applications and enable pioneering studies in cell biology.
Examples shown include 2D localized patterned sensing platforms on chip (Fig. 1), 2D substrates for cell differentiation (Fig.2), 3D high resolution structures made of biocompatible polymers (Fig. 3) or natural hydrogels (Fig.5) fabricated with two-photon lithography (Nanoscribe), hydrogel scaffolds printed by 3D stereolithography (Fig.4).

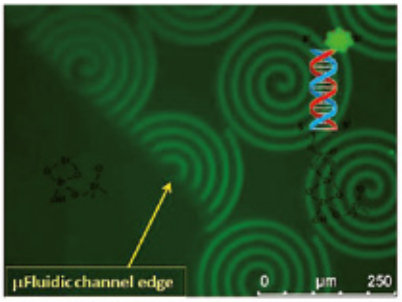
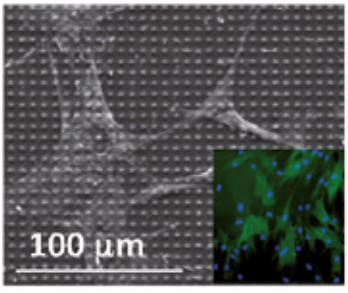



Fig.1. DNA hybridization on $ZrO_2$ 2D UV patterns on chip



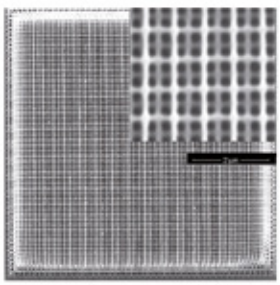



Fig.3. 3D biocompatible polymer woodpile structure

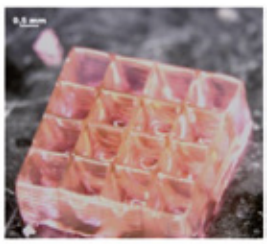
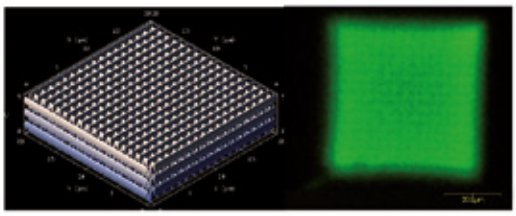
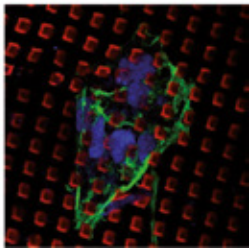


Fig. 4. 3D printed gelatin scaffold





Processi, prodotti e servizi
*Processes, products and services*

DII research group
LEP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SIKELOR project
Scientific Partners:
HZDR Helmholtz Zentrum Dresden Rosendorf (Germany).
University of Greenwich (United Kingdom), founded in 1891. UNIGW has a long history of collaborative research in manufacturing.
Industrial Partners:
Garbo s.r.l. (Italy) works on recycling of silicon carbide grits and polyol suspending agents from exhausted slicing slurries.
EAAT GmBH (Germany) is an innovative SME specialized in designing and manufacturing of client-specific electrical equipment.

Main research topics:
- Main research topics
- Electromagnetic Processing of Materials
- Numerical Modelling and Optimization

# SIKELOR Electromagnetic Processing of Recycled Silicon in the i-DSS Furnace

The Laboratory for the Electroheat of Padova, LEP, is a research group of the DII working in the field of Electromagnetic Processing of Materials, EPM. EPM makes use of electromagnetic fields for material processing, like heating, melting or other treating. Depending on the specific application and material, the frequency of applied electromagnetic fields is ranging from DC (direct resistance heating) up to some hundreds of kHz (induction heating) or some MHz (radiofrequency heating) and GHz (microwave heating). In LEP, we have expertise in several applications of EPM, like melting and processing ferrous and non-ferrous metals, cooking foods, but we are also studying EPM as a clinic treatment for curing the cancer. We present a research project financed by EU that will exploit the technological features of the i-DSS furnace designed and manufactured by LEP. i-DSS is an induction vacuum furnace for the production of multi-crystal silicon used for the production of solar cells.
Silicon used for the production of solar cells is a highly pure material, expensive because its manufacture is high energy consuming. Up to 50% of this valuable resource is lost into sawdust during the sawing process of silicon ingots, mostly for slicing the wafers. SIKELOR, SIlicon Kerfs Loss Recycling, is a project funded by EU for exploring innovative technologies to recycle silicon kerf losses.
The main problem is that Si particles are very small and the large surface-to-volume ratio (LSVR) causes formation of SiO2 with a detrimental effect on the crystallization. Overheating, in combination with electromagnetic stirring (EMST), provides means to remove SiO2. Another problem is carbon introduced into the kerf in the form of diamond particles from the wire. Leenov-Kolin forces are an effective means to separate these electrically non-conducting particles from the conducting Si melt (EMSE = Electromagnetic Separation). In the i-DSS furnace, EMST and EMSE will be developed and tested.

SiKELOR
SILICON KERF LOSS RECYCLING

# The Chemical Threat
# Indoor Building Materials Contamination by Airborne Chemical Warfare Agents

Chemical Warfare Agents (CWAs) are chemical substances whose toxic properties are used to kill, injure or incapacitate human beings. They are, by far, the most widely used and proliferated weapons of mass destruction, though they often get less attention than nuclear or biological weapons.
Buildings and facilities may be particularly vulnerable to attack with chemical warfare agents (CWAs). When the release of such agents is perpetrated in an enclosed place it could deliver doses high enough to injure or kill a large number of people. A release could be originated from inside the building, or targeted directly into the ventilation system.
The airborne chemical agents may penetrate porous materials in buildings, presenting residual agent off-gassing hazard afterwards. Differences in physicochemical properties of different CWAs, as well as the properties of the materials, may result in differences in persistence of the chemicals on the materials. Agent toxicity could cause lethality, by deep penetration into the human respiratory tract and/or by skin contact.
An experimental investigation has been carried out with the purpose to understand the behaviour of six materials, representative of indoor building surface, exposed to saturate vapours of three selected warfare chemical agents. This effort permitted to determine, for the different materials/agents, the contamination level, the desorption rates and agent residuals left in the sample material structure (persistence).
Building Materials, substrate sample: Plastic floor (PLF), Gypsum board painted (GYB), Raw sandstone (SDS), Painted concrete (PCN), Chem. agent resistant coating (CAR), Butyl rubber (BUR)
Chemical Warfare Agents: (CWAs): Sarin, (GB ), purity 98.7%; Soman, (GD), purity 90.6%; Sulphur mustard, (HD), purity 98.5%.
The measured samples were contaminated with appropriate amount of selected CW agent in vaporized form with required and documented aerial density of contamination.

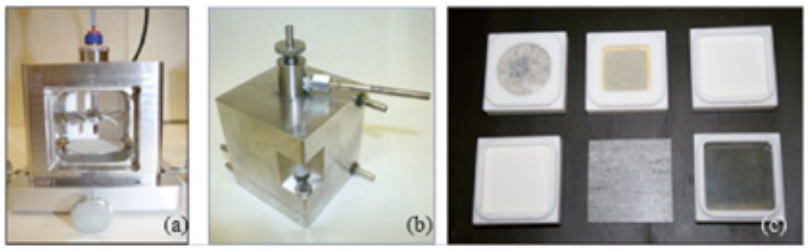


**Figure 1.** (a) Open contamination cell; (b) Evaporation cell; (c) Substrate samples with sealing.

For the three CWAs tested, the amounts of agent adsorbed and its persistency on the building materials increases over time with the porosity of the exposed surface. As expected, the different building materials behave differently when exposed to the vaporised CWAs, and these differences may be rationalized in terms of physiochemical properties such as vapour pressure, diffusion, and solubility in the matrices.
The contamination density found on some materials, after exposition to the CWAs vapours, is highly above the contact threshold level.
The experimental results suggest that in buildings construction phases, when high level of resilience capability is required, suitable materials must be selected considering also their resistance to CWAs contamination.
In fact, considering the spontaneous desorption ratio behaviour, passive protective measure such as selected materials will determine survivability of critical infrastructure (CI) and also safety for the post event operations.

Ambiente
*Environment*

DII research group
DECON/DEMIL

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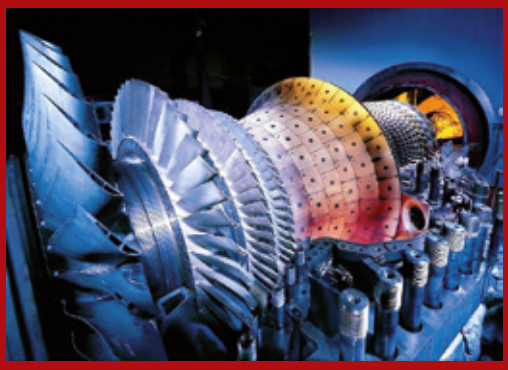
CBRN Subject Matter Expert

This work was carried out as part of a project supported by UNIFRONT Spin-off of the University of Padua.
NATO reference lab, Vyškov, CZ

Main research topics:

- Technologies against threats posed by environmental events and trends to individuals, communities or nations



"www.im.dii.unipd.it"

# Corso di laurea triennale in Ingegneria Meccanica

**Obiettivi formativi**
Il corso prevede due curricula: Industriale e Formativo.

Il curriculum **Industriale** è organizzato in modo da formare una figura professionale adatta ad un impiego immediato nel mercato del lavoro. Lo scopo è formare tecnici di livello universitario in grado di recepire i processi innovativi e di trasferirli tempestivamente nell'ambito delle applicazioni. Il laureato avrà quindi una formazione orientata alle funzioni di progettazione, produzione e gestione in ambito industriale di componenti, macchine e sistemi meccanici.

Il curriculum **Formativo** ha lo scopo di preparare con solide basi al successivo percorso della Laurea Magistrale, durante il quale saranno sviluppate competenze nella progettazione e produzione di prodotti e sistemi meccanici ad alto contenuto tecnologico e di innovazione.

**Cosa si studia**
**Il primo anno è comune** e comprende insegnamenti di base nell'ambito della matematica e della fi¬sica, mentre gli anni successivi sono differenziati.

***Curriculum Industriale:*** nel secondo e terzo anno l'attività didattica ha un taglio più applicativo che teorico. Al termine del percorso formativo triennale il laureato in Ingegneria Meccanica sarà dotato di solide competenze riguardanti la progettazione meccanica, sia strutturale che funzionale, la tecnologia meccanica, la meccanica dei veicoli, la gestione di impianti di produzione, la trasmissione e conversione dell'energia termica e meccanica, ecc. La maggior parte degli insegnamenti prevede una significativa attività di laboratorio, finalizzata all'applicazione pratica delle conoscenze acquisite con le lezioni teoriche.

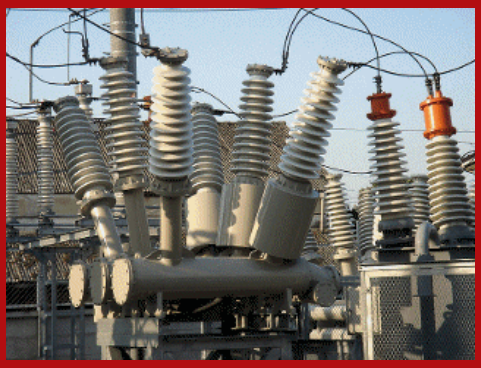
***Curriculum Formativo:*** gli insegnamenti previsti sono finalizzati ad una solida comprensione dei fondamenti delle discipline dell'Ingegneria Meccanica, in particolare di Costruzione di Macchine, Elettrotecnica, Fisica Tecnica, Materiali, Meccanica Applicata, Macchine e Tecnologia Meccanica, che costituiscono il nucleo caratterizzante il Corso di Laurea. L'insegnamento di tali discipline è organizzato in modo propedeutico e complementare a quanto previsto per il successivo livello di approfondimento nella laurea magistrale.

**Ambiti occupazionali**
L'ingegnere meccanico trova rapidamente impiego in aziende ed enti operanti nei settori delle macchine e degli impianti per la conversione di energia, dei mezzi di trasporto, della termotecnica, dell'automazione e in generale della produzione industriale di componenti, macchine e sistemi meccanici; potrà operare in studi di ingegneria, in uffici tecnici di enti pubblici e privati, negli enti territoriali e negli enti di ricerca. Alcuni ambiti occupazionali tipici sono: progettazione e costruzione di macchine ed impianti; sviluppo, progettazione e produzione di componenti meccanici e beni di consumo; progettazione di processi per l'industria meccanica; gestione di reparti; organizzazione di attività di manutenzione; direzione di uffici tecnici, centrali elettriche, aziende municipalizzate o assimilate, studi professionali, laboratori industriali e centri di ricerca. Alcuni esempi concreti sono visibili alla pagina Testimonianze del sito www.im.dii.unipd.it.

Con il curriculum Formativo il laureato potrà accedere direttamente ai Corsi di Laurea Magistrale in Ingegneria Meccanica, in Ingegneria dell'Innovazione del prodotto e in Ingegneria dei Materiali. L'accesso ad altri corsi di Laurea Magistrale è condizionato ad una integrazione di competenze.
Con il curriculum Industriale il laureato può accedere ai Corsi di Laurea Magistrale ma potrà essere richiesta una integrazione di competenze.

# Corso di laurea Magistrale in Ingegneria Elettrica

L'Ingegneria dell'Energia Elettrica si occupa di generazione, trasporto, gestione e utilizzazione dell'energia elettrica.
La laurea magistrale in Ingegneria dell'Energia Elettrica permette di acquisire un ampio spettro di conoscenze e competenze multidisciplinari, relative non solo alle tecnologie specifiche più progredite ma anche la visione strategica necessaria ad affrontare con successo le sfide tecnologiche e socio-economiche del futuro. L'energia elettrica avrà ruolo primario nello sviluppo economico e sociale, perché, essendo caratterizzata da elevatissima flessibilità ed ubiquità di utilizzo, è destinata ad avere penetrazione sempre maggiore nei sistemi industriali e sociali.
La laurea magistrale in Ingegneria dell'Energia Elettrica è la naturale prosecuzione della laurea triennale in Ingegneria dell'Energia nelle tematiche dell'energia elettrica.
Gli insegnamenti riguardano le strutture per la produzione, il trasporto e la distribuzione di energia elettrica, come le centrali elettriche, le reti elettriche di potenza e i sistemi elettrici industriali. A quest'ambito appartengono le tecnologie delle alte tensioni, le valutazioni economiche dell'energia elettrica e l'illuminotecnica.
Ampio spazio è dedicato alle macchine che trasformano energia meccanica in elettrica (generatori) e viceversa (motori) e ai convertitori statica (privi di parti in movimento, che eseguono, ad esempio, la conversione dalla corrente alternata alla continua e viceversa). In tale ambito rientrano gli azionamenti elettrici, l'automazione elettrica e i veicoli elettrici ferroviari e stradali.
Ampio spazio è dedicato anche ai dispositivi e sistemi di generazione elettrica innovativi (generatori fotovoltaici, eolici, ...), all'accumulo di energia elettrica, all'energia nucleare a fusione, alle applicazioni elettrotermiche industriali e medicali ed alle nanotecnologie elettriche. Sono infine comprese discipline trasversali quali i controlli automatici, le misure elettriche, i metodi di analisi, sintesi e progettazione all'elaboratore di sistemi e dispositivi elettromagnetici complessi e gli approfondimenti sui rapporti tra tecnologia e società.
Sono stati definiti due orientamenti denominati "Generazione e distribuzione dell'energia elettrica" e "Utilizzazione ed applicazioni dell'energia elettrica" che possono permettere allo studente di focalizzare la propria preparazione nell'ambito rispettivamente della progettazione e gestione dei sistemi/processi per la generazione e la trasmissione dell'energia elettrica oppure in quello delle applicazioni a livello industriale, civile e dei servizi.
Vari insegnamenti sono impartiti in lingua inglese, nel contesto di un programma di internazionalizzazione dell'offerta didattica che intende offrire agli studenti la possibilità di prepararsi ad operare in modo competitivo nel mercato internazionale. La flessibilità di configurazione del percorso formativo con le molteplici opzioni di scelta dei vari insegnamenti, unitamente alla possibilità di inserire nel proprio piano di studi insegnamenti a scelta libera per 18 crediti, permette a ciascun studente un'elevata personalizzazione del proprio curriculum di studi.
Gli studenti sono incoraggiati a svolgere una parte del loro curriculum di studi all'estero nell'ambito di programmi di collaborazione internazionale come gli europei Erasmus e Time.



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# Speciale Iniziative del DII per l'Anno della Luce

*Roberta Bertani, Pietro Fiorentin, Elena Pedrotti, Osvaldo Da Pos, Augusto Tassan*

## Anno internazionale della Luce e delle tecnologie basate sulla Luce

Il DII ha organizzato nel corso dell'anno appena concluso una serie di iniziative dedicate al 2015 Anno internazionale della Luce e delle tecnologie basate sulla Luce, proclamato dalle Nazioni Unite.

Sono stati organizzati alcuni seminari interdisciplinari dal titolo:
**Luce è… visione; Luce è… vita; Luce è… energia; Luce è… ambiente.**

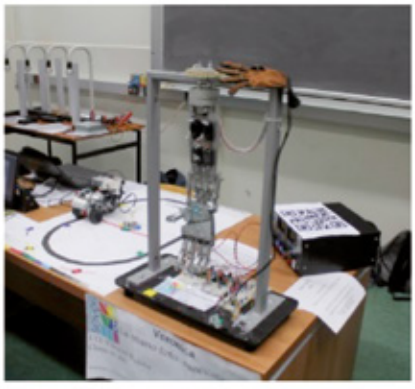
Complessivamente hanno partecipato circa 700 studenti e numerosi insegnanti. I seminari sono stati seguiti da visite a vari laboratori del DII *(Laboratorio di fotometria e illuminotecnica; Laboratorio di tecnologie fotovoltaiche; Laboratorio di conversione dell'energia solare; Laboratorio di fotochimica; Laboratorio di fotosintesi; Laboratorio di tecnologia dei materiali polimerici; Laboratorio di Microscopia Elettronica).*
È stato organizzato anche un concorso riservato agli studenti delle scuole secondarie in forma individuale o per gruppi o per classi, invitati a progettare e realizzare un elaborato sul tema della luce, cui hanno partecipato più di 70 studenti con 22 elaborati.




| | |
|---|---|
| 23 ottobre 2015: | *Luce è…visione* |
| Elena Pedrotti | *Che cosa è la luce* |
| Osvaldo Da Pos | *Come vediamo* |
| Sara Montagnese | *Luce e noi* |
| 30 ottobre 2015: | *Luce è…vita* |
| Massimo Guarnieri | *La conquista della luce* |
| Alberto Bertucco | *Luce e mondo vegetale* |
| Maria Teresa Conconi | *Luce e mondo animale* |
| 13 novembre e 18 dicembre 2015: | *Luce è…energia* |
| Fabrizio Dughiero | *Elettricità dal sole* |
| Davide Del Col | *Caldo e freddo dal sole* |
| Arturo Lorenzoni | *Risparmio energetico* |
| 27 novembre 2015 e 15 gennaio 2016: | *Luce è…ambiente* |
| Roberta Bertani | *Fotochimica per l'ambiente* |
| Andrea Bertolo | *Inquinamento luminoso* |
| Dario Camuffo | *Luce e beni culturali* |

1° classificato
Sezione artistica:
Colori nella luce,
luce nei colori

2° classificato
Sezione artistica:
Albero della vita



1° classificato Sezione Tecnologica
Veronica. La mano meccatronica

2° classificato: Impianto
fotovoltaico a scomparsa

La premiazione

# Innovative startups in Italy at a glance

Since 2012 when the decree "n. 179, October 18“ was introduced, the number of companies in the special register of innovative startups is constantly increasing.
By the end of December 2014 the number of innovative startups was 3.138 while at 31.12.2015 it was 5.154, with an increase of about 64%, or 160 new companies per month.
In 2014 the School of Entrepreneurship of the DII-Unipd started monitoring the innovative startups in Italy.

In the last two years 3.034 businesses were launched , of which 1.512 in 2014 and 1.522 in 2015. More than 75% of these enterprises are in the service sector and 59% have no employees, while 35% have employees in the range of 1-4.
The three sectors (ATECO) more populated are the Development of software and ICT consulting with 1.538 enterprises, the Research and Development sector with 765 enterprises and the information services sector with 418 enterprises.
The first two categories have also the highest total output value, 119.2 and 40.7 million euro respectively.
Conversely, the sectors with the highest average value of production are in the packaging of clothing, programming and transmission, and the manufacture of metal products with, 340.000, 299.000 and 283.000 euro respectively. However, these categories are much more traditional with less relevance on innovation.

Regarding equity, in the first position we find the repair, maintenance and installation of machines with 422.000 euro per enterprise; the second position is occupied by the production of pharmaceutical products with 290.000 euro. The advertising and market research sector is in third place with 146.000 euro.
In this case also, the most capitalized sectors are in quite traditional sectors.

It is evident from the Survey administered by SCENT that relatively few entrepreneurs know about the benefits provided by laws for innovative startups. However, about a third of the sample have in mind to take advantage of incentives provided by the laws in the near future.

| ATECO | Number of companies | Total output value (Euro) | Average output value (Euro) |
|---|---|---|---|
| Software production and IT consulting | 1.538 | 119.255.510 | 77.539 |
| Research and development | 795 | 40.723.821 | 51.224 |
| Manufacture of electronic and optical products | 204 | 27.374.641 | 134.189 |
| Manufacture of machinery | 175 | 23.815.553 | 136.088 |
| Architecture and engineering services | 186 | 17.895.761 | 96.213 |
| Advertising and market research | 85 | 14.766.545 | 173.724 |
| Manufacture of electrical equipment | 111 | 13.352.356 | 120.291 |
| Retail | 121 | 12.018.276 | 99.324 |
| Wholesale | 90 | 11.304.780 | 125.608 |
| Scientific/technical professional activities | 196 | 10.490.574 | 53.523 |
| IT services | 418 | 9.564.861 | 22.882 |
| Manufacture of metal products | 32 | 9.082.360 | 283.823 |
| Management consulting | 151 | 6.535.115 | 43.278 |
| Office support | 98 | 4.557.381 | 46.503 |

## Management e imprenditorialità *Management and entrapreneurship*

**DII research group**
**Management and Entrapreneurship**

Moreno Muffatto
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phone: +39 049 827 6725

Assisted by
Dr. Michael Sheriff, post-doc

http://www.dii.unipd.it/en/management-and-entrepreneurship

http://scent.dii.unipd.it

This study was carried out in collaboration with Infocamere
Financial support to this research was provided by the University of Padua

Main research topics

- Global Entrepreneurship Monitor (GEM)
- Entrepreneurship for Growth
- Innovative startups
- Performance Measurement and Management
- Technology Transfer
- Novel Business model generator for Energy Efficiency in construction and retrofitting

# Zero Sequence Behaviour of a Double-Circuit Overhead Line

Presentato da S. Dambone Sessa - *Dipartimento di Ingegneria Industriale, Università di Padova*

University of Padova
ITALY

Department of Industrial Engineering

2014 IEEE PES T&D CONFERENCE & EXPOSITION CHICAGO APRIL 14-17

## ZERO SEQUENCE BEHAVIOUR OF A DOUBLE-CIRCUIT OVERHEAD LINE

R. Benato* – S. Dambone Sessa* – F. Guglielmi* – E. Partal** – N. Tleis***

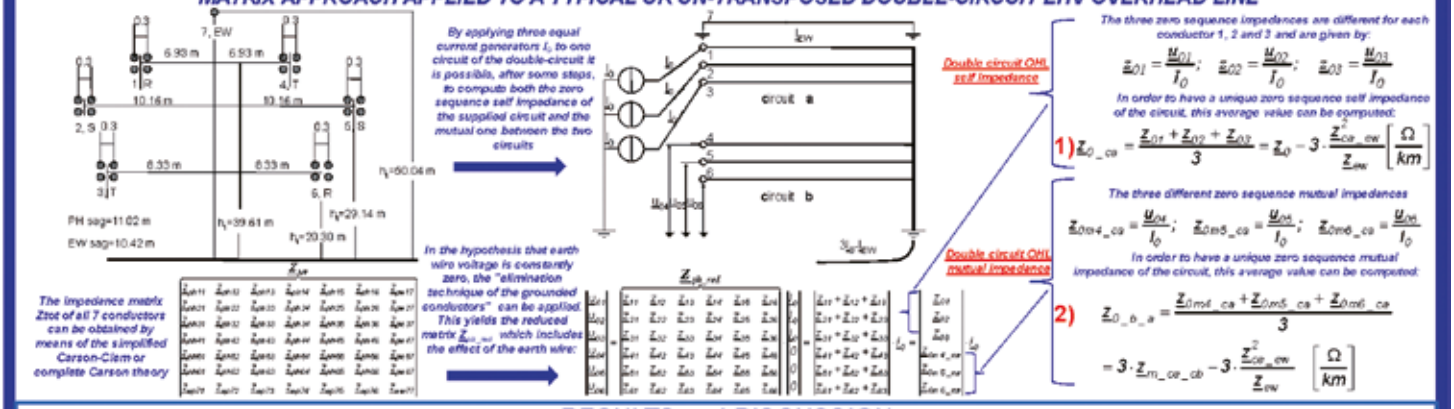
*Department of Industrial Engineering – University of Padova (ITALY), **National Grid Electricity Transmission (United Kingdom), ***Dubai Electricity and Water Authority

## ABSTRACT & CONCLUSIONS

Positive, negative and zero sequence kilometric impedances are the first steps for power flow and short circuit analyses and are also necessary for setting the distance relays. The paper shows a comparison of zero sequence impedances computed by means of two approaches: the IEC 60909-2 one and a matrix one which starts from Carson impedance matrix. The different zero sequence impedances are used to compute the effect on a phase-to-ground short circuit occurring in different location along one circuit of the double-circuit. In conclusion, the two aforementioned approaches are compared with the most accurate MCA (Multiconductor Cell Analysis) procedures without simplifications or approximations. **IEC 60909-2 formula adds the zero sequence self and the zero sequence mutual impedance between the two circuits. It has been demonstrate that this approximation of having a unique value of zero sequence impedance is misleading and gives great errors when phase-to-ground short circuit occurs along a circuit. It is worth noting that the zero sequence mutual impedance between parallel circuits installed on the same tower is not negligible. MCA shows that the simplified IEC approach underestimates heavily (more than 18%, depending upon the spacing between the circuits) the phase-to-ground fault current for a fault occurrence along one circuit of the double-circuit.** It is worth noting that the scope of IEC 60909-2 is giving sequence impedance formulae for short circuit computation in low voltage networks and for planning purposes in medium and high voltage ones. The authors aim at showing the limits of IEC 60909-2 application to the short circuits of high voltage double circuit overhead lines. The paper shows both a matricial computation of zero sequence impedances of a double-circuit OHL and a comparison of phase-to-ground short circuit currents with correct wye circuit along with MCA.

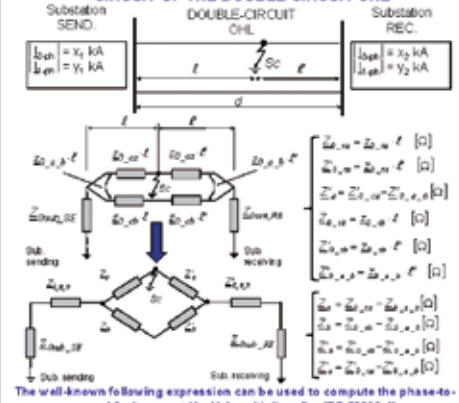
## INTRODUCTION

### MATRIX APPROACH APPLIED TO A TYPICAL UK UN-TRANSPOSED DOUBLE-CIRCUIT EHV OVERHEAD LINE




## RESULTS and DISCUSSION

### MATRIX APPROACH:PHASE-TO-GROUND SHORT CIRCUIT CALCULATION OCCURRING ANYWHERE ALONG ONE CIRCUIT OF THE DOUBLE-CIRCUIT OHL




The well-known following expression can be used to compute the phase-to-ground fault current Itp (1.1 multiplier after IEC 60909-1):

$$I_{tp} = \frac{1.1 \times 3 \times E_n}{Z_1 + Z_2 + Z_0}$$

positive - negative sequence impedances as seen from the fault location [Ω]

zero sequence impedance as seen from the fault location [Ω]

THIS METHOD GIVES THE POSSIBILITY TO CORRECTLY COMPUTE THE PHASE-TO-GROUND SHORT CIRCUIT CURRENT IN ANY POINT ALONG THE LINE INCLUDING BOTH ENDS.

### COMPARISON WITH IEC 60909-2 FORMULA

$$\underline{Z}''_{0\text{-}IEC} = \underline{Z}'_0 + 3 \cdot \underline{Z}'_{LME} - 6 \cdot \frac{Z'^2_{QLE}}{Z_{QQE}}$$

It is immediate to verify that the IEC formula is equal to the addition of 1) and 2). Consequently it adds the zero sequence self and zero sequence mutual impedances.

IEC approach is only correct if fault location is at sending or receiving ends. The zero sequence impedance computation as seen from fault location at sending end by means of matrix approach gives:

$$\underline{Z}_0 = \frac{\underline{Z}_{0sub\_SE} \cdot \left( \left( \frac{\underline{Z}_{0\_cc} - \underline{Z}_{0\_a\_b}}{2} + \underline{Z}_{0\_a\_b} \right) + \underline{Z}_{0sub\_RE} \right)}{\underline{Z}_{0sub\_SE} + \left( \left( \frac{\underline{Z}_{0\_cc} - \underline{Z}_{0\_a\_b}}{2} + \underline{Z}_{0\_a\_b} \right) + \underline{Z}_{0sub\_RE} \right)}$$

It is immediate to verify that this equation can be rewritten as:

$$\underline{Z}_0 = \frac{\underline{Z}_{0sub\_SE} \cdot \left( \frac{\underline{Z}_{0\_cc} + \underline{Z}_{0\_a\_b}}{2} + \underline{Z}_{0sub\_RE} \right)}{\underline{Z}_{0sub\_SE} + \left( \frac{\underline{Z}_{0\_cc} + \underline{Z}_{0\_a\_b}}{2} + \underline{Z}_{0sub\_RE} \right)}$$

where the part concerning the double circuit in parallel is simply:

$$\frac{\underline{Z}_{0\_cc} + \underline{Z}_{0\_a\_b}}{2} = \frac{\underline{Z}_{0\_IEC}}{2}$$

IT IS DEMONSTRATED THAT THE IEC 60909-2 IS APPLICABLE ONLY FOR SHORT CIRCUIT CALCULATION OCCURRING AT SENDING END OR AT RECEIVING END

### COMPARISON WITH MCA APPROACH

The proposed procedures are applied to the double-circuit OHL 400 kV 4x400 mm² ACSR. Let us consider a phase-to-ground short circuit occurring at midline

| | | $I_{tp}$ at the midline [kA] | $I_{tp}$ at sending-end [kA] | $I_{tp}$ at receiving-end [kA] |
|---|---|---|---|---|
| MCA | R-ground | 53.791 | 50.833 | 35.032 |
| | S-ground | 53.383 | 50.873 | 34.957 |
| | T-ground | 53.653 | 50.833 | 35.039 |
| Average MCA | | 53.609 | 50.846 | 35.007 |
| ST with equivalent wye circuit | | 53.475 | 50.799 | 34.948 |
| ST with IEC formula | | 50.870 | 50.784 | 34.933 |
| Percentage difference equiv. wye circuit with MCA | | 5.24% | -0.09% | -0.16% |
| Percentage difference IEC with MCA | | -12.32% | -0.13% | -0.21% |

DATA ASSUMED IN THE MCA OF 400 KV DOUBLE-CIRCUIT OHL IN UK GRID

| | | |
|---|---|---|
| Line length of | km | 135.42 |
| Span length | km | 0.366 |
| Earth resistivity | Ω m | 20 |
| Substation earthing resistance | Ω | 0.1 |
| Tower earthing resistance | Ω | 10 |
| Bundled Conductor | | 4 sub-cond. ACSR Zebra Φ=28.62 mm Spacing=0.3 m |
| Earth wire (EW) | | ACSR Zebra Φ=28.62 mm |
| Positive sequence kilometric resistance r at 20°C (50 Hz) | mΩ/km | 8.25 |
| Positive sequence kilometric series inductance | mH/km | 0.422 |
| Positive sequence kilometric shunt leakance $g_{pu}$ (50 Hz) | nS/km | 33.56 |
| Positive sequence kilometric capacitance c | μF/km | 0.0267 |
| Single-circuit ampacity $I_n$ referred to winter rating [8] | A | 4x800=3200 |
| Winter rating [8] of double-circuit OHL | MVA | 2.4217 |

Poster presented at:
2014 IEEE PES T&D Conference & Exposition
Chicago (USA), April 14-17, 2014

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UNIVERSITÀ DEGLI STUDI DI PADOVA

DIPARTIMENTO DI INGEGNERIA INDUSTRIALE

## Cover story

**Coltura di Scenedesums obliquus, in un reattore flat panel.**

L'immagine mostra una coltura di Scenedesums obliquus, in un reattore flat panel, illuminato grazie a LED ad alta intensità e insufflato mediante bubbling con una miscela di aria e CO2. S. obliquus è una specie microalgale molto interessante per le applicazioni industriali, grazie ad un'elevata efficienza fotosintetica, un contenuto di lipidi del circa 40% su massa secca, e una forte resistenza alle condizioni di coltivazione intensiva. In questo caso gli esperimenti sono stati condotti per verificare l'effetto della luce su reattori in continuo allo scopo di determinare i parametri cinetici utilizzati per la modellazione della crescita.

**Eleonora Sforza**

Dopo aver conseguito la laurea magistrale in Biotecnologie Industriali ha ottenuto il dottorato in Ingegneria Industriale con una tesi dal titolo: "Oil from microalgae: species selection, photobioreactor design and process optimization"

Attualmente è titolare di un assegno di ricerca senior e gestisce il laboratorio di Microalghe del Prof. Bertucco. Si occupa di ottimizzazione della crescita microalgale a scopi energetici e per la produzione di composti ad alto valore aggiunto, di growth modeling e di applicazioni ambientali delle microalghe per la depurazione di reflui.

**www.dii.unipd.it**

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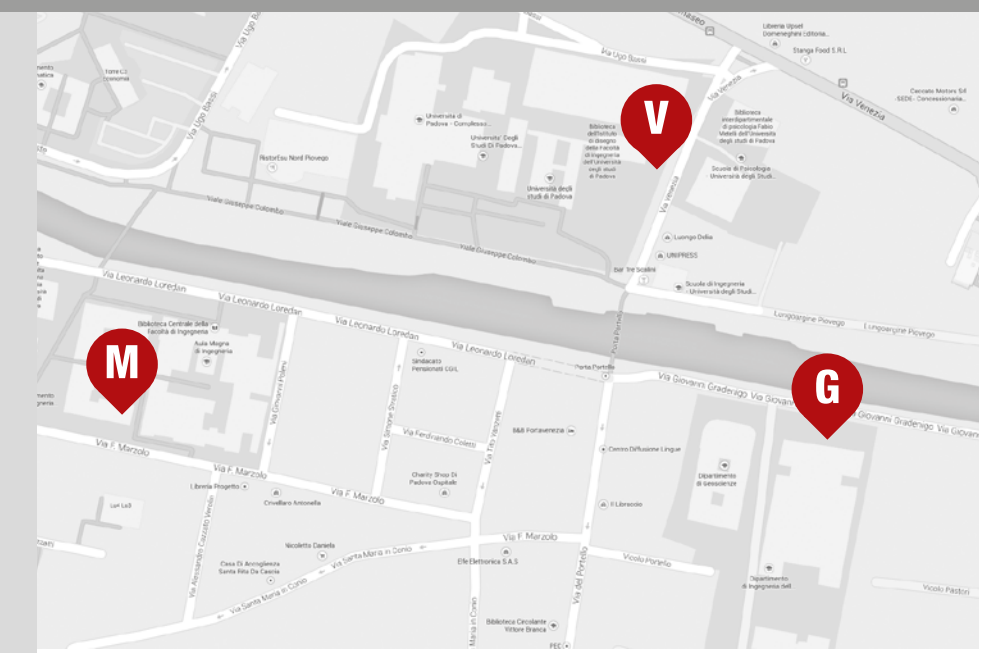
Vicedirettore: Stefania Bruschi

Segreteria amministrativa:
Sandra Dal Bianco

SEDI





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