Doctoral School in Materials, Mechatronics and Systems Engineering

Research subjects proposed for the 39th cycle

A mandatory attachment of the application is **a description of the research project (**max. 4 pages**).**
The research project must contain: i) a title, ii) an introduction to the problem with reference to the state of the art, iii) a clear description of the aim and the content of the research, iv) an estimation of the time sequence of the intended activities, v) literature references.

The project must be in one of the research areas of the Doctoral Programme, **preferably** on one of the following research subjects:

Materials Science and Engineering (area A)

- *Reference persons:* S. Rossi, F. Deflorian, M. Calovi, O. Massidda
Title: Introduction of pigments and particles in organic matrix to obtain organic coatings with increased properties. [1)]

Organic coatings are increasingly required in addition to the corrosion protection properties for other properties to increase the possibilities of using these layers. Hard micro and nano particles are added to improve the tribological behavior; pigments sensitive to temperature and UV to obtain smart coatings in particular for use as roof coatings and finally silver or copper particles to have a coating with antimicrobial properties. The aim of the work will be to identify some interesting properties in addition to those of corrosion protection for an organic coating and to evaluate the effectiveness of the identified solutions.

- *Reference persons:* A. Fambri, L. Lutterotti, A. Pegoretti
Title: Developments in structure analysis of oriented polymeric products (evaluation of processing, orientation and applications [1)]

Topics: XRD analysis and updated methodology. Texture analysis. Fiber and film stretching. Effect of twisting and drawing on mechanical performances. Creep and memory effect in view of thermo-mechanical applications. Reversible and cyclic applications.
The candidate will focus the research on the study of oriented polymeric materials by using methodologies of XRD structural analysis. In particular specific relationships of processing-properties of different type of polymeric products will be considered, such as fibers, films, and various systems in dependance of coupling, drawing, torsion of materials. Moreover, among various applications, the potentiality of twisted and drawn polymeric fibers could be considered for artificial muscles with thermal and/or electrical active contraction, on the basis of concept and design described in literature (Haines et al., Science 343(6173) 2014; Haines et al., PNAS 113(42) 2016).
General Reference: Fambri L., Lutterotti L., Effect of Processing and Orientation on Structural and Mechanical Properties of Polypropylene Products 2019 DOI: 10.5772/intechopen.85554

- *Reference persons:* A. Tirella, A. Motta
Title: Advanced Manufacturing Technologies for Next Generation Natural Based Bioinks [1)]

The project will integrate complementary manufacturing technologies in a single platform to build 3D microenvironments able to vary properties of human tissues, such as mechanics and diffusion of bioactive macromolecules. The manufactured tissue-on-chip models will enable us to investigate variations of viscoelastic properties, as result of the balance of elastic and viscous components is tuned by a feedback loop between resident cells and the extracellular matrix (ECM), and its interlink with pathologies.

Cutting across the themes of advanced materials, healthcare technologies, sustainable manufacturing and manufacturing the future, the manufactured tissue-on-chip model will have immediate usage for a variety of healthcare applications, such as study of diseased states, speed-up therapeutic development and testing efficacy; with direct impact on manufacturing future healthcare technologies.
The following objectives (OBJ) have been identified:
OBJ1: Formulation of natural-based bioinks to support injectability/printability, as well as cell viability and growth. Bioinks will mimic composition and mechanics of human soft tissues, as well as enabling diffusion of bioactive macromolecules;
OBJ2: Optimization of manufacturing technologies for the fabrication of lipid-based nanotechnologies to release therapeutics within bioinks from OBJ1;
OBJ3: Integration of single in-line microfluidic manufacturing systems to include lipid-based nanotechnologies into bioinks to fabricate tissue-on-chip models for testing therapeutics effects.

-*Reference persons:* M. Lobino, A. Quaranta
Title: Integrated photonics for quantum applications with thin film lithium niobate [1)]

This project aims at the design and characterization of reconfigurable devices in thin film lithium niobate. These devices will be used for the manipulation of nonclassical states of light, and the integration with innovative superconducting detectors, all realized on the same material platform.

-*Reference persons*: M. Lobino, M. Bernard
Title: Integrated photonics in thin film lithium niobate for generation of quantum states of light [A2)]

This project will develop an innovative platform in thin film lithium niobate for performing quantum optics experiments with integrated devices. It will focus on the development of innovative sources for single photons and squeezed vacuum based on periodically poled waveguides and reconfigurable circuits, and on the integration of superconducting single photon detectors on- chip. This project is part of an on-going collaboration between the Department of Industrial Engineering at the University of Trento, the Bruno Kessler Foundation (FBK), the Italian Institute for Nuclear Physics (INFN), and the National Research Council (CNR).

-*Reference person*: C. Zanella
Title: Optimization of Ni based alloy machining based on FMS [A1)]

The project focuses on the study and optimization of flexible manufacturing systems (FMS) for improved Ni alloy machining. Ni alloys are difficult alloys to machine and particular attention has to be given to the combination of tool choice (in term of material and geometry) and machining process parameters as cutting speed, cutting depth and lubrication conditions. The understanding of the relationship among the combination of such factors and the cutting quality is an essential part in order to define an optimization approach for the cutting set up. Flexible manufacturing systems, combine high productivity with flexibility in the operations and are usually optimized for increased productivity. The goal of the project is to define an optimization strategy that can combine the machining quality optimization to the exploitation of the FMS flexibility to create a model for the cutting performance optimization.

Finanziato dall'Unione europea NextGenerationEU
Ministero dell'Università e della Ricerca
Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA
UNIVERSITÀ DI TRENTO

-*Reference persons*: M. Bernard, M. Lobino
Title: Development of a Platform for Integrated Quantum Photonics based on Lithium [A3)]

"The candidate will work in the Integrated and Quantum Optics group, FBK, where he will develop technologies for integrated photonics.
The technological platforms on which the candidate will operate will be mainly Lithium Niobate On Insulator (LNOI) and silicon. LNOI is one of the most interesting materials for integrated photonics due to the wide

transparency window and its non-linear optical properties. The strong and fast electro-optic responsivity of Lithium Niobate will be exploited to design fast modulators and highly efficient correlated photon sources.
The candidate will develop techniques for thin films of LNOI processing aimed at the realization of such photonic devices on the platform. The candidate will exploit the technological platform to design optical devices and components, that he/she will fabricate and characterize in the laboratories of FBK and UniTN.
This project is funded by project PNRR MS4 C2 I1.3 PE00000023 – NQSTI - “National Quantum Science and Technology Institute (NQSTI)” – SPOKE 4 AF — CUP: C63C22000830006."

-*Reference persons*: A. Dorigato, S. Dirè, G. Moretti
Title: Novel eco-sustainable polymer nanocomposites with piezoelectric capability for energy harvesting applications. [A5)]

The need to develop new materials for energy harvesting, which can convert solar, thermal, and mechanical energy into electrical energy, has become increasingly important due to the growing demand for portable and wireless electronic devices, and to reduce energy dependence on fossil fuels. Piezoelectric materials, by converting mechanical stress or strain into electrical energy, are good candidates for the development of new actuators, energy storage and medical devices. However, their use is often limited by their low electro-mechanical coupling coefficient and poor mechanical and dielectric properties. Piezoelectric nanocomposites, which consist of a piezoelectric nanostructured phase coupled to a polymer matrix, can overcome these issues. These materials have shown remarkable piezoelectric properties, high thermal stability and energy conversion efficiency. In addition, the introduction of nanofillers can improve mechanical properties, dielectric constant and electrical conductivity. Considering that control of the interface in nanocomposites is critical to achieve the desired properties, several methods have recently been developed to tailor the chemical and physical properties of the interface (e.g., nanofiller surface modification, matrix functionalization, use of compatibilizing agents). The proposed project will therefore focus on the development of eco-sustainable and multifunctional polymer nanocomposites with high piezoelectric properties for use in the field of energy harvesting (actuators and devices for energy conversion and storage). Optimization of the synthesis process of ceramic nanofillers will be followed by an in-depth structural and microstructural characterization, conducted by FTIR, XRD and SEM spectroscopy. To increase filler/matrix compatibility, the synthesized nanoparticles will be functionalized with different organosilanes, and the grafting efficiency will be evaluated through EDXS, TGA and NMR spectroscopy. The nanofillers will then be introduced into different bio-based and/or biodegradable polymer matrices with properties suitable for the application under investigation, adding compatibilizing agents to promote the dispersion of the nanoparticles. Samples for analysis will be produced via environmentally friendly net-shape technologies (e.g., additive manufacturing). Determination of the microstructural and thermo-mechanical properties of the prepared nanocomposites will be followed by an extensive electrical and piezoelectric characterization, to assess their suitability in energy harvesting applications. Dielectric spectroscopy tests over a wide range of frequencies and temperatures and dielectric breakdown strength measurements will then be performed to assess energy density.

-*Reference persons*: M. Biesuz, S. Dirè, L. Pancheri
Title: Lead-free centrosimmetric piezoceramics for flexible actuators. [A6)]

Modern electronics and robotics are largely based on piezoelectric materials that convert mechanical into electric signals and vice versa. The best-performing piezo materials are ceramics perovskites operating in the vicinity of their morphotropic phase boundary. These typically contain high amounts of Pb oxide, which is dangerous for the environment and human health thus posing severe safety concerns. A general characteristic of piezoceramics is the presence of a non-centrosymmetric crystal structure, however, a recent publication [1] proved that under a DC bias also centrosymmetric oxides (like Gd2O3-doped CeO2 –GDC–) show a piezo response that could be even superior to the best performing Pb-containing piezoceramics available on the market.
This project aims at developing novel electroactive materials based on oxygen-deficient fluorite-structured oxides. In particular, the project will explore the followings:

1. The production of GDC thin films (<200nm) by sol-gel techniques (dip-coating, spin-coating) or spraying solutions/suspension using the Cerdrop equipment. The reduction of the film thickness to the nanoscale could allow (i) reducing the DC bias voltage needed to activate the piezo response; (ii) increasing the flexibility of the electro-active layer that might be integrated with flexible substrates in tactile systems and/or artificial muscles.
2. The development of new fluorite-structured solid solutions using sputtering deposition (similar to [1]) to understand (i) the effect of the oxygen vacancy content (the oxygen vacancy in Cerium oxide will be tailored using different amounts of trivalent cation doping) and (ii) lattice distortion effect at constant oxygen vacancy load on the piezo-response of the system (solid solutions between CeO2 and ZrO2/HfO2).
3. Studying the combination of the materials developed in 1 and 2 with flexible substrates to realize prototypes of devices such as artificial muscles that could be properly integrated within robotic systems or employing them for the development of ultrasound medical imaging equipment.

[1] D.-S. Park, et al., “Induced giant piezoelectricity in centrosymmetric oxides”, Science, vol. 375, pp. 653–657, Feb. 2022 - . https://doi.org/10.1126/science.abm7497)

- *Reference persons*: M. Fedel, E. G. Macchi
Title: Development of novel flow batteries based on low-cost earth-abundant active materials (project IPCEI Batterie 2 — CUP B62C22000010001) A4)

Redox flow batteries (RFBs) are a promising technology for large scale energy storage. In RFBs power and energy are decoupled: the former depends mainly on the size of the stack while the latter on the size tanks containing the redox active species. This feature makes RFBs ideal for economical, large-scale energy storage. However, cost reductions are needed for a widespread diffusion of this technology. The required cost reductions involve two main components of the system: the electrolytes and the stack. Both need to be optimized for enabling a large-scale deployment of RFBs. RFBs are a complex system so a trade-off between cost and performances must be found for both electrolytes and stack.
This work will focus on developing and validating the use of low-cost earth-abundant redox active materials (e.g., Al, Zn, Fe, Cu, Mn, I, S) in redox flow batteries analyzing different possible solutions for redox couples and electrolytes. The doctoral thesis will start with the development of an integrated approach for the evaluation of different electrolyte solutions (combining different redox active materials, supporting electrolytes and solvents) assessing material cost and availability (with a special focus on EU-sourced materials), safety, expected performances, probability of upscaling issues (e.g., cross-over, pumping losses, etc) and other parameters in other to select the most promising solutions. This pre-selection will be refined by integrating experimental data obtained from the electrochemical and physical characterization of the electrolytes. The use of solid boosters and/or complexing agents to improve the energy density will be a fundamental step to be evaluated experimentally. The selected best candidates will be then tested in lab-scale redox flow cells customized for the specific chemistry. Membrane/separator selection or development will also be addressed during this phase. Finally, issues related to the upscaling of the technology will also be analyzed in order to assess the real potential impact of the proposed innovative solutions. This grant is funded by project IPCEI Batterie 2 — CUP B62C22000010001.

- Reference persons: V.M. Sglavo, M. Testi
Title: Electrolysis systems operating at high temperature A7)

The production of electrolytic hydrogen from water appears as the most practical and promising technology to produce "green" hydrogen on a large scale. In this context, solid oxide cells (SOC, Solid
Oxide Cells) have potential advantages over polymeric membrane (PEM, Proto Exchange Membrane) or alkaline ones as they allow to produce hydrogen with greater efficiency, operating at high temperatures and without the need to use expensive catalysts based on noble metals. A further advantage of SOCs is that they can be reversible and operate both in electrolytic mode as fuel cells to use the fuel (primarily hydrogen) to produce electricity. With elevate efficiency The SOC technology differs according to the materials used in the construction of the cell and above all according to the transport mechanism of the ions inside the solid electrolyte which can be O2- anions (in the O-SOC), or H+ protons (in the H -SOC). The O-SOCs are characterized by high working temperatures (above 600°C), with a clear impact on aspects such as performance and durability, and by more mature materials and production technologies compared to the more recent H-SOCs, more promising for the development of next generation steam electrolysis technologies which can potentially operate at lower thermal regimes. In both cases it is possible to integrate numerous functions useful to produce hydrogen with compression, purification, filtration, and separation.
The fundamental objective of the PhD activity is the development of prototype cells of ionic conductive cells. It is possible to divide the planned activities into two main activities, closely related to each other and aimed at optimizing the devices and their performance. First activity will be performed in strong collaboration with UniTN-DII, concerning the production of materials and the realization of the prototype cells. Reference will be made to planar architectures where, initially, the compositions will refer to an electrolyte based on zirconia or Ceria suitably doped, hydrogen side electrode based on zirconia/nickel/copper or perovskites such as ferrites, manganites or cobaltites, the latter to be also use for the oxygen side electrode; compositions and structures will be identified above all on the basis of the expected operating temperatures and suitably modified in order to optimize performance, always keeping in mind the production process which will have to allow for the achievement of multilayer planar structures "alla ceramic". The prototype cells will be made using colloidal technologies (tape

casting, screen printing, digital printing) and subsequent co-sintering to then be characterized from a chemical-physical and structural point of view to be able to correlate the performances as identified in the subsequent activity. Second activity provides for the physicochemical, structural, and electrochemical characterization in "electrolysis" and fuel cell mode of the cells, in collaboration with FBK. The activity includes several sub-activities:

 Setup of a test bench for 5x5 cm cells or button cells up to 3cm in diameter, up to 800°C and with different test gases (H2 and ammonia)

 development of a shared test protocol developed with UniTN in order to evaluate:

o Cell performance (VI curves at different temperatures, EIS)
o Degradation (short/medium term test) as well as appropriate AST
o Post mortem analysis (SEM, XPS)
o Analysis of the cells produced, with data analysis and identification of the main performance indicators.

Mechatronic and Mechanical Systems (area B)

- *Reference persons*: D. Bortoluzzi, G. Moretti

Title: Mechatronic systems and innovative actuators for precision applications[1)]

Actuators constitute typical mechatronic system where the functionality and performance are strongly affected by the tight synergy among mechanical dynamics, electric/electronic behaviour and control strategies. Some actuation strategies (piezoelectric, electrostatic drives, etc.) present relevant potentialities to extend the frontier of their applications to cutting-edge technological fields. The research project is focused on the study of how this combination may be understood, improved and converted into a design for applications of high precision, accuracy and reliability. Particular applications will be explored where the working environment may enhance the performance, including high-vacuum for space technologies.

- *Reference persons*: P. Rech, M. Saveriano

Title: Reliability Evaluation and Improvement of EdgeAI accelerators [B1)]

Low-cost devices to accelerate Artificial Intelligence (AI) inference, called EdgeAI accelerators, have recently been introduced on the market. Neural Processing Units (NPUs), such as NVIDIA NVDLA, or Tensor Processing Units (TPUs), such as Google's Coral Edge TPU, are low-power devices expressly designed to accelerate computer vision and neural networks in general. By optimizing the data transfer, using internal buffers, and relying on dedicated functional units, EdgeAI accelerators reduce the inefficiencies associated with the execution of AI in traditional computing devices. These devices are appealing in several areas including, but not limited to Internet of Things, robotics, self-driving cars, and deep space exploration. Unfortunately, an accurate reliability characterization of EdgeAI devices is particularly challenging, since the available documentation is sparse and gives little information about their architecture. The goal of this PhD is to investigate at which level we can trust the AI execution on EdgeAI devices and design efficient and effective mitigation solutions to guarantee their employment in strategic applications, such as industry, military, and aerospace.
This PhD, which will be carried out in collaboration with the Rutherford Appleton Laboratories, in the UK, where the student has the opportunity to spend up to 1 year to perform experiments and interact with experts in the reliability area. Additionally, this PhD is part of a broader research that includes collaboration with the European Space Agency, Jet Propulsion Laboratory, and key industry partners such as Argotech and Intel.

- *Reference person*: G. Giordano

Title: Integrated Structural and Probabilistic Methodologies for Biological and Epidemiological Systems [B2)]

The PhD student will contribute to the development of integrated structural and probabilistic methodologies for biological and epidemiological systems, within the ERC project INSPIRE. INSPIRE Project: Systems in nature are extremely robust, despite huge uncertainties and variability. Studying their nonlinear dynamic behaviour is challenging, due to their complexity and the many parameters at play, but crucial to understand important phenomena, such as cellular dynamics, onset of diseases, epidemic spreading. Parameter-dependent simulations can predict the behaviour of natural systems case by case. Yet, the exact models and parameter values are poorly known, while qualitative behaviours are often preserved even with huge parameter variations, because they rely on the system interconnection structure. Parameter-free structural approaches can check whether a property is preserved for a whole family of uncertain systems exclusively due to its structure. However, when an expected property fails to hold structurally, novel approaches are needed to understand why, which system features prevent it, which key parameters must be finely tuned to enforce it. INSPIRE will develop a unifying framework to analyse and control families of uncertain dynamical systems in biology and epidemiology, which integrates for the first time structural, robust and probabilistic methods, tailored to the peculiarities of natural systems. The project will provide: i) methodologies to assess (practically) structural properties and unveil the mechanisms that enable/prevent a property, identifying the key parameters or motifs; ii) control paradigms that leverage such an insight to guarantee a desired global property through targeted local interventions; iii) scaling and aggregation approaches that exploit the properties of subsystems to mitigate computational complexity. The project outcomes, a mathematical theory as well as algorithms to analyse and control complex uncertain systems in nature, will strongly support the analysis and design of biomolecular feedback systems with a desired behaviour, the identification of therapeutic targets, the prediction and control of epidemic phenomena.

-*Reference persons*: M. Saveriano, A. Tirella, P. Rech
Title: Modeling of functional inks for 3D printed electronics using physics-informed neural networks [B4)]

Rapid fabrication of functional materials, including 3D printed electronics, is an emerging field with appealing applications in several areas including Internet of Things, Robotics, Biomedicine and Biotechnology. Rapid prototyping techniques, like 3D printing, can deliver unique features like complex printing patterns and the possibility to combine different inks to obtain embedded, conformal, flexible and/or stretchable devices, which is hardly attainable by traditional manufacturing methods. However, a functional understanding on the formulation of inks and how to combine different materials to fabricate a product with the desired electro-mechanical properties is still missing, particularly when they have to conjugate specific requirements, like biocompatibility.
This PhD project aims to develop a new data-driven approach to model the effects of different ink formulations on the functionalities of the printed product. In particular, the physical properties and printability of natural-derived biopolymers formulations will be studied varying the loading of conductive polymers and/or gold/silver nanoparticles to achieve the desired electro-mechanical properties. The model will be based on inks properties (that we can control and characterize during formulation) and will exploit modern techniques like physics-informed neural networks to increase the accuracy and robustness, while significantly reducing the amount of training data needed to achieve the desired performance. The model will reduce the number of attempts needed to fabricate a product and, as a consequence, the amount of waste material being produced.

-*Reference persons*: G. Moretti, S. Dirè, L. Fambri
Title: Design and development of soft robots with integrated electrostatic artificial muscles [B5)]

This PhD project aims to develop new concepts of highly-integrated soft robots based on a combination of compliant structures and polymeric artificial muscles.
While the shape of conventional robots progressively evolves towards advanced architectures, based on deformable links and capable of “soft” interactions with the surrounding environment, the actuation system still represents one of the most critical components for the development of integrated soft robots. Smart-material-based artificial muscles, such as electroactive polymer actuators, represent an extremely promising solution on this end, thanks to their large energy density, low stiffness, and suitability to be integrated onto soft structures.
This PhD project will be focused on a class of electrostatic artificial muscles that combine electroactive polymers and dielectric liquids. Building upon seminal works on liquid-based electrostatic muscles, the successful candidate will design, build and test soft robotic structures with integrated actuators, with the final objective of developing an integrated prototype of a soft arm (gripper + manipulator) for handling of delicate goods.
The PhD project will pursue a multi-disciplinary approach, at the intersection among mechatronics and material science. Specific activities will include: modelling and design of soft robotic structures and electrostatic muscles; performance optimization of electrostatic muscles through advanced material combinations (including custom-synthetised materials) and manufacturing processes (including screen printing of electronics); design and prototyping of integrated robot concepts; experimental characterisation and model validation.

-*Reference persons*: E. Rustighi, G. Moretti, D. Bortoluzzi
Title: Development of wearable vibrotactile and acoustic interfaces based on dielectric elastomers [B6)]

This PhD project seeks to develop wearable user interfaces that make use of smart-material based actuators to guide/assist users via tactile and acoustic feedbacks.
In the future, multi-sensory wearable interfaces will become a gold standard in applications such as assisting visually impaired subjects (directional guidance, warning), rehabilitation (postural correction), or virtual reality. While traditional electromagnetic actuators are bulky, rigid, and scarcely suitable for integration onto garments, the use of soft high-power-density polymeric transducers might pave the way to highly integrated smart garment concepts.
In this project, the candidate will develop lightweight audio-tactile communicators based on a class of electroactive polymers called dielectric elastomers (DEs), integrate them onto wearable structures (arm or wristband), and test them in relevant scenarios with users. A special focus will be put in designing distributed DE membrane actuators, capable to provide vibrotactile feedback through local activation, and produce acoustic outputs leveraging on distributed high-frequency structural vibrations.
The research project will blend modelling activities (model-based design, multi-physics modelling), experimental characterisation (including vibration measurements with laser Doppler vibrometers), and design/prototyping of integrated systems (smart garments).

Electronic Systems and Integrated Microelectronic Systems (area B)

- *Reference person:* L. Pancheri
Title: CMOS radiation sensors with avalanche signal amplification [1)]

The goal of this activity is the development of novel CMOS-integrated sensors exploiting linear-mode avalanche signal amplification. Silicon avalanche detector arrays are used in several research, industrial and consumer applications, for example particle tracking in medical, High-Energy-Physics and space experiments, X-ray spectroscopy and Time-Of-Flight optical ranging. The co-integration of arrays of detectors with low-noise or high-speed readout circuits will enable the creation of a new class of devices with State-of-the-art performance in terms of Signal-to-Noise Ratio and timing resolution. Another advantage of the proposed approach is the reduction of the fabrication costs per unit area if compared to currently available systems. Integrated detectors will be designed using TCAD simulations tuned with the foundry process parameters, fabricated in commercial CMOS processes and validated through extensive experimental laboratory characterization, in collaboration with research partner institutions.

- *Reference person:* D. Fontanelli, F. Antonelli
Title: Distributed Learning Paradigms with Robotics, IoT and Edge Computing in Digital Agriculture Domain [B3)]

This research aims to investigate the integration of distributed learning paradigms with robotics, IoT, and edge computing in the context of digital agriculture. It will explore the potential benefits of using distributed learning approaches, such as federated learning, continual learning, and reinforcement learning to improve crop yields and reduce costs and environmental impact by enhancing the overall efficiency of agricultural operations, also including active sensing, autonomous navigation, and decision-making. The research will explore IoT and edge computing to support the collection, processing, and analysis of data from distributed sensors in the field. The study will investigate the technical and economic factors that influence the adoption and implementation of these technologies and frameworks in agriculture, including issues related to scalability, resource constraints, and interoperability. Finally, the research will also explore the potential of combining these technologies and frameworks to create new opportunities for innovation and collaboration in digital agriculture.

-*Reference persons*: D. Brunelli, L. Pancheri, D. Maniglio, F. Biral
Title: 3D-printed sensors and electronics for smart healthcare and sport applications. [B7)]

Additive manufacturing is gaining momentum in the electronic industry thanks to the performance improvements of the so-called "printed electronic components".

These techniques, thanks to their properties of implementation easiness, fabrication speed, amount of required material and limited energy consumption, are of great interest when compared to standard technologies for electronic components manufacturing.
In addition, unlike standard "rigid" electronics, printed electronic objects can be compliant with flexible applications and roll-to-roll processes.
The purpose of this Ph.D. research activity is to investigate the employment of inkjet printing of conductive, semiconductive and insulating inks for the manufacturing of flexible sensors for healthcare and sport applications.
The PhD student is expected to design and realize prototypes on flexibles substrate of simplified geometry transducers using the "Ceradrop CeraPrinter F" printer available in the department (unique equipment in Italy, and one of the most advanced 3D printers for functional material and electronic components in the world).

Operational Research (area B)

-*Reference persons*: N. Suzic, F. Pilati
Title: Towards Mass Customization Production Systems in Industry 5.0 Era [1)]

Mass customization (MC) is a concept with increasing importance for manufacturing companies. MC is even more significant with coming to existence of real “markets of one” and the center position MC got in EU Industry 4.0 and the Industry 5.0 strategies. With the “markets of one” in place and digital technologies available, the stage is set for new transformation of companies towards MC. However, the operationalization of this transformation towards MC is not straightforward, since the design and management of MC production systems differs in high extent from the traditional production systems. This difference is seen in the need to apply specific enablers such as product modularization, form postponement, and product platforms, impacting in this way the production system design. Furthermore, the role of the assembly systems in ensemble with the aforementioned enablers for customized products becomes crucial. Thus, the goal of this PhD research is to develop a framework for implementing MC production system for today’s industrial reality. It is envisioned that the operationalization of this framework is supported by development of original mathematical models, optimization tools, intelligent algorithms and digital technologies to enable the decision making for production processes. Finally, the framework should be tested in the real industry MC scenario.

Funding:
1) UNITN (6 borse)
A1) UNITN and DII (Zanella, progetto FLY)
A2) UNITN and FBK
A3) FBK (PNRR) CUP: C63C22000830006
A4) FBK (IPCEI Batterie 2 — CUP B62C22000010001)
A5) DII ECCELLENZA (Dorigato) - CUP E63C22003890001
A6) DII ECCELLENZA (Biesuz) - CUP E63C22003890001
A7) FBK e Dipartimento di Fisica

B1) UNITN and DII (Fontanelli)
B2) UNITN e DII (ERC Giordano) CUP E63C22003020006
B3) FBK
B4) DII ECCELLENZA (Saveriano) - CUP E63C22003890001
B5) DII ECCELLENZA (Moretti) - CUP E63C22003890001
B6) DII ECCELLENZA (Rustighi) - CUP E63C22003890001
B7) DII ECCELLENZA (Brunelli) - CUP E63C22003890001