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Supervisor Expression of Interest
MSCA - Marie Sklodowska Curie Action - (PF) Postdoctoral Fellowship 2022

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Department Name:	Department of Mechanical Engineering
Research topic:	Structural Integrity by development of artificial intelligence-based Structural Health Monitoring systems
MSCA-PF Research Area Panels:	☐ CHE_Chemistry ☐ ECO_Economic Sciences **X ENG_Information Science and Engineering** ☐ ENV_Environmental and Geosciences ☐ LIF_Life Sciences ☐ MAT_Mathematics ☐ PHY_Physics ☐ SOC_Social Sciences and Humanities
Politecnico di Milano Areas:	☐ Cultural Heritage ☐ Smart Cities ☐ Horizon Europe Missions ☐ Health **X Industry 4.0**
Brief description of the Department and Research Group (including URL if applicable):	The research group of prof. Francesco Cadini (SIGMALab) belongs to the Dept. of Mechanical Engineering o the Politecnico di Milano. For at least 15 years, the SIGMALab has been at the forefront in the development of cutting-edge methodologies for structural integrity, with focus on increasing the potential of structural health monitoring (SHM) systems through the combined use of AI and physics-based models. In this context, the group coordinated a series of research projects in the framework of the European Defense Agency (EDA): HECTOR (monitoring and prognosis of cracks in the helicopter fuselage through a network of sensors on board), ASTYANAX (monitoring system for cracks in the fuselage of aircraft and prognosis through a network of sensors on board), SAMAS (SHM application to unmanned aircraft for assessing damage from external impacts on composite material structures), and SAMAS II (SHM application to helicopters–in progress)

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Title	Development of a smart hybrid CNT-GNP/CFRP composite capable of self sensing of delamination and crack growth during static and dynamic loadings

Brief project description:

Substituting traditional metallic materials such as aluminum and steel with Carbon Fiber Reinforced Polymers (CFRPs) led to considerable reduction of aircraft weight, thus, less fuel consumption and costs. Almost 50% of the constituent materials in an aircraft are made of CRFPs and this trend has being rapidly growing in high performance structural composites to meet the new engineering demands in terms of excellent mechanical properties, good fatigue life, high corrosion resistance, and low weight.

Apart from numerous benefits of CFRPs, fiber delamination resulting from poor bonding between fiber and epoxy is one of the most important challenges in the CFRP industry. Therefore, it is necessary to monitor the health of the whole structure during its operation to avoid potentially catastrophic failures.

Piezoresistive based sensors have shown numerous benefits compared to the traditional strain sensors because they can detect damage initiation at bulk scale (globally); however, traditional sensors are moslty localized. Likewise, early detection of the damage is quite challenging using old technologies such as non-destructive tests i.e. X-ray, eddy current, and ultrasonic. Furthermore, some of these technologies need to dismantle all parts at a high cost which prevent real-time monitoring implementation. Within this context, thanks to their excellent electrical conductivity, Carbon Nanotubes (CNTs) and Graphene Nanoplateles (GNPs) opened alternatives to engineers in creating multifunctional materials in which a piezoresistive property can be induced to the nonconductive host material. Therefore, this project is aimed to create a smart CFRP material using hybrid CNTs and GNPs capable of self-sensing of damage initiation including fiber delamination and crack growth. The idea is to not only enhance fracture toughness of the CFRP using reinforced epoxy, but to also impose new functional properties to the materials to be used as a piezoresistive sensor for damage monitoring. First, a hybrid CNT-GNP/epoxy composite in various weight concentrations will be prepared to reach ideal piezoresistive sensitivity. For the manufacturing of CFRP, a polytetrafluoroethylene (PTEF) release film with various dimensions and geometry will be inserted between laminates to stimulate the initial crack and delamination of fibres. Two different test setups including double cantilever beam (mode I) and end loaded split (mode II) tests subjected to static and dynamic loadings will be prepared to monitor crack extension and delamination. Subsequently, the change in normalized resistance will be monitored in real time to correlate the delamination and crack extension to normalized resistance change. The outcome of this project can be used as an indicator for real time monitoring of the health of structure by means of correlation of the electrical signal to the delamination growth, especially during dynamic loading which is more similar to real service condition of CFRP composites.