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Supervisor Expression of Interest
MSCA - Marie Sklodowska Curie Action - (PF) Postdoctoral Fellowship 2024

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Link "Pagina docente":
https://www4.ceda.polimi.it/manifesti/manifesti/controller/ricerche/RicercaPerDocentiPublic.do?EVN_PRODOTTI=evento&k_doc=593901&polij_device_category=DESKTOP&__pj0=0&__pj1=57dd31976dbfbb0826dc7c2a90c62a7b

Department Name: Civil and Environmental Engineering (DICA)

Research topic: Micro electromechanical systems (MEMS) in extreme conditions

MSCA-PF Research Area Panels:

- ☐ ECO_Economic Sciences
- ☐ ENG_Information Science and Engineering
- ☐ ENV_Environmental and Geosciences
- ☐ LIF_Life Sciences
- ☐ MAT_Mathematics
- ☐ PHY_Physics
- ☐ SOC_Social Sciences and Humanities
- ☐ CHE_Chemistry

Brief description of the Department and Research Group (including URL if applicable):

The Department of Civil and Environmental Engineering (DICA) was founded in 2013 and brings together professors and researchers involved in various research activities. One of the most important objectives of the department is to promote multidisciplinarity in Civil and Environmental Engineering, to face the problems of the sector with an integrated approach. The main mission of DICA is to operate on the topics of surveying, geology, geotechnics, hydraulics, hydrology, water resources management, transport networks, analysis and design of structures and infrastructures, seismic engineering, safety of historical structures, hydraulic and maritime constructions.

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Within DICA, the Mechanics of Materials and Structures (MMS) Research Group is a leading unit in the mechanics of micro electromechanical systems (MEMS), with intense industrial collaborations. The Group combines knowhow in computational mechanics, micromechanics, coupled physico-mechanical processes, and nano-to-micro scale modelling and simulation.

https://www.dica.polimi.it/research/sections/mechanics-of-materials-and-structures-section/?lang=en

TITLE of the project: Degradation of micro electromechanical systems (MEMS) in extreme exposure conditions

Brief project description:

Micro electromechanical systems (MEMS) are ubiquitous in our society and quintessential to our economy and welfare. Their importance will likely increase even further in the near future, with the global expansion of artificial intelligence and robotics.

The design of MEMS leverages a decades-long experience, but there are areas of application where the reliability of MEMS is still difficult to ensure. These areas are characterized by extreme service conditions, such as steep temperature gradients or exposure to high levels of radiation. Examples of such MEMS applications encompass microsatellites, interstellar probes, but also medical devices, operation and decontamination of nuclear facilities, robots supporting fire brigades, etc.

The performance of a MEMS device is often very sensitive to its microstructural degradation, but the degradation mechanisms of MEMS in extreme conditions are still poorly understood. These mechanisms originate at the molecular level, with impurities evolving in the crystal structure of the material. Eigenstresses are also present in the microstructure, and they also evolve over time under the action of thermal and radiation loads. All this is coupled with mechanical fatigue, since MEMS are dynamic systems undergoing billions of deformation cycles during their service life. All this poses two challenges for the design of MEMS in extreme conditions: (1) How to ensure their long-term integrity? (2) How to predict their progressive change in performance during degradation, which would allow for their recalibration to still operate effectively?

The research project will address these two challenges. The multi-scale modeling techniques that are available in the Research Group will be leveraged to clarify the main modes of degradation of typical MEMS structures exposed to high temperature gradients and intense radiations. Experimental data will be produced in collaboration with industrial partners that are already engaged in intense collaboration with the Research Group. The simulation and experimental results will be combined to inform Machine Learning approaches, all to develop predictive laws for the change in performance of MEMS in extreme operating conditions. The application to a specific patentable device will be explored too, in collaboration with the Group's industrial partners.