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Carlos III de Madrid



PhD position in Marie Skłodowska-Curie ITN-ETN

The outstanding challenge in Solid Mechanics: engineering structures subjected to extreme loading conditions

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In this project we aim to train early-stage researchers in what is referred to as an outstanding challenge in solid mechanics: developing novel solutions for the analysis and design of aerospace and defense structures subjected to extreme loading conditions. Structural elements used in aerospace and defense industries are frequently subjected to a large variety of unusually severe thermo-mechanical solicitations. One easily realizes that this type of structures (e.g. components for satellites) has to be designed to sustain extreme temperatures, which may vary hundred degrees in short periods of time, and extreme mechanical loadings like hypervelocity impacts. New specific structural solutions are constantly developed to fulfill such requirements, which place these industrial sectors in the forefront of the technological innovation. We have formed a consortium composed of 3 academic and 4 industrial partners which aims at developing specific training for early-stage researchers within the field of aerospace and defense structures subjected to severe thermo-mechanical loads. The leitmotif of this ITN is to train creative and innovative researchers ready to face structural-engineering challenges which arise in the vanguard of technological innovation. OUTCOME is a unique opportunity for 8 motivated early-stage researchers that are willing to set the basis of their scientific career within the field of Solid Mechanics.

PhD Research

Modelling of delamination and interface strength in printed circuit boards (PCBs)

Hosts

Cimulec - Ennery

University of Lorraine – Metz



Supervisors

Dr Laurent Bodin

Professor Marion Martiny

Professor Sébastien Mercier

Synopsis

A printed circuit board is a passive component which allows to interconnect electronic components soldered on the outer layers in order to realize a complex electronic system. It is a complex multi-layer assembly developed for a very specific goal which requires expertise in mechanical and material sciences. In order to reach the expected performance and lifetime in harsh environments dedicated high-performance base materials are required. During its lifetime, the PCB undergoes a large number of

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thermal cycles which can lead to the breakup of copper path. In addition, when active components are soldered on the PCB, a thermal shock is produced. It has been detected that the use of certain combination of based materials leads to delamination, which damages the PCB and limits its service-life. We will investigate the delamination process and the evolution of the strength of interfaces from both theoretical and experimental sides. Within this context, we will develop a research on the damage and failure processes of PCBs subjected to thermal cycling. A theoretical model will be specifically developed in order to predict the onset and evolution of damage and failure. The predictions of the theoretical model will be compared with own experiments specifically conducted for that purpose (to check the reliability of the model predictions). The planned experiments are peeling tests at various temperatures performed for various pairs of materials frequently used to manufacture the PCBs.

Research outputs

A theoretical model, validated with experiments and numerical calculations, to predict the onset and evolution of damage (here delamination) in PCBs subjected to thermal cycling. We will focus on the strength of the interface. On the one hand the research has a strong fundamental background in, for instance, the definition of interface strength at room temperature. The goal also is to test the interface at different temperatures. On the other hand we plan to obtain very practical conclusions based on ability of the theoretical model to describe the behaviour of *real* PCBs that developed damage and failure during their service-life. The results of this research will have great interest for the industry since they will significantly increase the current knowledge on failure of PCBs due to extreme thermal loading. In particular, the proposed research will strengthen the knowledge of CIMULEC in this field, increasing its competitiveness, which is essential for the future development of the company.

Multidisciplinary / intersectoral research approach:

CIMULEC will host the ESR which ensures that she/he will be merged in a multidisciplinary industrial environment since manufacturing of PCBs is a complex process with a large number of steps involving chemistry, electrodeposition, drilling, testing, materials selection, etc. The ESR will become familiar with all these techniques which enrich the education of the ESR in different engineering fields. CIMULEC and LEM3 (**University of Lorraine**) are involved in a Labcom LEMCI (common laboratory), so that the ESR will have frequent discussions with members of both institutions. The ESR will be hosted by CIMULEC and LEM3. The ESR will develop the core of the formulation of the theoretical model at LEM3 and CIMULEC. Taking advantage of the geographical proximity between **CIMULEC** and UL, and the existence of the Labcom LEMCI, the ESR will conduct periodic visits to both institutions. Furthermore, a dedicated secondment is planned at the University of Lorraine where she/he will perform the tests that will be used to validate the predictive capacity of the theoretical model. In addition, he/she will conduct a secondment at the **University Carlos III of Madrid** where she/he will conduct finite element calculations to be compared with the experiments and the theoretical model.

Training activities

The successful candidate will have access to the PhD program of the **University of Lorraine** as well as to the training activities organized within the OUTCOME consortium. These activities include, among others:

- **Attendance to the Workshop:** Extreme structural mechanics in aerospace applications to be organized by AEROSERTEC in Madrid.



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- **Attendance to the Workshop:** Extreme structural mechanics in defense applications to be organized by RAFAEL in HAIFA.
- **Attendance to the course:** Horizon 2020 Proposal Development to be organized by EUROPA Media in Budapest.
- **Attendance of the course:** Damage and failure of solids subjected to extreme loading conditions to be organized by the University of Lorraine.
- **Attendance to the course:** From PhD to Scientific Leadership to be organized by Yellow Research in Madrid.
- **Attendance to international conferences** on damage and failure of engineering materials.

Benefits

The successful candidate will be employed for 3 years and receive a grant **plus an additional mobility and family allowance** according to the rules for Early Stage Researchers (ESRs) in an EU Marie Skłodowska-Curie Actions Innovative Training Networks (ITN):

- Living allowance – 3452.1€ (per month)
- Mobility allowance – 600€ per month (per month)
- Family allowance – 500€ per month (per month – if applicable)

This amount is a gross contribution to the salary costs. Net salary will result from deducting all compulsory social security/direct taxes from the gross salary according to the law applicable to the agreement concluded with the ESR.

Additional information about the funding provided by the ITN projects can be found in: http://ec.europa.eu/research/participants/data/ref/h2020/wp/2014_2015/main/h2020-wp1415-msca_en.pdf

Key publications

Salahouelhadj A., Martiny M., Mercier S., Bodin L., Manteigas D., Stephan B. Reliability of thermally stressed rigid-flex printed circuit boards for High Density Interconnect applications, *Microelectronics reliability*. 2014; 54: 204-213.

Molinari A., Ravichandran G., Peeling of Elastic Tapes : Effect of large deformations, pre-straining and of a peel zone model, *The Journal of Adhesion*. 2008; 84: 961-995.

Kovalchick C., Molinari A., Ravichandran, G. Rate Dependent Adhesion Energy and Nonsteady Peeling of Inextensible Tapes. *Journal of Applied Mechanics*. 2014; 81: 041016.

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Profile

We are looking for highly motivated candidates who want to pursue a scientific career in mechanical engineering (academic or industrial). An ideal candidate would have a background in mechanical or civil engineering or physics or mathematics and a strong interest in collaborating with a team working attitude in an interdisciplinary project. The candidate must have some interests to develop both experimental, numerical and modeling researches. Good communication in English is required.

To apply for the proposed thesis in **France**, and in order to meet the specific requirements of the Marie Skłodowska-Curie funded PhDs, you must not have resided or carried out your main activity (work, studies, etc.) in **France** for more than 12 months in the last 3 years. Candidates must have a MSc degree or obtain a MSc degree by August 2016.

Applications

The candidates must provide a letter of motivation where they clearly state why, under their point of view, they should be enrolled in OUTCOME.

At least, one recommendation letter from the scientist/s who mentored the candidate during her/his master studies is required. The letter must clearly expose the profile of the candidate with emphasis in the qualities which make her/him suitable for being recruited in OUTCOME. Additional recommendation letters from any other professor/professional will be welcomed.

We are committed to provide flexible hours and home working conditions for researchers having family obligations. The following web-site contains relevant information **related to the EU equal opportunities policy** https://ec.europa.eu/research/science-society/women/wir/index_en.html. Moreover, the web-site <http://www.partnerjob.com/> facilitates geographic mobility by providing help to find a job for an accompanying partner.

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The application period closes in June 2016

The PhD starts in September 2016