Session Topic Number: *XX*

Keywords: *composites, joining, material interface, multiscale*

ESI VPS multiscale performance simulation for laser structured Composite-Metal joints

Sebastian Müller[1*], Patrick de Luca[2]

[1]ESI Software Germany GmbH, Liebknechtstraße 33, 70565 Stuttgart, Germany

[2] ESI Group, 25 Rue Marcel Issartier, 33700 Mérignac, France

*Corresponding Author: Sebastian.mueller@esi-group.com

An economic utilization of modern engineering materials can only be achieved through a combination of different materials depending on the local design requirements. This further leads to questions about the joinability of certain materials in a multi-material assembly. During the design of hybrid parts consisting of metallic alloys and fiber reinforced polymers (FRP) different joining techniques can be applied. Since the present study focuses on the application of an Automatic Tape Laying (ATL) process, the joint is established utilizing the adhesive bond generated during the consolidation process of the composite.

Laser structuring of the metallic surface has been found to allow for a significant improvement of the adhesive properties. However, in order to optimize the manufacturing process in terms of efficiency, it is required to quantify this effect. To this end, a numerical multiscale approach has been developed to examine the effective interface properties enabling to relate directly the joining process to the mechanical performance of the joint

Based on a micrograph of the material interface, an idealized representative volume element is identified (cf. Figure 1). Following the works of Cid Alfaro et al. (2010) and Hirsch and Kästner (2016) this microscopic model of the material interface is used in a numerical homogenization framework to identify effective cohesive interface properties (e.g. fracture strength and fracture toughness for mode I and mode II) (cf. Figure 2).

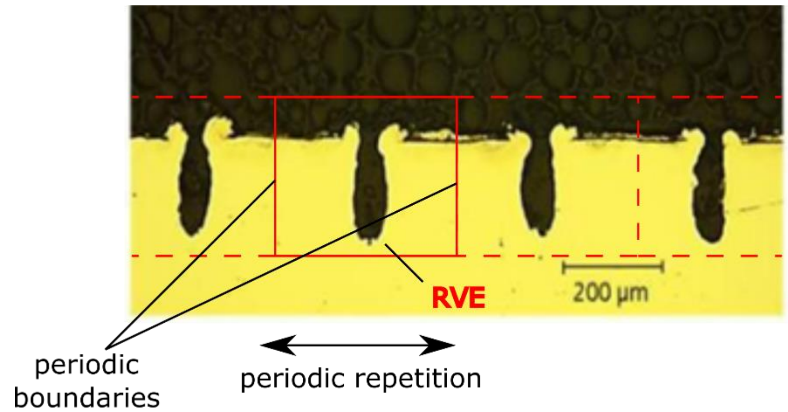

Figure 1. Micrograph of a laser structured composite-metal material interface and representative volume element (RVE). (Source micrograph: Fraunhofer ILT, Aachen Germany)

The scale bridging is accomplished using HILL's averaging principle. Applied to the present problem it can be stated that the virtual work density δW^{M} in a single point of the interface on the macro-scale is equivalent to the volume average of the total virtual work $\overline{\delta W^{\mathrm{m}}}$ in a defined area on the micro-scale. In fact, I think the figure 2 could be different in my understanding (to be discussed) you need to explain to me how you want it to look like

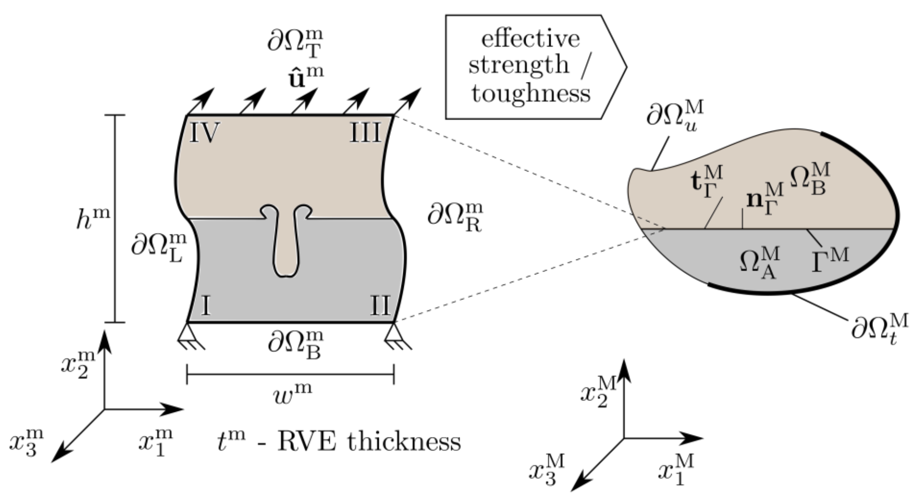

Figure 2. Micro-scale and Macro-scale domain definition.

Exploring the microscopic response of the RVE on a finite number of displacement driven deformations allows for the parametrization of effective cohesive material interface models to be used in a macro scale simulation. The entire approach is implemented in the commercial FE package ESI Virtual Performance Solution (VPS). Subsequently the method is examined for parametrized interface geometries as well as real patterns obtained from micrographs. The approach will be used in the demonstrators of the COMMUNION project [3] in order to define the surfaces texturizations that will deliver the requested mechanical performance of the assembly.

Literature

[1] M. Cid Alfaro, A. Suiker, C. Verhoosel, R. de Borst, Numerical homogenization of cracking processes in thin fibre-epoxy layers, European Journal of Mechanics - A/Solids 29 (2) (2010) 119–131.

[2] F. Hirsch, M. Kästner, Microscale simulation of adhesive and cohesive failure in rough interfaces, Engineering Fracture Mechanics - accepted (2016).

[2] The ComMUnion Project (http://communionproject.eu/)

Acknowledgement

This work is under the framework of EU Project Communion. This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 680567. The dissemination of results herein reflects only the author's view and the Commission is not responsible for any use that may be made of the information it contains