Luca Di Stasio

Early Stage Researcher

D-CPR Certified (FR, SE)

Driver License Cat. B (IT)

Italian & EU citizen

Stormvägen 299
SE-97634 Luleå, Sweden

+46 76 453 21 60

luca.distasio@gmail.com

www.lucadistasioengineering.com

Research Interests

- **Linear and non-linear behavior of materials and structures:** elasticity, fracture, plasticity, viscoelasticity, viscoplasticity, piezoelectricity, magnetostriction
- **Multi-scale computational modeling of materials:** Finite Element Method (FEM) and its variants, Lattice Boltzmann Method (LBM), Molecular Dynamics (MD), Discrete Element Method (DEM)
- **Modeling of fatigue, fracture, and damage in polymers and FRPC:** delamination, transverse cracking, fiber-matrix debonding, transverse cracking induced delamination
- **Experimental mechanics of FRPC:** mode I, II, III and mixed mode I-II delamination, automated observation of transverse cracks, estimation of stiffness reduction, loading rate effects, effect of curing history and degree of cure on mechanical properties
- **Theoretical, experimental and computational fracture mechanics:** interface cracks, Fracture Mechanics, Virtual Crack Closure Technique (VCCT), J-integral, Cohesive Zone Model (CZM), eXtended Finite Element Method (X-FEM)
- **Adoption and dissemination of Open Science practices:** open innovation, research data management, research software development and maintenance, open data, open source software
- **Learner-centered pedagogy and teaching in higher education:** signature pedagogies, threshold concepts, taxonomies, learning objectives, physical and virtual learning spaces

Research Area and Approach

My main research interest lies in Integrated Computational Materials Engineering (ICME) with a particular focus on Fiber-Reinforced Polymer Composite (FRPC) materials, made of both man-made (carbon fibers, glass fibers, epoxy) and bio-sourced constituents (wood, wood-based products, cellulose, natural fibers). ICME represents a novel paradigm in the field of materials development proposed around 10-15 years ago and still in its early stage of growth. The objective is the development and integration of predictive computational software, data analysis tools and automated experimental techniques in order to reduce the time-to-market of new materials. This is achieved not by eliminating experimental assessment, but through its automation by means of software (image analysis, signal analysis, machine learning) and hardware (low-cost hardware, robotics) innovation and by reducing the number of experiments needed through integration with predictive computational simulations and data science algorithms. My research interests thus lie at the cross-road of computational science, experimental mechanics and data science.

Current and Past Research

The work of my PhD thesis is devoted to the Linear Elastic Fracture Mechanics (LEFM) analysis of transverse cracking in thin-ply FRPC at the microscale by means of the Finite Element Method (FEM). At the microscale, transverse cracks originate from fiber/matrix interface cracks or debonds, which coalesce to form what macroscopically is seen as a transverse crack. Debonds have been investigated in the past, but studies have focused on very few geometrical configurations with a restricted number of fibers embedded in an infinite matrix or homogenized composite. The novelty of my approach is twofold: analyzing configurations representative of FRPC laminates' microstructure and simulating a large number of geometrical configurations by automated model generation, simulation, data analysis and reporting. Among other results, this approach has helped to prove a counter-intuitive claim: in cross-ply laminate the fiber/matrix interface crack, and thus initiation of transverse cracking, is not influenced neither by the thickness of the 90° layer nor of the 0° ply, very differently from what has been observed macroscopically for transverse cracks. Furthermore, I have proposed a novel vectorial formulation of the Virtual Crack Closure Technique (VCCT) with which I have shown, both analytically and numerically, for the VCCT-computed Energy Release Rate (ERR) of the FEM-based solution of the circular interface crack (fiber/matrix interface crack): the logarithmic, and thus unbounded, nature of the convergence of Mode I and Mode II ERR; the independence of total ERR from mesh refinement and crack path direction.
Apart from the work of my PhD thesis, I have been also working on: experimental assessment of transverse cracking in glass fiber/epoxy cross-ply laminates under different environmental and thermo-mechanical conditions (aging, high temperature, loading rate); experimental investigation of the effect of temperature, degree of cure and curing history on mechanical properties of epoxy matrix under different combinations of thermo-mechanical loads.

Future Research Directions

In the short to medium term perspective, I am currently laying the groundwork for several future works: derivation of the vectorial VCCT from Eshelby's elastic energy-momentum tensor and proposal of a new mode-partitioning strategy based on eigenvalue analysis; investigation of fiber/matrix debonding with concurrent non-linear (viscoelastic, viscoplastic) behavior of the surrounding matrix; 3D modeling of fiber/matrix debonding; 3D imaging of fiber/matrix debonding by means of in-situ micro-tomography; development of an image analysis algorithm for automated stress-free temperature identification through curvature measurements of asymmetric laminates and implementation with temperature feedback loop into low-cost hardware (e.g. android handset, Arduino, Raspberry Pi); creation and real-time update of specimens' digital twins through low-cost hardware (Kinect for Xbox); application of Bayesian inference to the prediction of elastic, viscoelastic, viscoplastic, failure and fracture toughness properties.
In the long term, I envision the development of the distributed, de-centralized, remotely-controlled, integrated laboratory for composite science and engineering: fully automated laboratories and high-performance computing clusters connected together by a de-centralized network (peer-to-peer) and accessible through an online platform, to allow collaborative projects on integrated computational-experimental analysis and design of materials between parties located far apart from each other.