Dr Eral Bele, Prof Paul Fromme (Mechanical Engineering, UCL)

# Detection and identification of damage in fibre/metal laminate systems using guided ultrasonic waves

**Description of Project:**

Leading manufacturers in the aerospace industry are working towards the introduction of new composite materials for the next generation of aircraft structures. In such weight-sensitive applications, the design requirements are to reduce weight while fabricating components with the same functionality and structural integrity. The engineering of such lightweight materials is increasingly being inspired by nature in using less material more efficiently, and this drive poses a unique set of challenges in structural integrity research.

Guided by nature inspired design, the research group is involved in the development of layered fibre/metal composite systems (see Figure 1) that combine the high ductility and toughness of metals with the high stiffness and resilience of fibre reinforced composites. Employing specific material and geometrical combinations, these systems can display higher ductility and toughness than that of any of the individual components, leading to, e.g., ultra-ductile precursors for stretch-forming and stamping processes of car parts and aircraft fuselages.

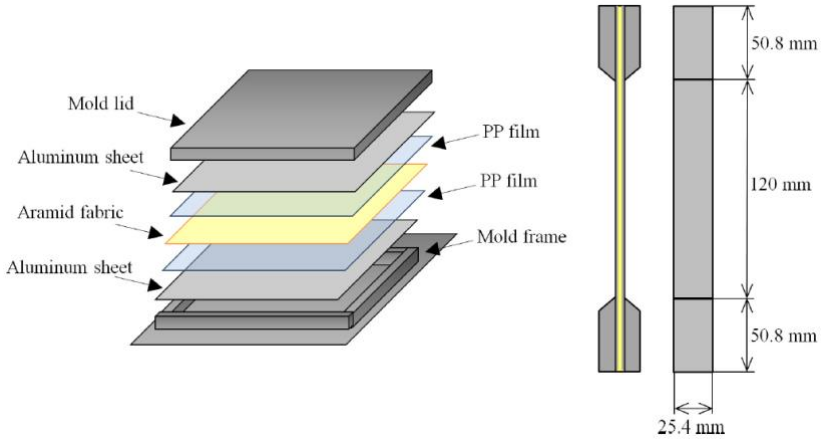


*Figure 1: Construction of a typical fibre-metal laminate (left), and tensile specimen (right).*

A critical need for the design of such materials is monitoring and modelling damage initiation during manufacturing and service. During manufacturing, delamination in the metal/composite interface, voids in the matrix, and fibre pull-out are the main mechanisms that limit ductility. In service, composite materials are especially susceptible to barely visible impact damage (BVID), limiting structural performance. Therefore, a requirement exists for the non-destructive inspection of these materials to characterize the internal structure, and to detect and monitor damage severity and extent before they have reached a critical size.

The overarching aim of this PhD project is to develop structurally efficient layered composite systems by investigating and modelling the role of damage mechanisms in mechanical performance. The main objectives include:

- Characterising the microstructure of the developed systems during typical manufacturing processes (e.g., hot-pressing) and testing their mechanical response during service loading (static, dynamic, and cyclic), supported by strain measurements through digital image correlation and in-situ characterisation through X-Ray Computed Tomography (CT).

- FEA modeling of damage initiation and evolution, considering the different length scales at which relevant damage modes are observed to nucleate and progress.
- Development of a non-destructive damage detection technique in the above processes, based on guided ultrasonic waves.
- Development of a synergistic damage mechanics (SDM) based model to predict remaining life of the composite structure.

The academic group at UCL has an internationally leading profile and an exceptional publication record, and this project will provide numerous opportunities for high-profile publications and conference presentations. The project involves considerable interaction with other members of the research group which has a very open, co-operative and friendly culture. The group actively promotes principles of equality, diversity, and inclusion in research. The UCL Department of Mechanical Engineering laboratories are very well resourced with equipment, computers, and consumables; the aim is to provide the best conditions for world-leading research. Aside from tuition fees and stipend, this studentship provides a research training support grant, to cover the cost of travelling, participations in seminars and conferences, and personal development training.

**Person Specification**: Applicants must have a UK-equivalent first-class degree in Mechanical, Structural, or Materials Engineering, or an equivalent discipline with a high technical content. Experience with ABAQUS (finite-element software) is a significant advantage.

**Closing Date and Start Date:** The closing fate for applications is 07 July 2022. The intended starting date is 26th September 2022, but this is negotiable.

**Value of award:** Full tuition fees and stipend of up to £ £19,062 per year for 4 years. Funding is provided through an EPSRC Doctoral Training Programme studentship, which also provides a supplementary Doctoral Training Research Support Grant of £4,800.

**Eligibility:** *Funding requirements dictate that only students with UK nationality, or any EU passport holders with settled status can receive the full value of the award. All other applicants are only eligible for partial funding (home fees and stipend).*

**Application Procedure:** Applicants should write to Dr Eral Bele (e.bele@ucl.ac.uk) and Prof Paul Fromme (p.fromme@ucl.ac.uk) with a recent CV, letter of interest, and a full transcript of exam results. Individuals who have yet to graduate must list all the modules (and corresponding grades) for which the results are known.