Queen's Doctoral Training Programme on
Secure Connected Intelligent Design and Manufacturing

Title: **DTP: A smart approach for laser dissimilar materials joining via machine learning and AI**

"This project is part of the Queen's Doctoral Training Programme in Secure Connected Intelligent Design and Manufacturing. Many of today's industrial approaches require **transformative changes to ensure long term societal, economic and environmental resilience and sustainability**. PhD projects in this programme explore the potential of emerging digital technologies, such as **artificial intelligence** (AI), **robotics, and the Internet of Things, to transform the way we design, manufacture and operate products and services**."

Project description:

Direct joining between plastics and metals is required **in nearly all engineering applications**, including automotive, aerospace, biomedical and space industries. This multidisciplinary PhD project is **to develop a smart laser-based joining technique to create the plastic-metal joints**.

Traditionally, hybrid plastic and metal structures are fabricated by using either mechanical fastening or adhesive bonding. **Laser joining technology is growing in importance** and has the potential to become a viable approach. Competitive advantages of laser direct joining include **clean and non-contact, fast joining cycles** (usually less than few seconds), **absence of volatile organic compound emissions** (which are often present in adhesive bonding), **high geometric accuracy and adaptability** to a wide range of part sizes and joint complexity.

In the laser direct joining process, the metal surface is firstly irradiated by a laser beam and then the heat transferred to the metal-plastic interface will melt the plastic counterpart. The joint will be created between the metal-plastic interface after cooling. The resultant joint strength is determined by the following: **(i) laser energy input, (ii) type of materials combination, and (iii) microstructure of the materials after being heated by laser**. On the other hand, the laser processing responses, which can be used for quality monitoring and closed-loop quality control, include the **(a) laser-generated plasma and (b) heat profile of the materials during the laser process**.

Laser direct joining between plastics and metals is a new process. To ensure the success of the joining process and the subsequent technology translation to industries, we need **to study and understand the scientific correlations between the aforementioned parameters**: **(a) & (b) and (i) to (iii)**. This will be investigated by our **multidisciplinary approach** including **machine learning & AI** as well as **laser-materials engineering** in this PhD project.

Aims and Objectives:

The aim of this PhD project is to **develop an online laser monitoring and control system to guarantee the success of the laser joining process**. Specific objectives include:

- To study and understand the fundamentals of laser-material processing;
- To characterise the microstructure and properties of plastics and metals <u>before and after</u> the laser process;
- To measure the joint strength as well as the modulus and hardness in the joint area.
- To develop AI/machine learning techniques to map the relation between (a) & (b) and (i) to (iii);
- To test and validate the developed algorithms on real laser joining processes;
- To publish research outcomes in appropriate journals of international standing and to publish and disseminate in other reputable outlets.

Key skills required for the post:

- Have a basic understanding on the mechanical testing techniques (tensile and hardness tests) and materials characterisation techniques for metals and plastics (SEM, XRD, DSC, FTIR, etc.)
- Knowledge or experience in laser-materials processing is preferable but not necessary.
- Knowledge or experience of AI/machine learning technique is desirable.

Key transferable skills that will be developed during the PhD:

The programme offers a bespoke research and training programme that aims to develop students into cross-disciplinary, industry-conscious thinkers and leaders who will influence the roadmaps of future advanced manufacturing technologies and their applications. They will have a balanced understanding of ICT (security,

communications and data analytics) in the context of their application to Advanced Manufacturing and High Value Design.	
Lead supervisor:	Dr Chi-Wai Chan (School of Mechanical and Aerospace Engineering)
Other supervisor(s):	Dr Mien Van (School of Electronics, Electrical Engineering and Computer Science) Prof Fraser Buchanan (School of Mechanical and Aerospace Engineering)
Guaranteed stipend:	This is a 3.5 year funded Queen's DfE DTPs studentship with Training Grant, to commence on 1 October 2020 (N.B. stipend for 20/21 is not yet known, but is likely to exceed £15,000). The studentship covers fees and maintenance and is available for UK residents (see full eligibility criteria - nationality, residency, and academic qualification at: http://go.qub.ac.uk/dfeterms). **When applying using the Queen's portal please ensure you include "DTP:" along with the project title.**
Conditional top-up available:	
PhD students in the School have the opportunity to apply to be demonstrators on undergraduate modules. Compensation for this can amount to in excess of £2,400 per year.# ***International experience and exposure:*** *(i) the successful applicant could have the chance to visit the University Research Facility in 3D Printing (U3DP) at the Hong Kong Polytechnic University for a short term attachment programme about laser joining/welding and laser 3D printing.*	

Queens University Belfast is a diverse and international institution which is strongly committed to equality and diversity, and to selection on merit. Currently women are under-represented in research positions in the School and accordingly applications from women are particularly welcome.