The Mechanics of Interface Fracture

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Material interfaces are often areas of weakness in material systems; hence, interface fracture toughness is always an important consideration when designing long-lasting material systems of either macroscopic or microscopic size. Unfortunately, however, interface fracture toughness is not purely an intrinsic material property which can be determined immediately from experiments. Instead it also depends on quite a few other parameters such as loading conditions, interface properties and crack extension size. Different parameters produce different partitions of fracture modes I, II, and III, which determine the interface fracture toughness. It has been a major research topic over the past few decades to develop a general theory for the determination of the partitions. A powerful methodology has recently been discovered at Loughborough University in the UK to develop such a general theory. The methodology applies to classical, shear deformable plate/shell theories as well as full 2D elasticity theory. Theoretical predictions for interface fracture toughness have been compared against (1) experimentally-measured delamination toughness results from macroscopic composite materials under both lateral loads and in post-buckling under compressive loads; (2) experimentally-measured spallation toughness results from microscopic alumina film cracking driven by compressive thermal residual stresses and pockets of energy concentration due to incomplete plastic relaxation; and (3) experimentally-measured adhesion energy results from nanoscale graphene membranes. In all cases, excellent predictions are observed, and important aspects of the mechanics of interface fracture are revealed.

Biographical Sketches

Professor Simon S. Wang received his BEng degree from Tsinghua University in China in 1982 and his PhD degree from Birmingham University in the UK in 1990. His earlier research work focused on developing accurate and efficient numerical methods for the mechanical analysis of plate and shell structures made from fibre-reinforced laminated composite materials. The mechanical problems included hyper-sonic aero-dynamic flutter, parametric resonance, impact response, vibration and vibration control, buckling, post-buckling and failure. His current research focuses on the mechanics of interface fracture.

Dr Christopher M. Harvey received his MEng degree in Aeronautical Engineering from Loughborough University in 2009, followed by his PhD from Loughborough University in 2012. Since 2012, he has been employed as Lecturer in Structural Mechanics at Loughborough University in the Department of Aeronautical and Automotive Engineering. Currently his research focuses on the analytical, numerical and experimental aspects of interface fracture.