# Enabling Multifunctional Materials and Composites through Additive Manufacturing and Nanoengineering

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**Abstract**

The rise of micro-, nano-, and molecularly-tailored multimaterial systems, particularly through **additive manufacturing (AM)** technologies, has paved the way for designing novel and improved functionalities. Leveraging advancements across disciplines, including extensive work on bulk microfibre heterogeneous composites, multimaterial and multifunctional 3D and 4D printing technologies present opportunities for cost-effective automation in fabrication. These technologies also offer greater flexibility in locally tailoring material architecture and properties in three dimensions. This presentation will provide an overview of our group's cross-disciplinary research activities, covering: (i) **tailored multilayers** (compliance-tailoring, morphology-tailoring and surface-tailoring); (ii) **nature-inspired materials** (nacreous materials and camouflage composites); (iii) **nanocomposites and 4D printing** (nano-biocomposites, piezoresistive self-sensing nanocomposites and morphing structures); (iv) **multiscale and multifunctional fibre composites** (hierarchical/multiscale composites and self-sensing cellular composites); and (v) **architected materials and metamaterials** (2D and 3D mechanical and multifunctional architected lattices for energy-absorbing structures, smart medical devices, energy storage, thermal management, and EMI shields). Manipulating matter at relevant length scales, in 3D and 4D, enables strain-, stress-, and functional-engineering towards enhanced performance, but also opens new opportunities in fabrication. The convergence of emerging micro- and nano-scale AM techniques, as well as the ability to design nano- and micro-architected hierarchical structures with more tightly controlled geometry, will allow the development of new material classes with unprecedented properties optimised for location-specific structural and/or functional requirements suitable for bio, defence, energy, automotive, and aerospace applications.

**Short Biography**

Prof. Kumar leads the Multifunctional Materials and Additive Manufacturing ($M^2AM$) Laboratory in the James Watt School of Engineering at the University of Glasgow. He obtained his Ph.D. in Solid Mechanics and Materials Engineering from the Department of Engineering Science, University of Oxford. His research interests revolve around mechanics, materials design & innovation and additive manufacturing with a focus on multiscale and multifunctional attributes, towards energy efficient, sustainable and decarbonising applications. His group's strength in combining theory, simulations and experiments has led to several novel contributions. He has been awarded the ASPIRE Award for Research Excellence ($A^2RE$) thrice. He also serves on the editorial boards of *Advanced Engineering Materials (Wiley)*, *International Journal of Adhesion and Adhesives (Elsevier), Scientific Reports (Nature), Materials Today Communications (Elsevier)* and *MetalMat (Wiley).* He has edited a book and 2 Special Issues, contributed 7 book chapters, authored more than 120 journal articles, and is currently leading two Special Issue journal collections. He has advised/mentored over 50 higher degree research students (MS/PhD) and research staff (postdocs/research scientists) and delivered over 50 invited/keynote talks. Twelve of his mentees/students moved on to faculty positions at leading universities across the globe. Kumar serves on the ASME Structures and Materials TC. He has also held short visiting appointments at the University of Cambridge, MIT and NTU Singapore, and has active collaborations worldwide, including at the University of Cambridge, TAMU, UT Austin, Georgia Tech, Harvard Medical School, MIT, etc.