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FOREWORD

Foreword to the Special Issue on Nanomanufacturing and Atomic & Close-to-Atomic Scale Manufacturing (ACSM)

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Nanomanufacturing (NM), developed over the past three decades, bridges nanoscience discoveries to nanotechnology products by scaled-up, reliable, and cost-effective manufacturing materials, structures, devices, and systems at the nanoscale (1–100 nm). At this scale, physical and chemical properties of the materials and tools have been dominated by classical Newtonian mechanics, although quantum confinement effects become increasingly observable. A number of top-down and bottom-up approaches were developed, including nanomechanical machining, nanolithography, energy beam machining, deposition and etching, nanoprinting, nano assembly, nano replication, etc. [1]. These techniques enabled a range of applications from medical imaging and renewable energy to sensor devices and quantum computing.

For continuing progress in this field, the continuous rapid shrinking of feature size to atomic scale, or the requirement of the improvement of sub-nm geometric accuracy, has encouraged researchers to seek alternative methods for scalable and high-throughput manufacturing technology, i.e., atomic and close-to-atomic scale manufacturing (ACSM), a key enabling technology of Manufacturing III [2]. When manufacturing precision moves from nanometre to atomic scales, quantum behaviour starts to dominate over Newtonian (classical) mechanics. Although order-of-magnitude improvements in the performance of materials and devices are promised, the nature of interactions is fundamentally changed, and significant consequences take place in surface properties [3]. Moreover, in ACSM, atomic precision is not the sole quality indicator—feature size and its performance at the atomic scale are equally important. Those opportunities and challenges drive our field to investigate the fundamentals, technologies, evaluations of ACSM in the next decades.

This special issue of "Nanomanufacturing and atomic & close-to-atomic scale manufacturing (ACSM)" collects three review papers and seven research articles in NM and ACSM. State-of-the-art atomic layer deposition methods, indirect metrology methods in NM, and preparation of atomically precise metal clusters are critically reviewed. Two articles about ACSM theoretical investigations are studied by flexible-enhanced molecular dynamics and first-principles methods. Included here are some of the latest developments in NM approaches including rotational-magnetorheological finishing, femtosecond pulsed laser irradiation, electrochemical etching, nanopatterning using molecular self-assembly and nanoindentation test using laser-induced shock waves.

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Dr. Nan Yu is a Lecturer in Digital Manufacturing at the University of Edinburgh and Deputy Director of MSc Digital Design and Manufacture. Nan has established early academic career as evidenced by over 40 publications in journals, conference papers and patents, 4 paper awards, 10 invited talks and £ 400 K as PI. His research interest covers ultraprecision machining, plasma processing, large-scale metrology, and ACSM. Dr. Yu received prestigious Marie Curie International Fellowship (2018–2020) and Irish Research Council Fellowship (2020–2021). He sits in the international scientific committee of European Society for Precision Engineering and Nanotechnology (EUSPEN), EPSRC early career forum in manufacturing research, and organising committees of international conferences (NanoMan and Lamdamap). He is a research affiliate of International Academy of Production Engineering (CIRP), and visiting academics in Dublin, Osaka and CERN.

Prof. Stuart Reid is the subtheme lead for microwave (ECR) ion beam etching and deposition/coating, is a Royal Society Industry Fellow and Head of Biomedical Engineering at the University of Strathclyde. He is leading a multidisciplinary team working across astrophysics, nanotechnology and stem cell research. Stuart spent the last 20 years developing technology for gravitational wave detector optics, and is co-inventor of "nanokicking", to control the behaviour of adult stem cells. Reid's lab pioneered the first high-energy ECR ion beam deposition process, holding the world-record in low IR absorption amorphous silicon. SR secured £7.7 M as PI, taken biomedical research from discovery to clinical trial, awarded patents, alongside a strong publication record (h-index 110). Stuart has been awarded numerous national prizes, including the RSE Presidents Medal (2016) and RS Wolfson Research Award (2017). Stuart is the twice elected co-chair of Optics for both the LIGO Scientific Collaboration (US) and Einstein Telescope (EU), coordinating research across 30 + institutions including Stanford, Caltech and MIT.

Prof. Rebecca Cheung is Chair of Nanoelectronics at the University of Edinburgh and Head of the Institute for Integrated Micro Nano Systems (IMNS), where the Scottish Microelectronics Centre (SMC) is based. She has an international reputation for her contribution in the development and application of micro- and nano- fabrication and was Program Chair for the International Conference on Electron, Ion, Photon Beam Technology and Nanofabrication (EIPBN) 2013—the world's premier conference in nanopatterning. She has received funding of over £10 M to support her research over the last 18 years and has published over 150 scientific articles and one book. She had been elected a Fellow of the Royal Society of Edinburgh in 2012, is a senior member of the IEEE, a Fellow of the IET and is an Honorary Professor with the School of Engineering and Physical Sciences at Heriot-Watt University.

Prof. Vasileios Koutsos is Chair of Soft Materials and Surfaces at the University of Edinburgh, and Deputy Head of the Institute for Materials and Processes. Vasileios has extensive experience in surface metrology and characterisation of materials and coatings using atomic force microscopy (AFM) and optical profilometry. He has authored over 100 international journal and conference proceedings publications and 6 book chapters (3 monographs). He has over 3500 citations and an h-index of 35 (Google Scholar). He has given over 50 invited and keynote talks at international conferences, meetings and seminar series. Prof. Koutsos has led, co-led and been involved in a number of funded projects from EPSRC, MRC, EU, and industry. He is Chief Editor of the International Journal of "Proc. IMechE, Part N: Journal of Nanomaterials, Nanoengineering and Nanosystems (JNNN)" and Associate Editor of the Open Access International Journal "Coatings".