

# Micromanufacturing of composite materials: simulation and practice

Prof. Zhengyi Jiang, University of Wollongong, Wollongong, Australia (presenter)

Fanghui Jia University of Wollongong, Wollongong, Australia

Di Pan, University of Wollongong, Wollongong, Australia

Mengyuan Ren, University of Wollongong, Wollongong, Australia

Muyuan Zhou, University of Wollongong, Wollongong, Australia

Haibo Xie, Hui, University of Wollongong, Wollongong, Australia

## Abstract

**Statement of the Problem:** With the trend of miniaturisation in fields of electronics, bio-medical, automobile, aerospace, and microelectron-mechanical systems (MEMS) industries, micromanufacturing is applicable to a wide range of materials, and can be used to economically fabricate metallic micro products with more complex geometry. To widen the range of applications of micro products, metallic composites start to attract increasing attention and interest in micromanufacturing, which could take the advantages of both component materials. Recent studies and achievements in advanced micromanufacturing have been concentrated on micro rolling of copper/SS304L composite for micro channels, micro deep drawing of aluminium/copper composite for micro cups, and micro flexible rolling of aluminium/copper composite. Apart from experimental analysis, finite element (FE) simulation could provide another way to supplement the obtained results from experiments and point out the possible ideas to further optimise the micromanufacturing technologies and applications. When the sample size is scaled down to micro-scale, size-effects related deformation behaviour, such as inhomogeneous and scattering of material properties, are usually characterised by the distribution of grains with different orientations, geometries and sizes. The microstructural tessellation was introduced in microforming modelling to generate polycrystalline which can be applied to describe the distribution of grain size and scatter of material property. Meanwhile, some important issues, such as the accurate constitutive model, bonding conditions and interface cohesion were addressed in order to obtain a model of composite materials with high precision. The strain- stress distribution and evolution, the deformation tendency and grain- heterogeneity related anisotropic behaviour of each component material were investigated in both micro rolling and micro deep drawing. Future research directions can place emphasis on the use of eco-friendly water-based nanolubricants combined with numerical simulation for the green micromanufacturing of metallic composite products.

## Conclusion & Significance:

1. Novel FE model considering size effects in micro manufacturing has been developed.
2. The FE model incorporated with grain heterogeneity can describe the deformation of composite material in submillimeter size with high precision.
3. Accurate constitutive relation between component materials further narrows the gap between the simulation and experimental results for metallic composites.
4. Impacts of bonding conditions between metallic layers have been explored in both experiments and simulations.

## Image

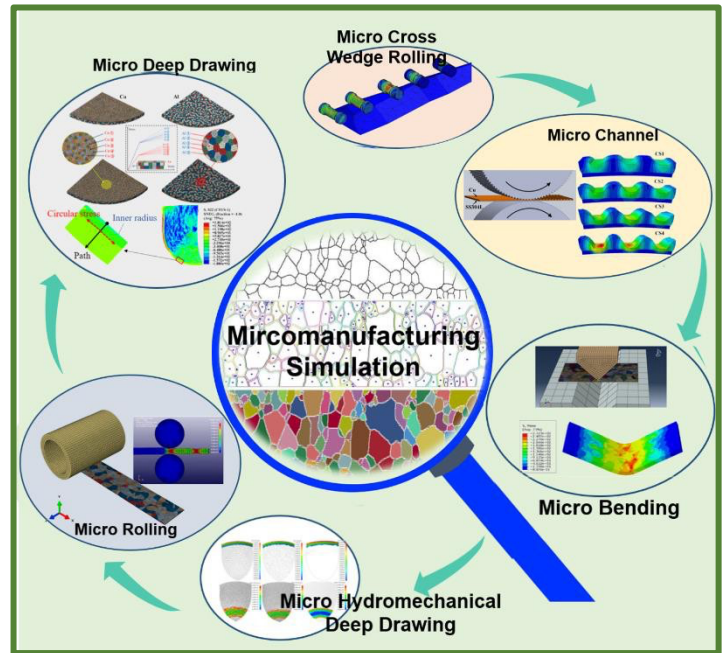


Figure 1.

Graphical abstract

## Publications:

1. Z. Jiang, J. Zhao, and H. Xie, *Microforming Technology: Theory, Simulation and Practice*, Academic Press, London, 2017.
2. M. Ren, F. Lin, F. Jia, H. Xie, M. Yang and Z. Jiang, Micro rolling fabrication of copper/SS304L micro composite channels, *Journal of Manufacturing Processes*, 90(2023):1-13.
3. F. Jia, J. Zhao, H. Kamali, Z. Li, H. Xie, L. Ma, C. Zhou and Z. Jiang, *Journal of Materials Processing Technology*; 307(2022):117662.

## Keywords:

Micromanufacturing;  
Composite materials;  
Finite element modelling;  
Constitutive model.

## Photograph



## Biography

Prof Zhengyi Jiang is Distinguished Professor, Director of ARC ITTC-Rail and Director of ARC ITTC Composites&Mining at the University of Wollongong (UOW). His research interest includes multiscale materials processing, advanced rolling technology, tribology in metal forming, development of novel lubricants in metal forming, microforming, manufacturing of composites, contact mechanics and numerical simulation of metal forming. He has over 580 journal articles, 5 monographs and 26 co-authored books. He has been awarded over 40 prizes and awards including ARC Future Fellowship, ARF (twice), Endeavour Australia Cheung Kong Research Fellowship and Japan Society for the Promotion of Science (JSPS) Invitation Fellowship, two Australian Academy of Sciences awards for International Cooperation and Exchange and UK Leverhulme Trust Visiting Professorship.

e-mail [jiang@uow.edu.au](mailto:jiang@uow.edu.au)