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Introduction to the honorary themed collection for Thomas P. Russell

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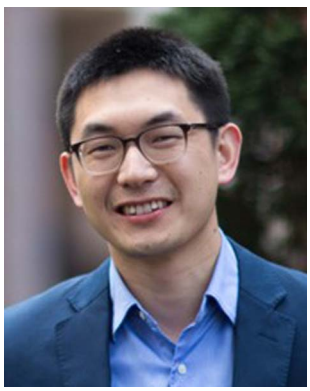
It is with great pleasure that we present this special collection of research papers in honour of Professor Thomas P. Russell, a true pioneer in the fields of polymer science and engineering, self-assembly and solar energy conversion. As we celebrate his 70th birthday, it is fitting to reflect on his many contributions to the field and the impact he has had on the research community.

Throughout his career, Professor Russell has made significant contributions to our understanding of block copolymer thin films, interfacial behaviour of nanoparticles, and X-ray and neutron scattering methods for studying the structure and dynamics of polymer thin films. His research on block copolymers has revolutionised the field of soft matter nanotechnology and his dedication to the development and application of X-ray and neutron scattering methods have enabled unprecedented materials evaluation.

One of Professor Russell's most notable contributions lies in the field of block copolymers. He pioneered the use of block copolymer thin films as templates for the creation of nanostructured materials,[1] leading to advances in fields such as electronics, optics and energy storage. His work has led to a better understanding of the self-assembly behaviour of block

Ilja Gunkel's main research interests are polymer self-assembly and functional nanostructured materials. He holds a PhD in physics from the Martin Luther University Halle-Wittenberg and has previously worked as a postdoctoral researcher at the Lawrence Berkeley National Laboratory, where Prof. Thomas P. Russell was his mentor. He is currently a group leader at the Adolphe Merkle Institute, where his research focuses on nanostructured polymers and their use in the fabrication of functional materials, with particular emphasis on solid polymer electrolytes for lithium batteries and materials with novel optical properties.



Xiaodan Gu is the Nina Bell Suggs Endowed Associate Professor at the School of Polymer Science and Engineering, University of Southern Mississippi. He completed his PhD in Polymer Science and Engineering at the University of Massachusetts in 2014, working under the guidance of Prof. Thomas P. Russell. Dr Gu's current research interests center around functional conjugated polymers and their devices, high-throughput sample processing, characterization, and data-driven materials design.

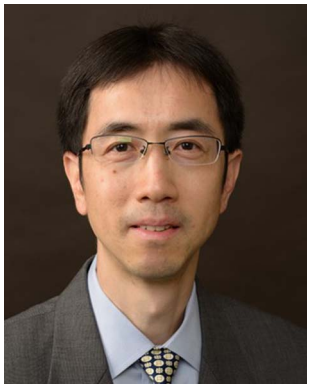
copolymers[2] and the ability to precisely control the structure and orientation of these materials at the nanoscale.[1,3,4] As shown in the themed collection, the use of block copolymers as templates for the fabrication of materials with applications including energy storage (https://doi.org/10.1039/D2TA09353G) and for patterning of materials used, for example, in optoelectronics (https://doi.org/10.1039/D2NR06742K) remain active areas of research. The themed collection also features work by Professor Russell himself, who, fittingly, contributes a study assembly of polyelectrolyte star block copolymers at the oil–water interface (https://doi.org/10.1039/D2NR05113C).

Another area of research for Professor Russell is the interfacial behaviour of nanoparticles. He discovered that nanoparticles can segregate at the interface between immiscible fluids and form a liquid-like assembly,[5,6] leading to robust encapsulation strategies, porous membranes and double and triple emulsions. He extended these ideas to polymer blends and block copolymers, enabling the spatial organisation of nanoparticles through self-assembly processes. Using functionalised nanoparticles and complementary end-functionalised polymers, he developed a nanoparticle surfactant that self-regulates the number of chains attached to the nanoparticles and increases the interfacial forces holding them in place. This led to the structuring of fluid domains[7] with potential applications in all-liquid batteries and ultra-low friction materials. The themed collection includes a recent example of such so-called structured liquids (https://doi.org/10.1039/D2SM01559E).

Jodie Lutkenhaus is holder of the Axalta Chair and Professor in the Artie McFerrin Department of Chemical Engineering at Texas A&M University. She received her doctorate in chemical engineering from Massachusetts Institute of Technology with Prof. Paula Hammond and completed a post-doc with Prof. Thomas P. Russell in 2008 at the University of Massachusetts, Amherst. Her research interests include redox-active polymers, polyelectrolytes, 2D nanomaterials, and layer-by-layer assemblies.

Jiun-Tai Chen received his BS degree in 1999 and his MS degree in 2001 from the Department of Applied Chemistry at the National Yang Ming Chiao Tung University (NYCU). He joined Prof. Thomas P. Russell's group in 2003 and obtained his PhD in polymer science and engineering from the University of Massachusetts, Amherst in 2008. He then joined the University of Texas at Austin as a postdoctoral fellow. In the summer of 2010, he joined the Department of Applied Chemistry at NYCU as an assistant professor. He is currently a Distinguished Professor and the Associate Dean of the College of Science at NYCU. His research interests include the fabrication and characterisation of polymer nanomaterials for optoelectronic applications.

Du Yeol Ryu's main research interests are polymer self-assembly and transition behaviours, particularly in block copolymers and thin films. He received his MS and PhD with a major in chemical engineering from Pohang University of Science and Technology (POSTECH), Korea, in 1999 and 2003, respectively. He was then appointed as a postdoctoral researcher at the University of Massachusetts, Amherst (2003.09–2005.08), where Prof. Thomas P. Russell was his mentor. He is currently a professor of chemical and biomolecular engineering at Yonsei University, Korea, where his research focuses on self-assembled nanostructures and quasicrystals, interface engineered materials, and organic–inorganic hybrid structures.



Zhiqun Lin is currently a professor of chemical and biomolecular engineering at the National University of Singapore (NUS). He received his PhD in polymer science and engineering from the University of Massachusetts, Amherst in 2002 under the supervision of Prof. Thomas P. Russell. His research interests include solar cells, batteries, photocatalysis, electrocatalysis, block copolymers, conjugated polymers, functional nanocrystals, hierarchically structured and assembled materials, and surface and interfacial properties.

Professor Russell has also made major contributions to the development and application of X-ray and neutron scattering and reflectivity methods for the study of materials.[2,8,9] His work has led to the development of new techniques for characterising soft materials such as block copolymers and organic photovoltaics. In the themed collection, his friend and collaborator Majkrzak highlights Professor Russell's pioneering applications of neutron reflectometry to probe the nanoscale structure of polymer thin film systems (**https://doi.org/10.1039/D2NR06756K**). Building on Professor Russell's pioneering work, Ganesh, Fuentes-Cabrera, Kumar and co-workers demonstrate the automated analysis of neutron reflectivities of block copolymer thin films using machine learning tools in this themed collection (**https://doi.org/10.1039/D2NR07173H**). In recent years, Professor Russell has pioneered the use of soft X-rays to quantitatively determine the structure and morphology of complex polymeric systems, including three-phase triblock copolymer morphologies[10] and organic photovoltaic active layers.[11] He has also made significant contributions to the field of organic photovoltaics itself, where he has developed new methods for controlling the morphology of the active layer in these devices, resulting in higher efficiencies and improved stability.[11] Professor Russell's work has helped to lay the scientific foundations for the design of next-generation organic photovoltaics. This themed collection includes several organic photovoltaics studies reporting high efficiencies (**https://doi.org/10.1039/D2TA09364B**, **https://doi.org/10.1039/D2TA09936E**, **https://doi.org/10.1039/D2TA07113D**).

In addition to his impressive research achievements, Professor Russell has made significant contributions to the scientific community through mentorship, education and outreach. He has trained numerous students and post-doctoral researchers who have gone on to become leaders in their fields. He has also held key advisory positions at several major user facilities and national laboratories.

In summary, this collection of research papers serves as a testament to Professor Russell's many contributions to the field of polymer science and engineering. His innovative research and commitment to the advancement of materials science have had a profound impact on the field and will continue to inspire future generations of researchers. We are honoured to celebrate his achievements and ongoing contributions through this special collection.

References

1 T. Thurn-Albrecht, J. Schotter, G. A. Kastle, N. Emley, T. Shibauchi, L. Krusin-Elbaum, K. Guarini, C. T. Black, M. T. Tuominen and T. P. Russell, Ultrahigh-density nanowire arrays grown in self-assembled diblock copolymer templates, *Science*, 2000, **290**(5499), 2126–2129.

2 S. H. Anastasiadis, T. P. Russell, S. K. Satija and C. F. Majkrzak, Neutron reflectivity studies of the surface-induced ordering of diblock copolymer films, *Phys. Rev. Lett.*, 1989, **62**(16), 1852.

3 P. Mansky, Y. Liu, E. Huang, T. P. Russell and C. Hawker, Controlling polymer-surface interactions with random copolymer brushes, *Science*, 1997, **275**(5305), 1458–1460.

4 S. H. Kim, M. J. Misner, T. I. Xu, M. Kimura and T. P. Russell, Highly oriented and ordered arrays from block copolymers *via* solvent evaporation, *Adv. Mater.*, 2004, **16**(3), 226–231.

5 Y. Lin, H. Skaff, T. Emrick, A. D. Dinsmore and T. P. Russell, Nanoparticle assembly and transport at liquid-liquid interfaces, *Science*, 2003, **299**(5604), 226–229.

6 X. Liu, N. Kent, A. Ceballos, R. Streubel, Y. Jiang, Y. Chai, P. Y. Kim, J. Forth, F. Hellman, S. Shi and D. Wang, Reconfigurable ferromagnetic liquid droplets, *Science*, 2019, **365**(6450), 264–267.

7 S. Shi, X. Liu, Y. Li, X. Wu, D. Wang, J. Forth and T. P. Russell, Liquid letters, *Adv. Mater.*, 2018, **30**(9), 1705800.

8 T. P. Russell, X-ray and neutron reflectivity for the investigation of polymers, *Mater. Sci. Rep.*, 1990, **5**(4), 171–271.

9 B. J. Factor, T. P. Russell and M. F. Toney, Grazing incidence X-ray scattering studies of thin films of an aromatic polyimide, *Macromolecules*, 1993, **26**(11), 2847–2859.

10 C. Wang, D. H. Lee, A. Hexemer, M. I. Kim, W. Zhao, H. Hasegawa, H. Ade and T. P. Russell, Defining the nanostructured morphology of triblock copolymers using resonant soft X-ray scattering, *Nano Lett.*, 2011, **11**(9), 3906–3911.

11 D. Chen, A. Nakahara, D. Wei, D. Nordlund and T. P. Russell, P3HT/PCBM bulk heterojunction organic photovoltaics: correlating efficiency and morphology, *Nano Lett.*, 2011, **11**(2), 561–567.