ANZIAM J. 57(2015), 1–2
doi:10.1017/S144618111500019X

EDITORIAL: MODELLING APPROACH TO NANOSCALE SCIENCE AND TECHNOLOGY

The revolution in nanoscale science and technology during the last few decades has been driven by two formidable technological trends. The first has been dubbed Moore's law, named after Gordon Moore, the Intel executive who noted that the number of components per integrated circuit was doubling roughly every 18 months. Remarkably the semiconductor industry has been able to refine their 'top-down' manufacturing processes to keep Moore's law on track for more than 50 years. The feature sizes of today's integrated circuits have been reduced to tens of nanometres.

Secondly, not to be outdone, chemical scientists have developed 'bottom-up' techniques that allow self-assembly of complex molecular structures with multi-scale architectures, with sizes that span the atomic to the macroscopic. The length scale where the 'top-down' and the 'bottom-up' trends meet – the nanoscale – is also where life operates. Indeed, nanoscale science and technology combine physics, chemistry and biology in many new and exciting ways.

What role then does mathematics have in nanotechnology? Mathematics has been proven particularly important due to the difficulties and expense of conducting experiments at this scale. When the act of observing can change the behaviour of the observed, mathematical models and theory play a significant part in supporting our understanding. Nanoscale science is often conducted in silico before it becomes in situ. The immense scope for the rearrangement of atoms on the nanometre scale also demands the use of mathematics to whittle down the possibilities for those that are most fruitful for pursuit through experiment. In particular, nanoscale science and technology have proven to be a rich source of problems for applied mathematics.

Australian and New Zealand mathematicians have been prominent in this field, and this special issue brings together contributions from some of the leading practitioners in both countries. The papers selected for this issue cover topics from the low-dimensional physics of electrons confined in nanomaterials to the penetration of nanoparticles through cell walls. Indeed, the first paper in this issue by Winkler and Zülicke concerns the electronic properties of graphene, which consists of a single sheet of carbon, just one atom thick.

The second paper by Baowan relates to the safety of nanomaterials. There are concerns that nanoparticles could pass through cell walls, potentially causing damage to organisms that might be exposed to nanoparticles in the environment. Baowan models this process, examining how particle size affects the likelihood of transmission through a pore in a model cell wall.

Lee and Hill consider the construction of nanodevices using fullerenes, nanometre-sized spherical cages of carbon atoms, and carbon nanotubes. While such devices do not exist yet, the authors suggest that functioning logic devices can be constructed from these building blocks. Lim and Thornton also explore the applications of carbon nanotubes in a different context. They construct a model that could be used to optimize carbon nanotube geometry for gas storage. The storage of hydrogen gas, for instance, is one of the significant technical challenges that has inhibited the uptake of hydrogen fuel cell technologies.

The paper by Thamwattana deals with the understanding of how cells regulate the transmission of ions through their cell walls, a process that is vital for cellular life. This is a nanoscale process, since cells do this using organic nanotubes embedded in cell walls, but it also has implications for nanotechnology. Thamwattana's work indicates that nanotubes can be constructed to mimic the behaviour of their natural counterparts. Finally, Zhang et al. consider the macroscopic properties of nanostructured surfaces. These surfaces are increasingly finding applications in micro- and nanofluidics, where the interaction between liquids and surfaces can be used to control liquid flows.

This special issue shows a breath of applications and approaches that mathematics offers in the field of nanoscience, and illustrates the research capacity of the mathematical community to address some of the challenging topics in scientific and industrial sectors in Australia and New Zealand.

BARRY J. COX,
School of Mathematical Sciences,
University of Adelaide,
Adelaide 5005,
Australia
email: barry.cox@adelaide.edu.au

SHAUN C. HENDY,
Te Pūnaha Matatini and Department of Physics,
University of Auckland,
Auckland 1011,
New Zealand
email: shaun.hendy@auckland.ac.nz

https://doi.org/10.1017/S144618111500019X Published online by Cambridge University Press