UCD Impact Case Study

Towards Mass Production for Precision Micro/Nano Devices

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SCIENTIFIC · HEALTH · TECHNO-LOGICAL · ACADEMIC · ECONOMIC

SUMMARY

Many industries require precision components. Manufacturing these components can involve engineering materials and features at tiny scales, on the order of microns or even nanometers (billionths of metres).

Dr Nan Zhang at UCD School of Mechanical and Materials Engineering aims to help bring innovations in precision manufacturing from the lab-based prototypes to the large volume of manufacturing that industry needs. The research is building capacity in Ireland to enable the mass production of precision micro/nano devices.

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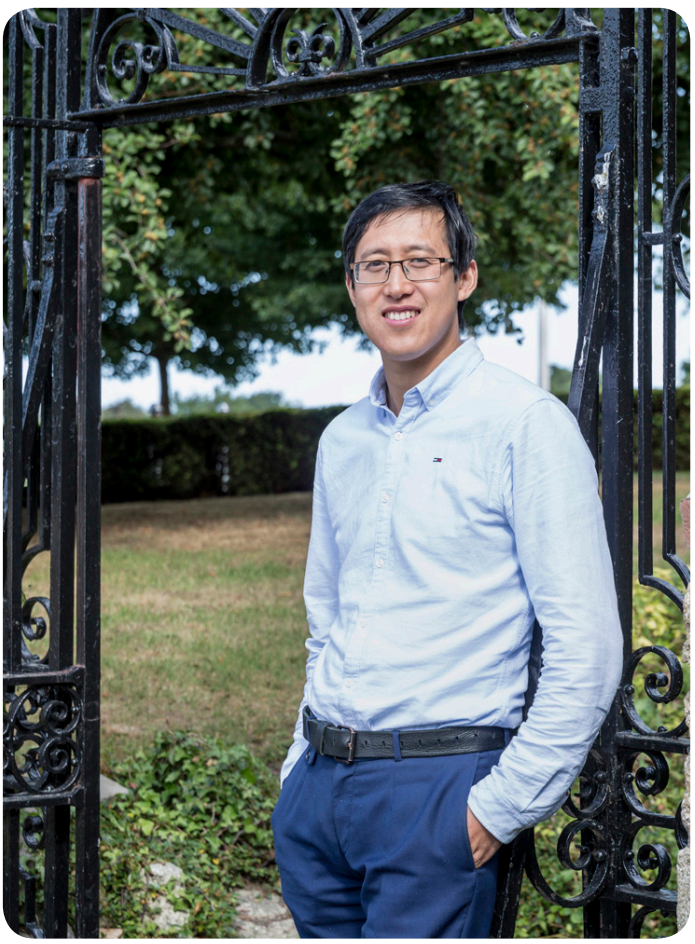
Precision at Scale

Much of the technology around us depends on precision-manufactured devices. They are integral parts of vehicles, electronics, communications and medical devices, to name a few. Often, industry requires that these precision-engineered objects are made in large volumes to service their production needs, but scaling up from lab-based methods to make such components to the number and quality required by industry is a challenge.

Dr Zhang's research looks at how to cross that gap. He applies micro/nano-mould tool manufacturing technologies and micro/nano-replication technologies to fundamental and applied problems relevant to designing, developing and producing new devices.

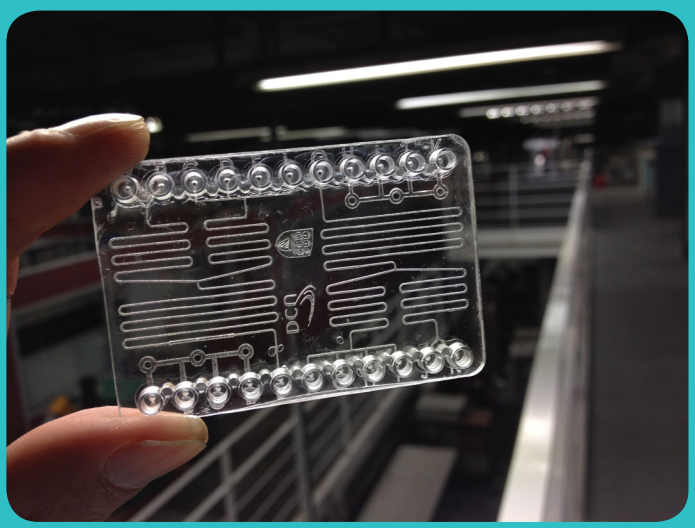
"Our research focuses on how to design, develop and manufacture small and precision components," explains Dr Zhang. "We look to span the bridge between small-scale and large-scale production."

His work focuses on the manufacture of microfluidic devices (for example, small plastic chips that contain tiny channels for monitoring and testing HIV), functional surfaces and free-form optics, and his group explores possibilities with materials such as bio-plastics for manufacturing bioresorbable medical scaffords, and with novel tool materials such as bulk metallic glasses, which have an amorphous structure and so have useful properties for manufacturing.



"There are many processes that we can choose for precision manufacturing of micro/nano devices, and we have technology and process know-how at UCD that allows us to design, build and validate many prototypes, including plastic microfluidics and micro-structured medical devices," says Dr Zhang. "It's important that we research the materials and processes, because ultimately these objects will need to be mass produced for industry and that needs to be taken into account in order to scale up."

Dr Zhang's research can support industries to develop innovative new technologies and precision-engineered parts and devices that will be not only technically but also economically feasible for mass production.



Building Capacity in Ireland

One of the most important contributions of Dr Zhang's work is to provide expertise and capabilities in Ireland for precision tool manufacture. "We are developing precision mould tooling technology and in Ireland, at the moment no-one else is doing this kind of research," he explains. "We are manufacturing multi-scale mould tools for mass production, we are using moulding and nanoimprinting techniques to replicate forms and features, and we are prototyping and producing micro and nano devices."

The demand for such precision tools is set to grow, according to Dr Zhang, who cites microfluidics as an example. His work **seeks to enable microfluidic devices**, such as flow cytometry, which analyses the physical and chemical characteristics of particles in a fluid.

"The overall microfluidics market will be large, it is expected to be worth tens of billions of Euro globally by 2025, and Ireland needs to build manufacturing capacity in this area," he says. "There are companies in Ireland using microfluidics in innovative ways, but not manufacturing them. This is where our research will **help industry to develop new processes and products.**

Material Benefits

Dr Zhang explores how using materials with different properties can be harnessed to enable mass production of precision structures and features. Those materials include bulk metallic glasses, and his research in this area seeks to open up new, multi-scale abilities for manufacturing tools.

"Conventional approaches in manufacturing often use metals, but these have grains on the micrometer scale and often we need to manufacture patterns on a nanometre scale, which is one thousand times smaller," he explains. "With metallic glasses, the structure is amorphous, there are no crystal grains, and this material can be patterned at the nanometre level."

In parallel, Dr Zhang combines 2D materials with precision electro-forming process to develop high performance precision nickel micro/nano mold tools. Hardness of mold is significantly increased, while friction of coefficient is reduced. This indicates longer tool life and less potential demoulding damage.

Improving Replication

Another goal of Dr Zhang's work is to improve the **replication of precision features in manufacturing**, particularly using micro-injection and nano-imprinting methods.

"To replicate the small channels in microfluidics, we need a specific moulding technology, and we use variotherm-assisted precision injection moulding, which is a technique used for mass production," he explains. "We also use nanoprinting of features for photonics and functional surfaces, such as lenses and solar cells, and making nanostructured surfaces in medical devices to encourage cells to attach and grow to those surfaces or to prevent fouling by bacteria."

Enabling New Medical Technologies

Many strands of Dr Zhang's work have applications in the medical device sector. One project is on the design of efficient stents that can be implanted into blood vessels to keep blood flowing. "We would like to have nano-structures

on the surface of stents," he explains. "We want them to have nano pores where drugs can be placed to reduce the risk of blood clots, and to design surfaces that promote the healthy remodeling of the tissues in the blood vessel."

The design and manufacturing approaches that underpin these types of innovation on a mass scale can help to ensure that the medical devices industry in Ireland remains strong, he adds. "In the long term, being able to manufacture these kinds of functional, high-performance surfaces could be very important for the Irish manufacturers in the medical device sector."

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