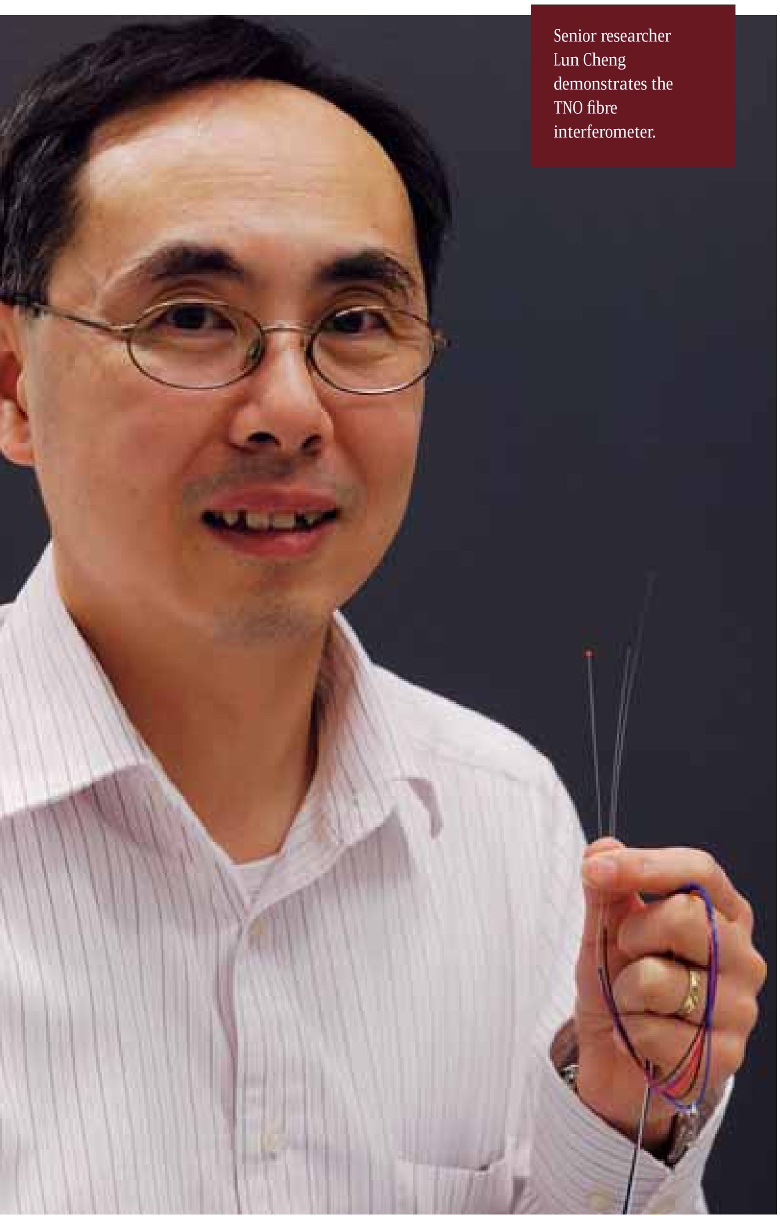
Measuring nanometers with light

On 2 April several optical innovations from TNO were showcased at the Photonics Event 2009. These included a patented fibre interferometer capable of detecting displacements and height variations of about one nanometer – without ever touching surfaces and with a tiny measuring head only three millimetres in diameter.



Senior researcher Lun Cheng demonstrates the TNO fibre interferometer.

Photo: Fred Kamphues

In the field of nanotechnology, it is essential that you know what is happening in the production process at the nanoscale and be able to measure the size of the structures being made. That means you need a fast, affordable and compact measuring system with nanometer resolution. 'Our system will be able to meet all those requirements,' asserts Lun Cheng, inventor of the TNO fibre interferometer.

Interferometry is nothing new: split a beam of light and reflect one beam onto an object to be measured and the other onto a fixed mirror as a reference beam. Recombine the reflected beams to create the interference pattern. If that pattern shifts, then the object has apparently moved – the degree to which it has can be easily calculated. By projecting a beam perpendicular to a surface, you can measure height variations – and thus also structures.

One of the strengths of interferometry is its resolution. One nanometer is well within reach, and it is possible to go even smaller – all with a measuring range of up to one hundred metres. Another advantage is that no contact is required, so there is no risk of damage. But it also has disadvantages: interferometers are bulky and highly sophisticated, which makes them expensive. TNO's invention addresses these drawbacks.

VERY FLEXIBLE

'In the fibre interferometer we have fused together several optical fibres and the ensuing measurement fibre is only 0.25 millimetres in diameter,' proclaims Cheng. 'These optical fibres could reach up to miles long and are very flexible. The fibre interferometer could therefore be built into highly sophisticated equipment very easily, without the need for electrical cables.'

Even though the patented invention from TNO was only unveiled earlier this month, the technology has already been used several times for projects within TNO. It was used in a machine for optical manufacturing at the nanoscale and in Kolibri, a platform TNO is developing with Mecal that is stable at picoscale (see *TNO magazine* 2009/1). The invention has also already been used in measurement systems, such as in the TNO particle scanner that can detect particles as small as 35 nanometres on wafers with great speed, with proposed future use for positioning the specimen holder in a scanning electron microscope.

TNO does not plan to start producing and selling fibre interferometers on a mass scale. 'We are looking for a suitable partner who can commercialise systems for standard applications,' Cheng says. What TNO will continue doing is develop special versions of the technology, such as a vacuum compatible model. 'And we often build complex systems with our partners,' Cheng adds, 'where we can use fibre sensors to solve some of the measurement obstacles.'

FBG

There is another technology TNO relies on when building such systems that also uses optical fibres: the Fibre Bragg Grating (FBG). This device measures strain, velocity, humidity and other physical/chemical parameters. Cheng has built FBGs into dyke gauges for studying dyke weak spots, tunnel sections and bridges to measure deformation and pipes to measure the rate of flow of liquids and gases. These applications were also showcased by TNO at the Photonics Event 2009.

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