High definition diagnostic ultrasonics on the nanoscale

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Scientists and Engineers at The University of Nottingham have built the world's smallest ultrasonic transducers capable of generating and detecting ultrasound. These revolutionary transducers which are orders of magnitude smaller than current systems — are so tiny that up to 500 of the smallest ones could be placed across the width of one human hair.

While at an early stage these devices offer a myriad of possibilities for imaging and measuring at scales a thousand times smaller than conventional ultrasonics. They can be made so small they could be placed inside cells to perform intracellular ultrasonics. They can produce ultrasound of such a high frequency that its wavelength is smaller than that of visible light. Theoretically they make it possible for ultrasonic images to take finer pictures than the most powerful optical microscopes.

The work, by the Applied Optics Group in the Division of Electrical Systems and Optics has been deemed so potentially innovative that last year it was awarded a £850,000 five year Platform Grant by the Engineering and Physical Sciences Research Council (EPSRC) to develop advanced ultrasonic techniques. The team has also been supported by additional funding of £350,000 from an EPSRC grant to underpin aerospace research.

Matt Clark, of the Applied Optics Group, said: "With the rise of nanotechnology you need more powerful diagnostic tools, especially ones that can operate non-destructively and ones which can be used to

access the mechanical and chemical properties of the samples at this scale. These new transducers are hugely exciting and bring the power of ultrasonics to the nanoscale."

The ultrasonic transducers consist of sandwich or shell like structures carefully engineered to possess both optical and ultrasonic resonances. When they are hit by a pulse of laser light they are set ringing at high frequency which launches ultrasonic waves into the sample. When they are excited by ultrasound the transducers are very slightly deformed and this changes their optical resonances which are detected by a laser.

The devices can be constructed either by micro/nano lithography techniques similar to those used for microchips or by molecular self assembly where the transducers are constructed chemically.

Perhaps the most familiar application of ultrasonics is medical imaging but it is also widely used in engineering applications and for chemical sensing. These tiny transducers open up the possibility of using these techniques on the smallest scales, for instance inside cells and on nano-engineered components.

Dr Clark said: "Imagine imaging inside cells in the same way that ultrasonic imaging is performed inside bodies. Theoretically we could get higher resolution with the nano-ultrasonics than you can with optical microscopes and the contrast would be very interesting. In addition the transducers can be made into highly sensitive chemical sensors — ultrasonics SAW sensors are used on the normal scale for electronic noses — this would allow you to distribute chemical sensors in tissue or in paint — so you could make paint with chemical sensors to detect corrosion or explosives in it."

Provided by University of Nottingham