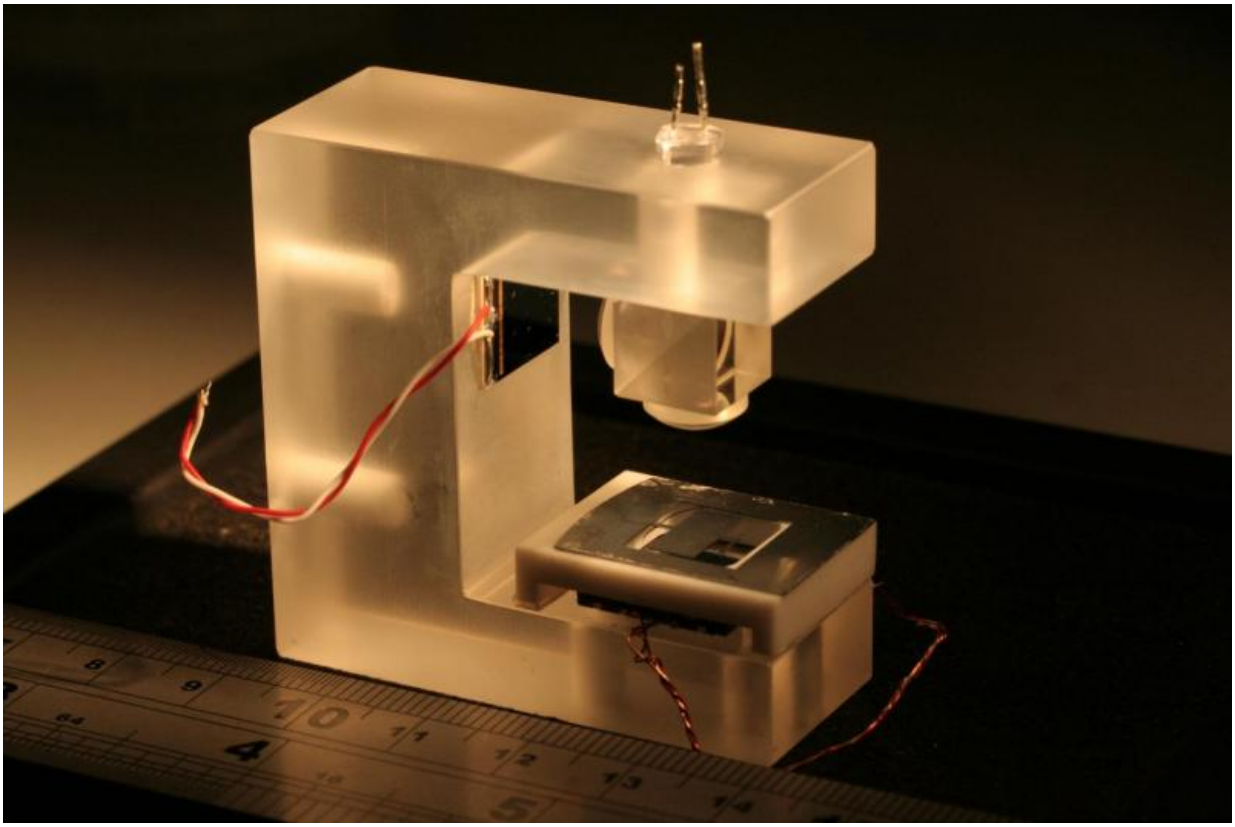
# MEMS technology adapted into super-sensitive gravity detector

March 31 2016



A photograph of the MEMS and its fused silica support structure. The MEMS is illuminated by a light emitting diode (LED) and the motion of the proof mass detected by the photodiode underneath the MEMS wafer. Credit: Giles Hammond

Scientists have found a way to adapt a system often found in

smartphones to create a super-sensitive detector capable of measuring minute changes in gravity.

In a paper published today in *Nature*, researchers from the University of Glasgow describe how they have adapted cheap, widely-available technology to make a small but powerful gravimeter for the first time. Affordable, portable gravimeters could have a wide range of applications, including volcano monitoring, environmental surveying, and oil exploration.

The detector, built at the University's James Watt Nanofabrication Centre, is a collaboration between the School of Physics and Astronomy (Institute for Gravitational Research) and the School of Engineering (Electrical & Nanoscale). The work is one of the first research outcomes from QuantIC, the UK's centre of excellence for research, development and innovation in quantum enhanced imaging, which was established in 2015.

Gravimeters measure the gravitational field of the Earth. Although these devices have been available commercially for decades, and are often used in the oil and gas industry to discover fossil fuel deposits, widespread uptake has been limited due to their expense and large physical size.

The team's new device, which they have named 'Wee-g', uses the same cheap, mass-producible micro-electromechanical systems (MEMS) which are used in smartphones' internal accelerometers. While the MEMS technology in phones uses relatively stiff and insensitive springs to maintain the orientation of the screen relative to the Earth, Wee-g employs a silicon spring ten times thinner than a human hair.. This allows Wee-g's 12mm-square sensor to detect very small changes in gravity.

The team used their device to measure the Earth tides from the basement of the University's Kelvin building. Many people are familiar with the idea that the gravitational pull of the moon affects the tides of the planet's seas and oceans, but the moon and the sun also exert a subtle effect on the Earth's crust, an effect known as the 'Earth tides'. The pull of the sun and the moon displace the crust, creating a very slight expansion and contraction of the planet of around 40cm.

Dr Giles Hammond of the University's School of Physics and Astronomy, one of the co-authors of the paper, said: "The Earth tides are a well-established phenomenon, which we're able to accurately predict using mathematical models.

"One of the factors which separates gravimeters from simple accelerometers is stability, allowing users to monitor variations in gravity over the course of several days-weeks. We used our Wee-g system to monitor the Earth tides under Glasgow over the course of several days, and our results aligned perfectly with the variations in gravity the model had predicted.

"The significance of this is two-fold: firstly, we've shown that a MEMS device can maintain its stability over a long period of time, and secondly, that a device which could easily be built using existing mass-production technology can act as a very accurate gravimeter."

Co-author Richard Middlemiss said: "There are a lot of potential industrial applications for gravimeters, but their cost and bulkiness have made them impractical in many situations. Wee-g opens up the possibility of making gravity measurement a much more realistic proposition for all kinds of industries: gravity surveys for geophysical exploration could be carried out with drones instead of planes; and networks of MEMS gravimeters could be places around volcanoes to monitor the intrusion of magma that occurs before an eruption – acting

as an early warning system .

"We're currently working to make the device smaller and more portable and viaQuantIC we're building industrial partnerships within several sectors to exploit the device commercially."

**More information:** R. P. Middlemiss et al. Measurement of the Earth tides with a MEMS gravimeter, *Nature* (2016). DOI: 10.1038/nature17397

Provided by University of Glasgow