Integrated displacement sensor with broad optical bandwidth

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Recent developments in micro- and nano-optomechanical systems have given rise to on-chip mechanical sensing platforms, potentially leading to compact and integrated optical motion sensors. However, these systems typically exploit narrow spectral resonances and therefore require tuneable lasers with low linewidth and spectral noise, which makes the integration of the read-out extremely challenging. In order to move towards fully-integrated optical sensing systems, wide optical bandwidth and integrated read-out are needed. Here, we report a major step towards the practical application of nanomechanical sensors, by presenting a sensor with ultrawide (~80 nm) optical bandwidth. It is based on a nanomechanical directional coupler with integrated dual-channel waveguide photodiodes, as shown in Fig 1(a) and (b). The sensor was fabricated on the InP membrane-on-silicon (IMOS) platform, which allows integration of passive components, lasers and detectors in a thin InP membrane [1]. Displacement is transduced into a transmission change by inducing a mismatch in propagation constants between the two coupling waveguides, as illustrated in Fig 1(c). A small displacement imprecision of only 30 fm/Hz$^{1/2}$ is measured (Fig 1(d)) as well as large dynamic range (>20 nm). The broad optical bandwidth releases the need for a tunable laser and the on-chip photocurrent read-out replaces the external detector, opening the way to fully-integrated nanomechanical sensors.

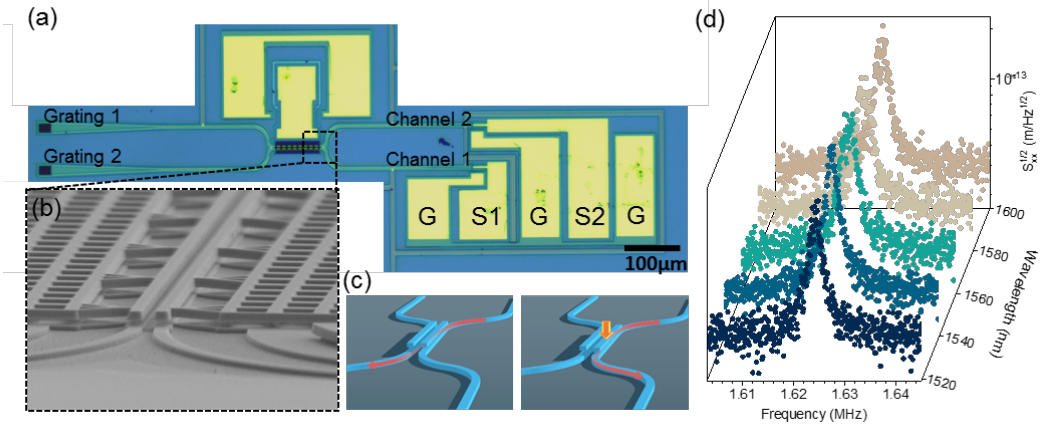

FIG 1. (a) Optical microscope image of the integrated displacement sensor. G stands for ground, S1 and S2 stand for signal of channel 1 and channel 2. (b) Scanning electron microscope (SEM) image of the nanomechanical directional coupler used as a transducer. (c) Schematic illustration of light passing through the direction coupler before (up) and after (down) actuation. (d) Brownian motion measured at different laser wavelengths, showing the displacement imprecision of 30 fm/Hz$^{1/2}$ at noise floor.

References

[1] J.J. Van der Tol, Y. Jiao, L. Shen, A. Millan-Mejia, V. Pogoretskiy, J.P. Van Engelen, and M.K. Smit, "Indium phosphide integrated photonics in membranes." IEEE Journal of Selected Topics in Quantum Electronics, 24(1), pp.1-9, 2017.