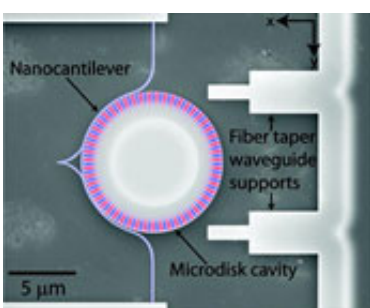


Researchers develop integrated nanomechanical sensor for atomic force microscopy

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Scanning electron micrograph of the cantilever-microdisk system. The image has a calculated z-component of the magnetic field overlaid on the structure.

(PhysOrg.com) -- The atomic force microscope (AFM) is an important tool for nanoscale surface metrology. Typical AFMs map local tip-surface interactions by scanning a flexible cantilever probe over a surface. They rely on bulky optical sensing instrumentation to measure the motion of the probe, which limits the sensitivity, stability, and accuracy of the microscope, and precludes the use of probes much smaller than the wavelength of light.

As reported in [Nano Letters](#), CNST researchers have fabricated a novel integrated sensor combining a nanomechanical cantilever probe with a [high sensitivity](#) nanophotonic [interferometer](#) on a single [silicon chip](#). Replacing the bulky laser detection system allowed them to build

cantilevers orders of magnitude smaller than those used in conventional AFMs.

Because each of these smaller structures has an effective mass less than a picogram, the detection bandwidth is dramatically increased, reducing the system response time to a few hundred nanoseconds.

While probe [stiffness](#) was kept comparable to conventional microcantilevers in order to maintain high mechanical gain (how much the tip moves when it senses a force change), the probe size was reduced to a mere 25 μm in length, 260 nm in thickness, and only 65 nm in width.

Readout is based on “cavity optomechanics”, with the probe fabricated adjacent to a microdisk optical cavity at a gap of less than 100 nm. Due to this close separation, light circulating within the cavity is strongly influenced by the motion of the probe tip.

The cavity has a high optical quality factor (Q), meaning that the light makes tens of thousands of round-trips inside the cavity before leaking out of it, all the time accumulating information about the probe’s position.

The combination of small probe-cavity separation and high Q gives the device sensitivity to probe motion at less than 1 fm/ $\sqrt{\text{Hz}}$, while the cavity is able to sense changes in probe position with high bandwidth.

The entire device is nanofabricated as a single, monolithic unit on a silicon wafer. It is therefore compact (chip-scale), self-aligned, and stable.

Fiber optic waveguides couple light into and out of the sensor, so that it can be easily interfaced with standard optical sources and detectors.

Finally, through simple changes to the probe geometry, the mechanics of the probe tip can be greatly varied, allowing for the different combinations of mechanical gain and bandwidth needed for a variety of AFM applications.

More information: Optomechanical transduction of an integrated silicon cantilever probe using a microdisk resonator, K. Srinivasan, et al., [Nano Letters](#) 11, 791-797 (2011).

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