Measuring displacements on the scale of nanometers

June 18 2012

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European researchers are developing novel optical methods of detecting displacements on the scale of nanometres. Project results could have widespread application in areas as diverse as nanomanufacturing and the design of new touch screens.

Optical waveguides such as standard optical fibers are structures that 'guide' the flow of electromagnetic (EM) waves, transmitting light from one end to the other.

They are widely used in fibre optic displacement sensors to measure changes in distances related to movement of device components during perturbations. Such applications include aerospace turbine engines, magnetic resonance imaging (MRI) systems and even rocket sections during firing.

Advances in fiber-optic techniques have led to development of new devices capable of measuring very small displacements (microdisplacements) or vibrations. One such technique recently reported is based on physical contact of suspended silicon nanowire waveguides capable of precisely detecting in-plane displacements on the sub-nanometer scale.

European researchers initiated the NANO-DISP project to investigate theoretically and experimentally the technical parameters of the aforementioned setup with respect to effects on optical characteristics such as sensitivity and measurement range.

During the first reporting period, researchers evaluated in-plane sensing by low-sensitivity, long-range sensors and by high-sensitivity, short-range sensors.

Waveguide tips with elliptical geometry were used to produce both types of sensors. Results demonstrated that both the sensing angle and length of the tip affected optical characteristics.

Two identical waveguides with tapered tips and abrupt tip ends formed a second configuration to test highly sensitive sensors. Scientists observed that tip width, tip-end size, tip angle and tip thickness all affected optical characteristics.

Optimal sensitivities of these devices were the highest of all three types tested (peak of 0.97 nm compared to 1.10 nm of the high-sensitivity elliptical tip device and 5.74 nm of the low-sensitivity elliptical tip device) and at the shortest ranges (97–330 nm compared to predicted values of 135–674 nm and 674–1062 nm, respectively).

Work in the first phase of the project has enabled optimisation of microfabrication techniques, manufacture of several devices, testing of device optical characteristics and correlation to device geometries.

Continuation of NANO-DISP efforts should lead to the first set of guidelines regarding customisable embedded synchronous submicron distance/displacement sensors useful over a very large range of optical frequencies. Results will be applicable to such fields as nanopositioning of manipulators for nanomanufacturing and enhanced touch screen function.

Provided by CORDIS