Nanoscale Surface Plasmonics Sensor With Nanofluidic Control

This sensor has applications in health centers, clinical labs, pharmaceutical firms, drug research labs, and other facilities engaged in biomarker screening.

John H. Glenn Research Center, Cleveland, Ohio

Conventional quantitative protein assays of bodily fluids typically involve multiple steps to obtain desired measurements. Such methods are not well suited for fast and accurate assay measurements in austere environments such as spaceflight and in the aftermath of disasters. Consequently, there is a need for a protein assay technology capable of routinely monitoring proteins in austere environments. For example, there is an immediate need for a urine protein assay to assess astronaut renal health during spaceflight. The disclosed nanoscale surface plasmonics sensor provides a core detection method that can be integrated to a lab-on-chip device that satisfies the unmet need for such a protein assay technology.

Assays based upon combinations of nanoholes, nanorings, and nanoslits with transmission surface plasmon resonance (SPR) are used for assays requiring extreme sensitivity, and are capable of detecting specific analytes at concentrations as low as picomole to femtomole level in well-controlled environments.

The device operates in a transmission mode configuration in which light is directed at one planar surface of the array, which functions as an optical aperture. The incident light induces surface plasmon light transmission from the opposite surface of the array. The presence of a target analyte is detected by changes in the spectrum of light transmitted by the array when a target analyte induces a change in the refractive index of the fluid within the nanochannels. This occurs, for example, when a target analyte binds to a receptor fixed to the walls of the nanochannels in the array. Independent fluid handling capability for individual nanoarrays on a nanofluidic chip containing a plurality of nanochannel arrays allows each array to be used to sense a different target analyte and/or for paired arrays to analyze control and test samples simultaneously in parallel.

The present invention incorporates transmission mode nanoplasmonics and nanofluidics into a single, microfluidically controlled device. The device comprises one or more arrays of aligned nanochannels that are in fluid communication with inflowing and outflowing fluid handling manifolds that control the flow of fluid through the arrays. The array acts as an aperture in a plasmonic sensor. Fluid, in the form of a liquid or a gas and comprising a sample for analysis, is moved from an inlet manifold through the nanochannel array, and out through an exit manifold. The fluid may also contain a reagent used to modify the interior surfaces of the nanochannels, and/or a reagent required for the detection of an analyte.

This work was done by Jianjun Wei and Sameer Singhal of CFD Research Corporation, and David H. Waldeck and Matthew Kofke of the University of Pittsburgh for Glenn Research Center. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steven Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18967-1.

Advanced Dispersed Fringe Sensing Algorithm for Coarse Phasing Segmented Mirror Telescopes

The algorithm reduces sensitivity to calibration errors.

NASA's Jet Propulsion Laboratory, Pasadena, California

Segment mirror phasing, a critical step of segment mirror alignment, requires the ability to sense and correct the relative pistons between segments from up to a few hundred microns to a fraction of wavelength in order to bring the mirror system to its full diffraction capability. When sampling the aperture of a telescope, using auto-collimating flats (ACFs) is more economical. The performance of a telescope with a segmented primary mirror strongly depends on how well those primary mirror segments can be phased. One such process to phase primary mirror segments in the axial piston direction is dispersed fringe sensing (DFS). DFS technology can be used to co-phase the ACFs. DFS is essentially a signal fitting and processing operation. It is an elegant method of coarse phasing segmented mirrors. DFS performance accuracy is dependent upon careful calibration of the system as well as other factors such as internal optical alignment, system wavefront errors, and detector quality. Novel improvements to the algorithm have led to substantial enhancements in DFS performance.

The Advanced Dispersed Fringe Sensing (ADFS) Algorithm is designed to reduce the sensitivity to calibration errors by determining the optimal fringe extraction line. Applying an angular extraction line dithering procedure and combining this dithering process with an error function while minimizing the phase term of the fitted signal, defines in essence the ADFS algorithm. The error function, for the time being, is defined as the rms value of the particular signal fitting. ADFS is a unique and significant enhancement to the DFS algorithm, allowing one to reduce requirements upon calibration while obtaining significantly better and more repeatable results than using the simple DFS algorithm. In addition, this enhancement does not require any additional hardware. Moreover, ADFS can overcome hardware related alignment errors such as DFS device positional uncertainties affecting the signal dispersion direction, and still allow one to obtain precise and repeatable piston estimations.

ADFS allows dispersed fringe sensing to be less sensitive to calibration errors.