Dielectrophoresis-Based Particle Sensor Using Nanoelectrode Arrays

An array of nanostructure electrodes can provide a more sensitive reading than conventional microelectrodes.

Ames Research Center, Moffett Field, California

A method has been developed for concentrating, or partly separating, particles of a selected species from a liquid or gas containing these particles, and flowing in a channel. An example of this is to promote an accumulation (and thus concentration) of the selected particle (e.g., biological species such as *E. coli*, salmonella, anthrax, tobacco mosaic virus or herpes simplex, and non-biological materials such as nano- and microparticles, quantum dots, nanowires, nanotubes, and other inorganic particles) adjacent to the first surface.

Additionally, this method can also determine if the particle species is present in the liquid. This is accomplished by providing an insulating material in an interstitial volume between two or more adjacent nanostructure electrodes. It can also be accomplished by providing a functionalizing substance, located on a selected region of the insulating material surface, which promotes attachment of the selected species particles to the functionalized surface, and measuring a selected electrical property such as electrical impedance, conductance, or capacitance.

A time-varying electrical field E, having a root-mean-square intensity of E^2 rms, with a non-zero gradient in a direction transverse to the liquid or fluid flow direction, is produced by a nanostructure electrode array with a very high-magnitude gradient near exposed electrode tips. A dielectrophoretic force causes the selected particles to accumulate near the electrode tips, if the medium and selected particles have substantially different dielectric constants. An insulating material surrounds most of the nanostructure electrodes, and a region of the insulating material surface is functionalized to promote attachment of the selected particle species to the surface. An electrical property value Z(meas) is measured at the functionalized surface, and is compared with a reference value Z(ref) to determine if the selected species particles are attached to the functionalized surface.

Some advantages of this innovation are that an array of nanostructure electrodes can provide an electric field intensity gradient that is one or more orders of magnitude greater than the corresponding gradient provided by a conventional microelectrode arrangement, and that, as a result of the high-magnitude field intensity gradients, a nanostructure concentrator can trap particles from high-speed microfluidic flows. This is critical for applications where the entire analysis must be performed in a few minutes.

This work was done by Jun Li, Alan M. Cassell, and Prabhu U. Arumugam of Ames 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 the Ames Technology Partnerships Division at 1-855-NASA-BIZ (1-855-6272-249). Refer to ARC-15967-1.

Multi-Dimensional Damage Detection for Surfaces and Structures

This system determines the size, depth, and location of damage in a multi-layered system.

John F. Kennedy Space Center, Florida

Current designs for inflatable or semi-rigidized structures for habitats and space applications use a multiple-layer construction, alternating thin layers with thicker, stronger layers, which produces a layered composite structure that is much better at resisting damage. Even though such composite structures or layered systems are robust, they can still be susceptible to penetration damage.

The ability to detect damage to surfaces of inflatable or semi-rigid habitat structures is of great interest to NASA. Damage caused by impacts of foreign objects such as micrometeorites can rupture the shell of these structures, causing loss of critical hardware and/or the life of the crew. While not all impacts will have a catastrophic result, it will be very important to identify and locate areas of the exterior shell that have been damaged by impacts so that repairs (or other provisions) can be made to reduce the probability of shell wall rupture. This disclosure describes a system that will provide real-time data regarding the health of the inflatable shell or rigidized structures, and information related to the location and depth of impact damage.

The innovation described here is a method of determining the size, location, and direction of damage in a multilayered structure. In the multi-dimensional damage detection system, layers of two-dimensional thin film detection layers are used to form a layered composite, with non-detection layers separating the detection layers. The non-detection layers may be either thicker or thinner than the detection layers. The thin-film damage detection layers are