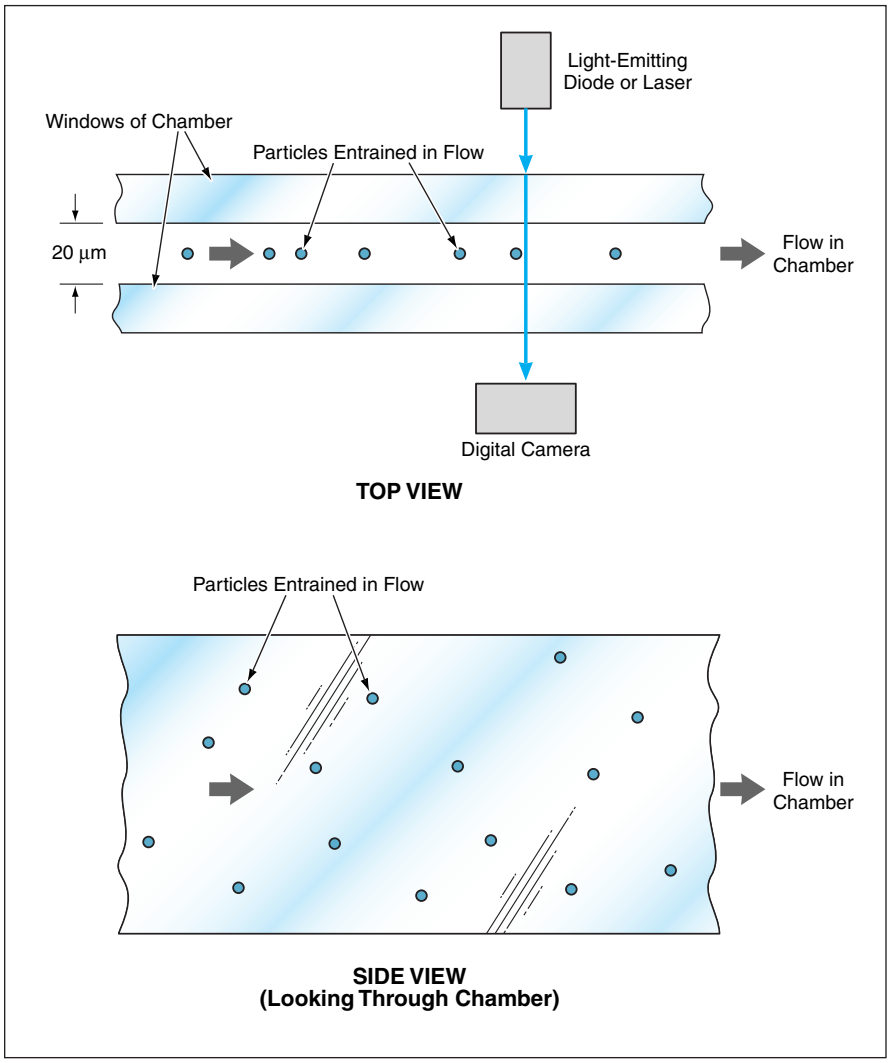


An **Instrumented Laminar-Flow Chamber**, depicted here in greatly simplified form, is designed and operated in a manner that guarantees that microparticles of interest traverse the chamber abreast, so that they can all be illuminated with laser light and monitored by a digital camera.

The instrumentation on the chamber includes one or more laser(s) and/or light-emitting diode(s) for illuminating the microparticles in the flow path, and a high-resolution digital camera with a magnifying lens for capturing sequential images of the illuminated microparticles as they move across the chamber. The MFS acts partly as a spectrophotometer in that it measures the amount of light reflected or transmitted by each microparticle at the laser wavelength(s).

The chamber is only 20 µm thick, and the liquid is pumped through it at a rate of about to 200 µL/min, giving rise to a low-shear laminar flow that forces the entrained microparticles to move across the chamber abreast. Hence, no microparticle shadows another microparticle, and as a result, every microparticle can be optically observed and analyzed separately from every other microparticle.

Special-purpose software running on a Pentium III 400-MHz computer processes the image data to locate individual microparticles and track their trajectories. If the microparticles of interest have known spectral characteristics (for example, if they have been dyed), then the software can identify the microparticles of interest and/or distinguish them from other microparticles (e.g., sediment) by means of the amounts of light transmitted or reflected by the various microparticles at different wavelengths. Tracking of microparticle trajectories can yield data on sedimentation rates, which are useful for identifying and distinguishing among microparticles of different sizes and compositions. Image data are also analyzed to determine microparticle sizes and shapes, which are also indicative of microparticle identities. The software can count and track more than 1,000 microparticles simultaneously as well as perform statistical analysis of microparticle data. A complete cycle of acquisition and processing of image data is only 5 seconds long.

This work was done by Dennis R. Morrison of **Johnson Space Center**.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center, (281) 483-0837. Refer to MSC-23277.

Scattering-Type Surface-Plasmon-Resonance Biosensors

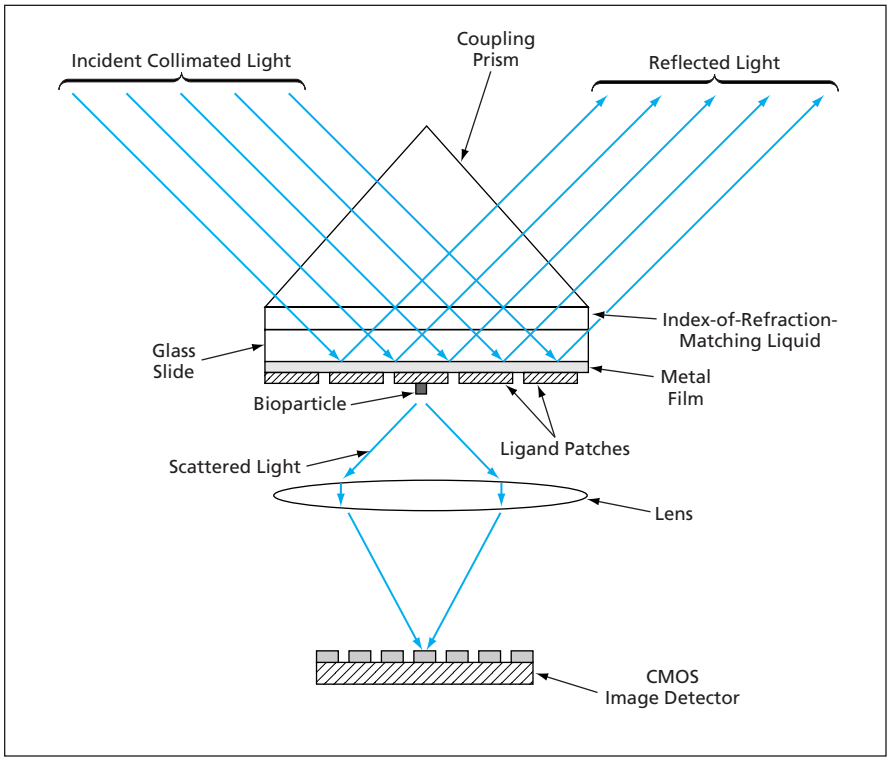
Sensitivities would greatly exceed those of reflection-type SPR biosensors.

NASA's Jet Propulsion Laboratory, Pasadena, California

Biosensors of a proposed type would exploit scattering of light by surface plasmon resonance (SPR). Related prior biosensors exploit absorption of light by SPR. Relative to the prior SPR biosensors, the proposed SPR biosensors would offer greater sensitivity — in some cases, enough sensitivity to detect bioparticles having dimensions as small as nanometers.

A surface plasmon wave can be described as a light-induced collective oscillation in electron density at the interface between a metal and a dielectric. At SPR, most incident photons are either absorbed or scattered at the metal/dielectric interface and, consequently, reflected light is greatly attenuated. The resonance wavelength and angle of incidence depend upon the permittivities of the metal and dielectric.

An SPR sensor of the type most widely used heretofore includes a gold film coated with a ligand — a substance that



Light Scattered by SPR from a bioparticle/ligand binding site would be focused to a bright spot on an image detector.

binds analyte molecules. The gold film is thin enough to support evanescent-wave coupling through its thickness. The change in the effective index of refraction at the surface, and thus the change in the SPR response, increases with the number of bound analyte molecules. The device is illuminated at a fixed wavelength, and the intensity of light reflected from the gold surface opposite the ligand-coated surface is measured as a function of the angle of incidence. From these measurements, the angle of minimum reflection intensity is determined.

These measurements and the determination of the angle of minimum reflection intensity are performed before and after (and can be performed during) exposure of the sensor to a sample containing the analyte molecules. Any shift in the angle between such successive determinations is indicative of a change in the concentration of analyte molecules in the sample. This type of sensor is characterized by low sensitivity for the following reasons:

- A small number of analyte molecules gives rise to a small shift in the angle of minimum reflection intensity.
- Because one is measuring a reflection dip rather than a reflection peak, the measurement can be strongly affected by noise. The difficulty of determining the small angular shift is analogous to the difficulty of measuring the shift of a dark spot on a bright background.

A biosensor according to the proposal would afford a much greater signal-to-noise ratio by exploiting SPR in a different way that would involve, literally, a bright spot on a dark background. A proposed sensor (see figure) would include a coupling prism, an index-of-refraction-matching liquid, a glass slide, and a metal film thin enough to support evanescent-wave coupling. The metal surface to be exposed to the specimen would be coated with ligand in a regular array of patches. The array of patches would be observed by a miniature microscope that would include a lens and a complementary oxide/semiconductor (CMOS) image detector. The microscope would be designed so that each ligand patch would occupy many CMOS pixels and the resolution of the microscope would be close to the optical limit (about one wavelength of the incident light).

The sensor would be illuminated with collimated light at a wavelength and angle of incidence chosen so that SPR would occur whenever and wherever analyte molecules became bound to the ligand. In the absence of such binding, there would be little scattered light. In the presence of such binding at any spot on the ligand, the strong SPR scattering from that spot would cause the spot to be imaged brightly in the microscope. Even a bioparticle smaller than a wavelength of light could induce sufficient SPR scattering to be detectable.

This work was done by Yu Wang, Bedabrata Pain, Thomas Cunningham, and Suresh Seshadri of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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Refer to NPO-40683, volume and number of this NASA Tech Briefs *issue, and the page number.*

Diode-Laser-Based Spectrometer for Sensing Gases

John H. Glenn Research Center, Cleveland, Ohio

A diode-laser-based spectrometer has been developed for measuring concentrations of gases and is intended particularly for use in analyzing and monitoring combustion processes under microgravitational conditions in a drop tower or a spacecraft. This instrument is also well suited for use on Earth in combustion experiments and for such related purposes as fire-safety monitoring and monitoring toxic and flammable gases in industrial settings.

Of the gas-sensing spectrometers available prior to the development of this instrument, those that were sensitive enough for measuring the combustion gases of interest were too large, re-