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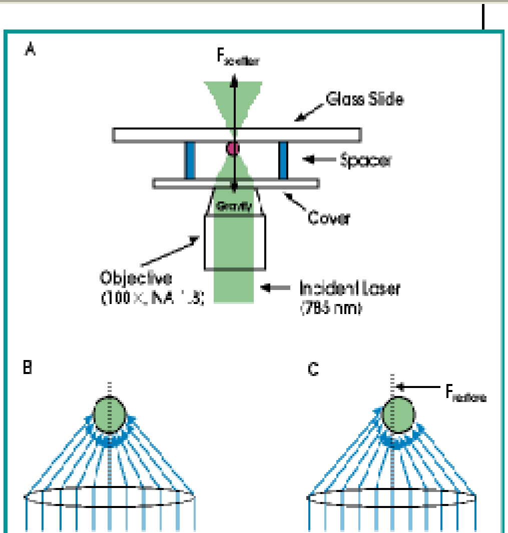
Tweezers Catch and Analyze Particles

Researchers at East Carolina University in Greenville, N.C., have developed a combined laser tweezers and Raman spectroscopy technique that enables them to capture and measure both transparent and nontransparent particles. The system could prove useful in industrial and scientific laboratories.



A new laser tweezers setup (left, A) enables the trapping and analysis (below) of both transparent and nontransparent objects. On a nontransparent particle, the scattering force of a laser beam focused on the top of the particle (B) pushes it against the glass slide. The force also can catch a particle and center it on the Z-axis (C). Courtesy of Yong-qing Li.

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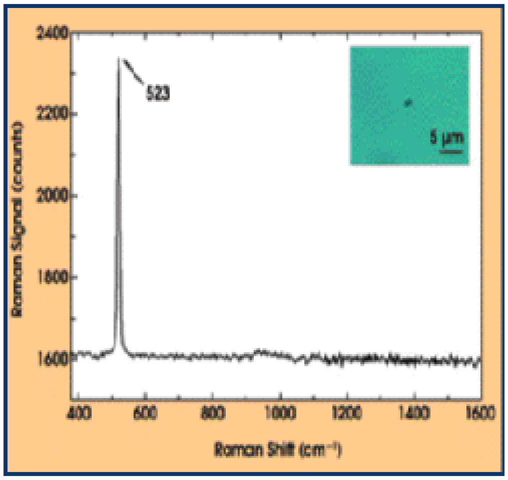
A trapping laser generates two basic forces, scattering and gradient, explained Yong-qing Li, the principal investigator in the research effort. The scattering force tends to push a particle away from the focal point of a TEM_{00}-mode laser beam, while the gradient force pushes a particle toward the focal point. With transparent objects, such as cells, the gradient force is larger and traps the particle in the beam. However, nontransparent objects get pushed outside the beam, making it difficult to use a TEM_{00}-mode laser for trapping.

Other research groups have used TEM_{01}-mode beams, the "doughnut" mode, to encircle nontransparent particles in laser light, which pushes and traps them on the beam's center, where the intensity is lowest. But this method does not work well for transparent particles.



To solve this problem, Li and colleague Changan Xie used the scattering force of the TEM_{00}-mode laser to their advantage. Their method depends on placing the solution containing the particle to be interrogated in a well formed by a glass coverslip suspended by spacers over a glass slide. The apparatus sits on an Olympus inverted microscope and includes a diode laser operating at 785 nm, a spectrograph and a CCD camera.

Pushing the particles

When the trap is activated, the setup focuses the laser light through the 100X magnification, 1.3-NA objective to a fine point on the top of the chosen particle. The laser's scattering force aligns the particle with the Z-axis and pushes the

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particle along it, away from the microscope objective. Therefore, by adjusting the focus, the researchers can push the particle until it has been trapped against the glass slide.

The trapping laser also serves as the excitation laser for Raman spectroscopic measurements. Thus, with one setup, the researchers can trap opaque or transparent objects and identify them by their Raman spectra.

The researchers have tested the system on a variety of particles, including paint, silicon, germanium, potassium niobate, and living cells and bacteria. Possible applications include detecting and identifying biological agents, such as for medical diagnosis and therapy, and process management for semiconductor manufacturing and wastewater treatment, Li said.

He said the team is working to make the system smaller and easier to use, with an eye toward commercialization. "With a high-resolution, miniature CCD spectrometer and miniature microscope, we expect to substantially miniaturize the system. We also plan to develop an automated sampling system so that the instrument can be used with minimal operation."

by Kevin Robinson

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