



NANOANTENNAS

Task

The amplification of evanescent nearfields through the use of optical antennas is utilized, for instance, in the scanning near-field optical microscope (s-SNOM) and in surface enhanced infrared absorption (SEIRA) spectroscopy. SEIRA is an optical measuring process for detecting the absorption bands that are characteristic of a certain molecule. In order to detect signals from individual molecules or molecules in low concentration, such as in thin films, the light backscattered into the farfield by these molecules must be amplified. Using the s-SNOM measuring process, the chemical and structural properties of a test sample can be optically resolved with a sensitivity of below 20 nm, which is fundamental for analytical applications in biology and chemistry.

Method

Ultrashort laser pulses are focused using a microscope objective onto 30 nm thin gold films. The high intensities, which are achieved even at pulse energies of a few 10 nJ owing to the short pulse duration of 100 fs, induce ultrafast melting of the gold film across its entire thickness. The melt dynamics cause the material to be transported upwards from the center of the irradiated area (jet). Given the very small quantity of energy input, the gold jet solidifies as it moves upwards, forming a stable antenna (Fig. 3).

Result

Nanojets as optical antennas, for instance for SEIRA or s-SNOM applications, can be manufactured with a diameter of less than 100 nm. By suitably selecting the focusing, the pulse energy and the gold film thickness, the size of the nanoantennas can be controlled very precisely. As a result, the system can be adjusted, for instance, to the characteristic absorption bands of certain molecules in SEIRA spectroscopy.

Applications

Nanojets as optical antennas can be used in analytical areas of chemistry, biology and mechanical engineering. The amplification of evanescent nearfields enables optical detection with a spatial resolution in the region of 10 nm and the detection of minute concentrations down to individual molecules.

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3 Individual nanojet.

4 Nanojet field.