One of the first truths we learn in optics is that light is nothing more than intertwined electric and magnetic vector fields. As vectors, these fields are characterized by a size (modulus) and a direction in space. However, most of the optical probes designed to detect light are only sensitive to the intensity of the electric or magnetic fields, in other words, the square of the modulus. On page 53 of this issue, Lee and co-workers report an experimental technique that can capture and map the vectorial nature of the electric fields down to the nanoscale. This could lead to important applications in physics and biochemistry.

The technique is based on the scanning near-field optical microscope (SNOM), invented twenty years ago by two independent groups — Dieter Pohl and colleagues at IBM–Zurich and Aaron Lewis, then at Cornell University, and co-workers. In the original experiments, the two teams shone light through a sharp dielectric tip that was covered with metal. Because the opening of the tip is smaller than the wavelength of the light, evanescent, or non-propagating, electromagnetic waves are generated at the very end of the probe. By placing the tip just above the surface of a sample, these evanescent waves can be transformed into propagating ones when scattered by the nanoscale features on the sample. A detector placed in the far-field region can record this scattered light and, by scanning the tip over the surface, an optical image of the object can be constructed. Thanks to the evanescent nature of the light emerging from the tip, the resolution of a SNOM is not limited to half the wavelength of the incident light, as in conventional optical microscopes. In principle, there is no fundamental barrier to the resolution that can be obtained with such a device.

To improve the resolution even further, the ingredient added to the apertureless SNOM by the Korean–German team is simple and clever: a polarizer is placed immediately before the CCD camera that is used to collect the light scattered by the nanoparticle (see Fig. 1). For each probe-tip position used during the scan process, the polarization angle is rotated between 0° and 360° in 10° increments, and a complete map of the vector state of the incident field is built up.

Why is it so important to identify the components of the electric field? For one thing, it tells us how light behaves in the vicinity of subwavelength structures. In-depth knowledge of the electric-field vector on the nanoscale could help in the design of miniaturized optical components that may replace their electronic counterparts in the future. In addition, near-field vector imaging is also important in biosensing applications because the interaction between light and biological molecules strongly depends...
Superfocusing of terahertz waves

The promising field of terahertz imaging has long been limited by poor resolution. Researchers now believe that the intriguing properties of surface-plasmon polaritons on corrugated wires could help beat the diffraction limit and inspire a new generation of terahertz photonic devices.

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Spectroscopy and imaging in the terahertz (far-infrared) band of the electromagnetic spectrum are now benefiting diverse areas of science and starting to find important commercial applications. For example, the pharmaceutical, medical and security industries are exploring the idea of using the technology to measure the thickness of tablet coatings, detect skin cancer and image weapons hidden beneath clothes.

Unfortunately, the long wavelength (about 300 μm) of terahertz radiation creates serious limitations for the imaging resolution, which is very poor compared with visible imaging techniques, which operate at far shorter wavelengths. This is more than an aesthetic problem for applications of terahertz imaging in nanotechnology and clinical medicine, where subwavelength image resolution is required to resolve microscopic features or perform spectroscopy on small volumes.

Fortunately, a solution may soon be at hand. Reporting in Physical Review Letters, Maier and colleagues from the United Kingdom and Spain propose an elegant solution to this problem using surface-plasmon polaritons (SPPs) on corrugated wires to guide and ‘superfocus’ terahertz radiation. The results are particularly promising for the development of new types of terahertz photonic devices including a near-field terahertz endoscope with enhanced resolution.

An SPP is a coupled electromagnetic and electron-plasma polarization wave that can be excited at the surface of a metal. At frequencies approaching the plasma resonance of the metal (often in the UV or visible), the unique propagation characteristics (dispersion) of an SPP open the door to a variety of interesting effects, such as the generation of intense, localized electric fields on subwavelength structures.

Great progress has been made in recent years in engineering compact ‘plasmonic’ devices from micro- and nanostructured metals to exploit the properties of SPPs at visible frequencies. Subwavelength localized plasmonic waveguides and plasmonic devices