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Imaging Chiral Plasmons

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Chirality is a broad concept that characterizes structures of systems in almost all hierarchy of materials in natural sciences. Molecular chirality is sometimes essential in biological functions. Also in nanomaterials sciences, chirality plays a key role. It is of fundamental importance to investigate internal structures (geometrical distributions) of chiral optical responses in nanomaterials, to design chiral features of the materials and their functions. We developed near-field optical activity (typically circular dichroism, CD) imaging systems that allow us to visualize local structures of optical activity in nanomaterials, and observed near-field CD images of two-dimensional gold nanostructures fabricated with electron beam lithography lift-off technique. We found that the amplitudes of local CD signals were as large as 100 times the macroscopic CD signals of the same samples, for two-dimensional chiral gold nanostructures [1]. Even highly symmetric achiral structures that never give CD signals macroscopically gave locally very strong CD signals (a typical example for a rectangular nanostructure is shown in Figure 1) [2,3]. In this case, average of the signal over the nanostructure yielded roughly null CD intensity.

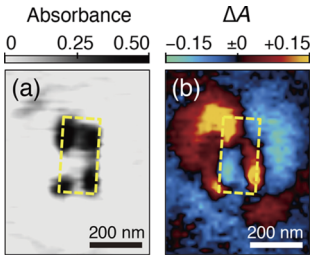

Figure 1. Near-field optical images (at 633 nm) of a gold rectangle [2]. (a) Transmission image. (b) CD image.

While achiral nanostructures show in general local CD activities as mentioned above, circularly symmetric (two-dimensionally isotropic) nanostructures, such as circular disks, never give CD signals at any local positions. However, when the circular disk is illuminated with linearly polarized light, the circular symmetry is broken, and thus the system potentially yields locally chiral optical (i.e., circularly polarized) fields. To demonstrate that, we extended the near-field CD microscope, and enabled irradiation of well-defined linearly polarized near-field on the sample and detection of scattered-field ellipticity and polarization azimuth angle. We found for circular gold disks that the scattered field was actually elliptically polarized. The ellipticity and the azimuth angle of the scattered field depended on the incident polarization angle and relative position on the disk.

The results obtained here may provide basic principle to get highly chiral optical fields, which may give us a chance to pioneer analytical applications of chiral optical fields.

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