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Nanonics MultiView — Near-Field Scanning Microscopy and Imaging without Compromise

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Nanonics Imaging is world leader and major innovator of the scanning probe/near-field scanning optical microscopy technology on the global market. This article is presenting the new concept in system functionality which gives a unique solution for new advanced areas of scientific application. The award winning MultiView 1000™ is the first system available that fully integrates all forms of scanned probe microscopy with conventional optical microscopy. The Nanonics MultiView SPM/Confocal microscope, therefore, introduces near-field scanning optical and atomic force microscopy to new worlds of research such as waveguide and metamaterials characterization. As an example of application of our systems at the frontier of nanotechnology we would like to present the brief note about research done by group of Prof. Shalaev from Purdue University, USA [1, 2]. For more details describing technical aspects and practical application of our scanning probe/near-field scanning optical microscopes please visit our web-page.

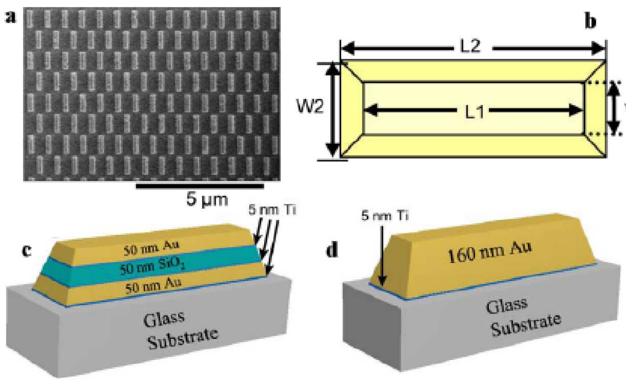

Fig. 1. (a) Electron microscopy image of the paired nanorod array. (b) Elementary cell dimensions: L1 and L2 are the top and bottom lengths, respectively, while W1 and W2 identify the widths (sample name: L1, L2, W1, W2, X period–Y period); (paired nanorod: 703 nm, 812 nm, 120 nm, 213 nm, 666–1852); (single nanorod: 691 nm, 781 nm, 104 nm, 205 nm, 666–1806). Vertical structures of paired (c) and single (d) nanorods.

1. Introduction

Since last decade the metamaterials are extensively studied as the potential materials having negative refractive index and optical magnetism. Mostly, such metamaterials are engineered in the form of periodic arrays of nanorods, nanoantennas and nanowires (Fig. 1, [1]). Employing the near-field scanning optical technique (NSOM), therefore, became crucial for optical research in plasmonics as the surface features have the size smaller than the wavelength of light.

2. Experimental

NSOM measurements of the gold nanorods arrays have been performed using MultiView2000 from Nanonics Imaging. Microscope head was accompanied by cantilevered glass–metal coated fiber probes designed by Nanonics. NSOM probes had aperture diameter less than 100 nm. Brief sketch of the experimental setup is shown in Fig. 2.

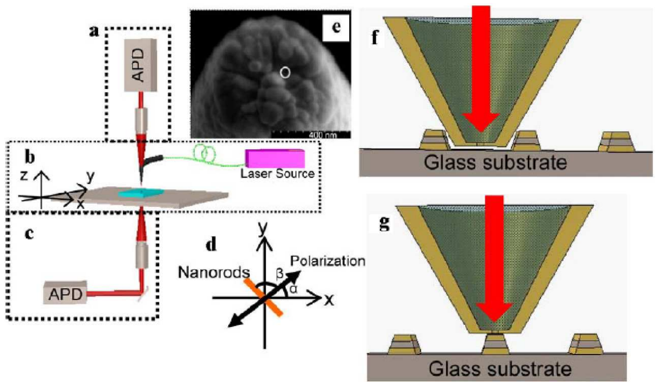

Fig. 2. NSOM: (a) reflection and (c) transmission detection modules; (b) NSOM stage and illumination unit; (d) orientation of the polarization axis and the nanorod; (e) FESEM image of a typical metallized tip where the circle represents the aperture of the tip. Two key relative positions of the tip and paired gold nanorods: a gold-coated tip is in the valley between the nanorods (f) and on top of the nanorod pair (g).

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Supplier: Nanonics Imaging Ltd. www.nanonics.co.il

Transmission and reflection mode experiments were carried out using illumination through the fiber probe. An image was collected by raster scanning of the sample and detecting the intensity of the light as a function of the scan position. This mode enables to obtain atomic force microscopy (AFM) topography and NSOM images simultaneously.

Designed around Nanonics' patented, award winning 3D Flatscan^{TM} scanner technology and incorporating sophisticated cantilevered optical fiber probes, the instrument can simply and transparently be combined with any inverted, upright, or dual optical microscope (Fig. 3).

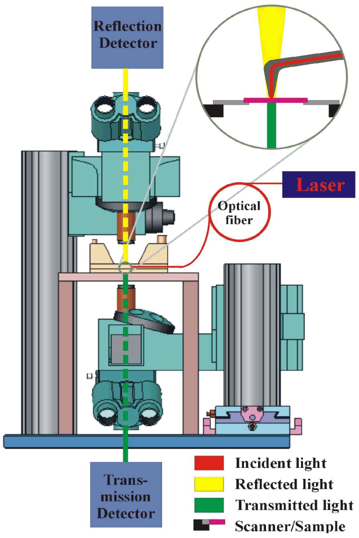

Fig. 3. Nanonics MultiView SPM/NSOM system incorporated with dual microscope, avalanche detectors and laser source. Present configuration is employed at the Purdue University.

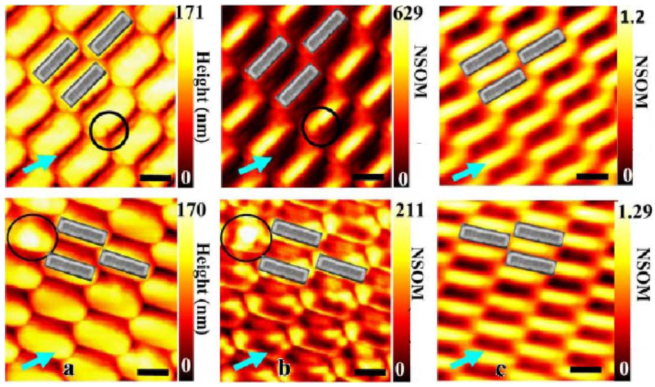

Fig. 4. Reflection and transmission images of a paired gold nanorod array at 532 nm: (a) topography images collected with the reflection images. (b) NSOM reflection images (upper: quasi-parallel polarization, lower: quasi-perpendicular polarization). (c) NSOM transmission images normalized by the light intensity from the aperture probe measured through the glass. The indented nanorod edge and the gold particle on the nanorod inside the circles verify no shift between the topography and NSOM images. Arrows represent the polarization axis. Scale bar is 500 nm. Representative FESEM images of the nanorods are inserted for the position reference.

3. Results

The near-field images obtained by Nanonics system illustrate the great performance and contrast for both transmission and reflection modes (Fig. 4). High spatial resolution of the system and its flexibility allow us to deal successfully with detection of the subtle polarization dependence (Fig. 5). Application of the same probe for AFM and NSOM measurements ensures that the topography and optical images are in excellent correlation.

In the next step of NSOM studies of gold paired nanorod arrays, Shalaev et al. (Ref. [2]) have investigated spectral response of the arrays in broadband spectral range using supercontinuum light source and spectrometer as a detection system. Unique spectral mapping of double layered nanorods has been obtained (Fig. 6).

Nanonics MultiView integrated system is a great tool for understanding of the local spectral response of the variety of metamaterials. Thanks to implementation of this system into the state-of-the-art laboratories, near-field

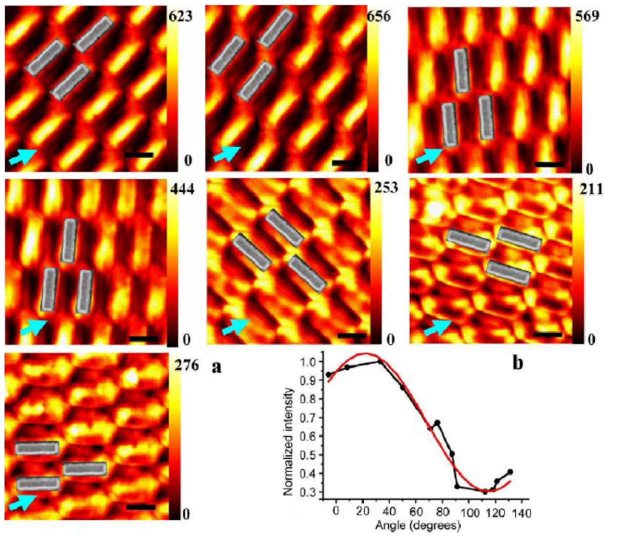

Fig. 5. (a) Reflection NSOM images at 532 nm. The paired nanorod sample (sample A) was rotated in the counterclockwise direction from the polarization axis through about 150 degrees. Angle is 16, 30, 72, 93, 113, 140 and 153 degrees from the left to right and from the top to bottom. Arrows in the NSOM images represent the polarization axis. Representative FESEM images of the nanorods are inserted for the position reference. Scale bar is 500 nm. (b) Intensity as a function of sample orientation averaged from 5 μm $\times$ 5 μm reflection NSOM images at 532 nm. NSOM images were normalized by the maximum light intensity at 30 degrees. Red line represents a fitted cosine squared function.

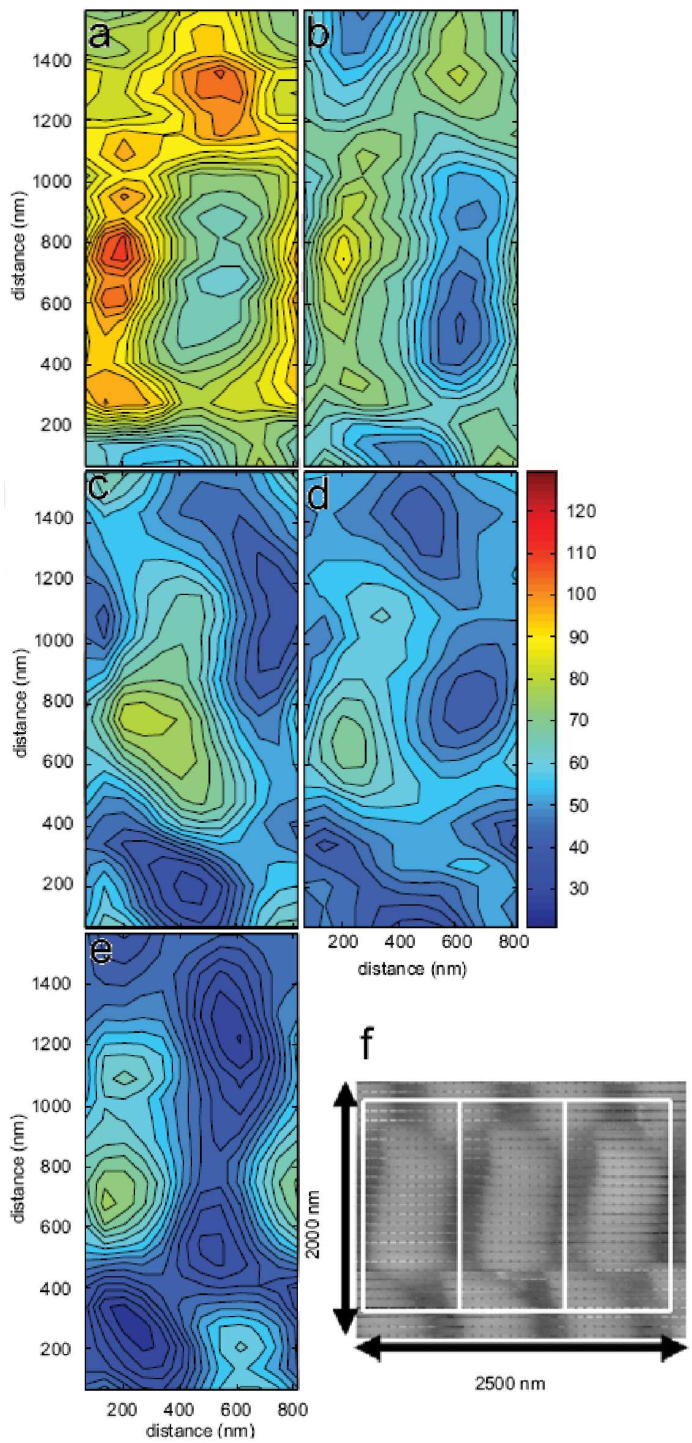

Fig. 6. Near-field spectral mapping, transmittance (from 20% to 130%): (a) 525–550 nm, (b) 625–650 nm, (c) 725–750 nm, (d) 800–825 nm, (e) 900–925 nm, and (f) the corresponding AFM image from the data collection, showing data collection points and the three "unit cells" that were averaged.

broadband spectroscopy became a powerful experimental technique that will allow intimate spectral mapping of meso- and nanosized structures.

References

[1] Ji-Young Kim, V.P. Drachev, Hsiao-Kuan Yuan, R.M. Bakker, V.M. Shalaev, *Appl. Phys. B* **93**, 189 (2008).

[2] R.M. Bakker, V.P. Drachev, Hsiao-Kuan Yuan, V.M. Shalaev, *Physica B* **394**, 137 (2007).