2004

Optical modulation at GHz frequencies using plasmonic nanolenses

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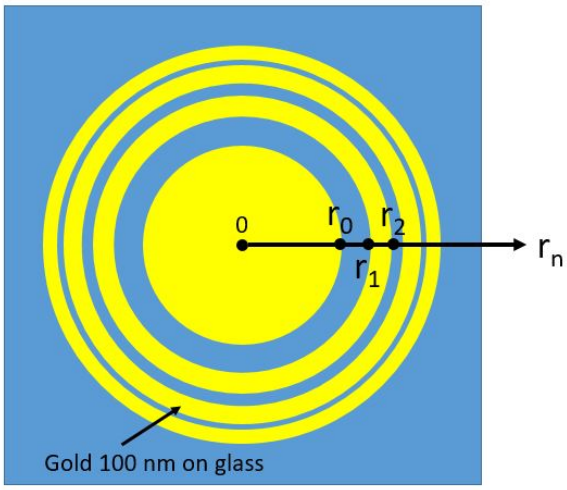
［2］Research Progress

This initial research phase, i.e. the design and simulation phase, shows that one can create a very small optical spot (in this case with a width of ~1 μm) using our Fresnel lens design. The next step is the fabrication and testing of the lens, and the checking of the GHz response when the lens is illuminated by a femtosecond optical pulse. As this modulation process is extremely complicated, it is not accessible at present to standard simulations.

［3］Results

（3－1）Research results

This project is aimed at the design of plasmonic nanolenses appropriate for GHz modulation. This study involves a microlens that adjusts the refractive index gradient acoustically at GHz frequencies. It operates with GHz surface acoustic waves or bulk waves excited by femtosecond laser pulses, in a circular-symmetric environment. The first step of this research involved designing and simulating the device using commercial finite-element analysis software (COMSOL). Figure 1 shows the design chosen, represented by a gold Fresnel-zone-plate pattern of concentric rings, 100 nm thick, on a glass substrate. This lens was designed to have a focal length of 0.1 mm. the simulated modulus of the electric field for incident plane waves is shown in Fig. 2. It is clear that focusing occurs at a region about 0.1 mm distant from the lens plane, as required by the design.



r_0 = 8.94 um, $r_{n=1\text{-}9}$ = 12.67 μm, 15.53 μm, 17.96 μm, 20.10 μm, 22.04 μm, 23.83 μm, 25.50 μm, 27.07 μm, 28.57 μm

Fig. 1: Design of the microscopic Fresnel zone plate.

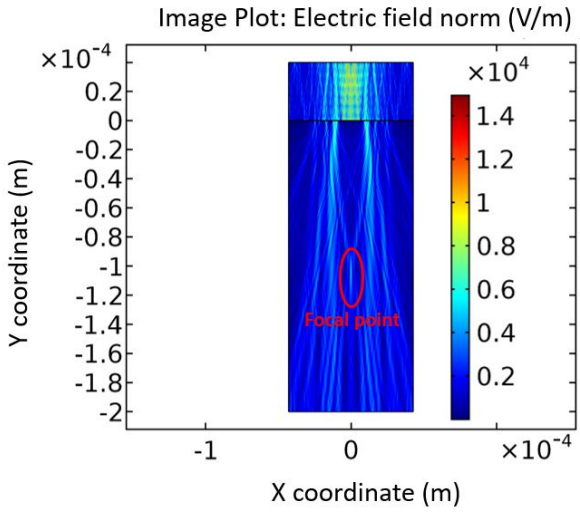


Fig. 2: Simulation of the modulus of the electric field in the region of the zone plate, showing focusing in the downsteam region.

（3－2）Ripple effects and further developments

Although the design of the lens has been done and have been confirmed by simulation, we need now to proceed to the fabrication and testing stage. Fabrication will be the responsibility of the Hokkaido University counterparts. We are hoping that by demonstrating optical modulating we can further enhance its effects by the positioning of nanoapertures at the lens focal point. The research resulted from analogies with larger-scaler systems with applications to scanning, and so we hope that this research will lead to similar perspectives in ultrafast imaging.

［4］Achievements (List of Publications)

（1）'Ultrafast optical modulation by gigahertz acoustic perturbation of extraordinary optical transmission'
R. Ulbricht, H. Sakuma, Y. Imade, P. H. Otsuka, M. Tomoda, O. Matsuda, H. Kim, G. Park and O. B. Wright
Appl. Phys. Lett. 110, 091910 (2017)

（2）'Upholding the diffraction limit in the focusing of light and sound'
A. A. Maznev and O. B. Wright
Wave Motion 68, 182-189 (2017)

（2）'Extraordinary transmission of gigahertz surface acoustic waves'
S. Mezil, K. Chonan, P. H. Otsuka, M.Tomoda, O. Matsuda, S. H. Lee and O. B. Wright
Sci. Rep. 6, 33380 (2016)

（4）'Optical tracking of picosecond coherent phonon pulse focusing inside a sub-micron object'
T. Dehoux, K. Ishikawa, P. H. Otsuka, M. Tomoda, O. Matsuda, M. Fujiwara, S. Takeuchi, I. A. Veres, V. E. Gusev and O. B. Wright
Light Sci. Appl. 5, 16082 (2016)

Traveling Report

Name：Oliver B. Wright
Affiliation：Hokkaido University
Period of time：Jan 31 to Feb 3. 2017
Destination：Sapporo - Hamamatsu
Purpose：Visit team members in Shizuoka in order to conduct research regarding Optical modulation at GHz frequencies using plasmonic nanolenses and have discussion with the Shizuoka team.
Name of receiver：Prof. Hidenori Mimura