Form 1

2017 Report Form for Collaboration with Research Center for Biomedical Engineering

Year/month/date	2018/3/20
Number	2067

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date: 2018/3/20

To Chairman, Board of Directors, Research Center for Biomedical Engineering

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Report Form for Collaboration Research

Research Theme	Optical modulation with a plasmonic nanolens
Research Area	1. Biomaterials 2. Bioengineering 3. Functional molecules ④ Chemistry/Electrical Engineering/Mechanical Engineering/Materials Science
Research Period	From: Date/month/Year 2018/7/1 To: Date/month/Year 2018/3/31

Applicant Organization			
Name	Department	Title	Role
Oliver B. Wright	Faculty of Engineering, Hokkaido University	Prof.	Theory, analysis
Hidenori Mimura	Research Institute of Electronics, Shizuoka University	Prof.	Theory, analysis
Yuta Imade	Faculty of Engineering, Hokkaido University	Mr	Experiment, theory, analysis
Collaboration Partners in the Research Center	Prof. Hidenori Mimura		

Research Results (Including Purpose, Results, Figures, etc.)

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). The present research stage involved fabrication and characterization. Figure 1 shows an optical micrograph of the sample, fabricated with the help of Prof. S. Juodkasis of Swinburne University, Melbourne, representing 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.

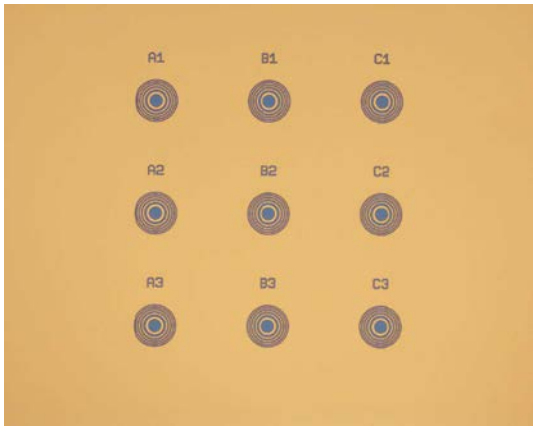

Fig. 1: Electron micrograph of the fabricated nanolens. Each lens is about 100 microns in diameter.

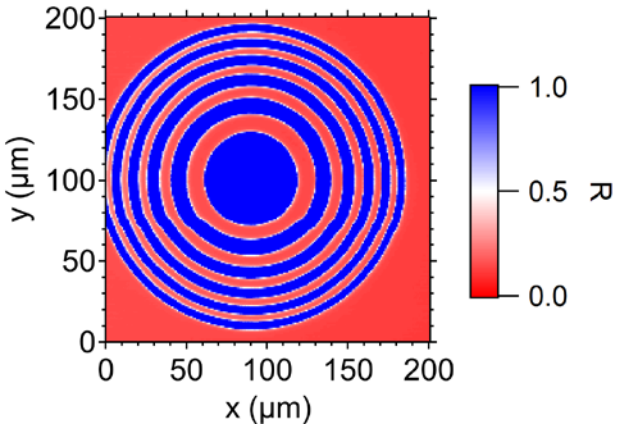

Fig. 2: Reflectance image of a nanolens obtained by point by point scanning of an 830 nm focused beam of 200 fs infrared optical pulses.

We have begun characterization of this lens using ultrafast optical point by point probing. So far we made a reflectance image of this lens, as shown in Fig. 2.

List of Publications Related to the Collaboration Research

'Gigahertz optomechanical modulation by split-ring-resonator nanophotonic meta-atom arrays'
Y. Imade, R. Ulbricht, M. Tomoda, O. Matsuda, G. Seniutinas, S. Juodkazis and O. B. Wright
Nano Letters 11, 6684 (2017)

'Active chiral control of GHz acoustic whispering-gallery modes'
S. Mezil, K. Fujita, P. H. Otsuka, M. Tomoda, M. Clark, O. B. Wright and O. Matsuda
Appl. Phys. Lett. 111, 144103 (2017)

'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)

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

List of Presentations (Conference, Meeting, etc)

O. B. Wright, GHz Ultrasonics in Metamaterials, 2017 ICU Honolulu, Dec. 18-25 USA

List of Awards

Research plan for the next year (from April 1, 2018 to March 31, 2019), if the collaboration research is continued. Prior consent from the collaboration partner in the Research Center is necessary.

This research concerns a project we started two years ago to develop an ultrafast optical modulation system based on a plasmonic or Fresnel lens with sub-micron features that can be modulated with GHz surface acoustic waves. After extensive optical simulations using COMSOL commercial software, we have designed and fabricated an appropriate Fresnel lens with a 1 mm focal length that is ideal for fabrication and evaluation. We propose to test its optical characteristics with the help of Shizuoka University, and then proceed with GHz acoustic modulation experiments at Hokkaido University. The goal is to demonstrate a significant modulation of light by means of a nanoaperture placed in the focal plane of the lens when the lens is excited by a train of optical pump pulses and modulated by GHz ultrasonic surface or bulk waves.

We expect to achieve the following:
1) Spectral characterization of the nanolens focal length and transmission using equipment based in Shizuoka University.
2) Characterization of the GHz modulation properties of the nanolens when combined with a nanoaperture using a femtosecond-laser system at Hokkaido University. In particular, we shall implement temporal Fourier transforms to understand the dependence of the optical modulation on ultrasonic frequency and pinpoint the optimal GHz frequency for optical modulation.