

Proceedings of the

Advanced Architectures in Photonics

September 21–24, 2014

Prague, Czech Republic

Volume 1

Editors

Jiri Orava

University of Cambridge
Department of Materials Science and Metallurgy
27 Charles Babbage Road
CB3 0FS Cambridge
United Kingdom

Tohoku University
WPI-Advanced Institute for Materials Research
(WPI-AIMR)
2-1-1 Katahira, Aoba-ku
980-8577 Sendai
Japan

Tomas Kohoutek

Involved Ltd.
Siroka 1
537 01 Chrudim
Czech Republic

Proceeding of the Advanced Architectures in Photonics
<http://aap-conference.com/aap-proceedings>

ISSN: 2336-6036
September 2014

Published by **Involved Ltd.**
Address: Siroka 1, 53701, Chrudim, Czech Republic
Email: info@involved.cz, Tel. +420 732 974 096



This work is licensed under a
[Creative Commons Attribution
3.0 Unported License](https://creativecommons.org/licenses/by/3.0/).

CONTENTS

[Preface](#)

T. Wagner (Chairman)	i
----------------------------	---

FULL PAPERS

[Innovative nanoimprint lithography](#)

S. Matsui, H. Hiroshima, Y. Hirai and M. Nakagawa	1
---	---

[Nanofabrication by imprint lithography and its application to photonic devices](#)

Y. Sugimoto, B. Choi, M. Iwanaga, N. Ikeda, H. T. Miyazaki and K. Sakoda	5
--	---

[Soft-mould imprinting of chalcogenide glasses](#)

T. Kohoutek, J. Orava and H. Fudouzi	9
--	---

[Electric nanoimprint to oxide glass containing alkali metal ions](#)

T. Misawa, N. Ikutame, H. Kaiju and J. Nishii	11
---	----

[Producing coloured materials with amorphous arrays of black and white colloidal particles](#)

Y. Takeoka, S. Yoshioka, A. Takano, S. Arai, N. Khanin, H. Nishihara, M. Teshima, Y. Ohtsuka and T. Seki	13
--	----

[Stimuli-responsive colloidal crystal films](#)

C. G. Schafer, S. Heidt, D. Scheid and M. Gallei	15
--	----

[Opal photonic crystal films as smart materials for sensing applications](#)

H. Fudouzi and T. Sawada	19
--------------------------------	----

[Introduction of new laboratory device 4SPIN® for nanotechnologies](#)

M. Pokorny, J. Rebíček, J. Klémes and V. Velebný	20
--	----

[Controlling the morphology of ZnO nanostructures grown by Au-catalyzed chemical vapor deposition and chemical bath deposition methods](#)

K. Govatsi and S. N. Yannopoulos	22
--	----

[Visible photon up-conversion in glassy \$\(\text{Ge}_{25}\text{Ga}_{5}\text{Sb}_{5}\text{S}_{65}\)_{100-x}\text{Er}_x\$ chalcogenides](#)

L. Strizik, J. Zhang, T. Wagner, J. Oswald, C. Liu and J. Heo	27
---	----

POSTERS presented at AAP 2014

[Solution processing of As-S chalcogenide glasses](#)

T. Kohoutek	31
-------------------	----

[Ga-Ge-Sb-S:Er³⁺ amorphous chalcogenides: Photoluminescence and photon up-conversion](#)

L. Strizik, J. Oswald, T. Wagner, J. Zhang, B. M. Walsh and J. Heo	32
--	----

[Multi-wavelength and multi-intensity illumination of the GeSbS virgin film](#)

P. Knotek, M. Kincl and L. Tichý	33
--	----

[Towards functional advanced materials based using filling or ordered anodic oxides supports and templates](#)

J. M. Macák, T. Kohoutek, J. Kolar and T. Wagner	34
--	----

[Introduction of new laboratory device 4SPIN® for nanotechnologies](#)

M. Pokorny, J. Rebíček, J. Klémes and V. Velebný	35
--	----

[Profile and material characterization of sine-like surface relief Ni gratings by spectroscopic ellipsometry](#)

J. Mistrik, R. Antos, M. Karlovec, K. Palka, Mir. Vlcek and Mil. Vlcek	36
--	----

[Preparation of sparse periodic plasmonic arrays by multiple-beam interference lithography](#)

M. Vala and J. Homola	37
-----------------------------	----

[High-performance biosensing on random arrays of gold nanoparticles](#)

B. Spackova, H. Sipova, N. S. Lynn, P. Lebruskova, M. Vala, J. Slaby and J. Homola	38
--	----

PREPARATION OF SPARSE PERIODIC PLASMONIC ARRAYS BY MULTIPLE-BEAM INTERFERENCE LITHOGRAPHY

M. Vala, J. Homola

Institute of Photonics and Electronics, Chaberská 57, Prague, Czech Republic

1 INTRODUCTION

A novel method for fabrication of sparse periodic arrays of plasmonic nanostructures for applications in surface enhanced Raman scattering (SERS) or affinity biosensing is presented. The technique is based on interference of eight or more coherent optical beams originating from diffraction of a collimated laser beam on a special transmission phase mask. This arrangement ensures the fulfilment of strict phase relations among all interfering beams and yields a high-contrast interference pattern with periodically ordered narrow maxima.

2 MULTIPLE-BEAM INTERFERENCE LITHOGRAPHY: PRINCIPLE

Interference lithography (IL) is a common technique for preparation of various types of periodic nanostructures. The contrast of the standard two-beam interference pattern and thus attainable dimensions of the prepared nanostructures could be improved by utilizing a larger number of coherent beams to form the recording interference pattern.

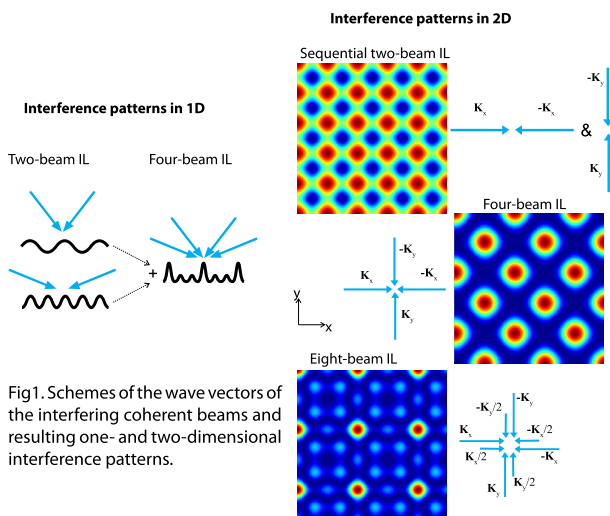


Fig. 1. Schemes of the wave vectors of the interfering coherent beams and resulting one- and two-dimensional interference patterns.

3 INTERFEROMETER SETUP

A beam from a 325 nm line of a He-Cd laser was collimated by a dublet lens and transmitted through a special phase mask (Fig. 2). All transmitted diffraction orders impinging on a photosensitive layer on a glass substrate placed closely (0.15 mm - 4 mm) behind the phase mask.

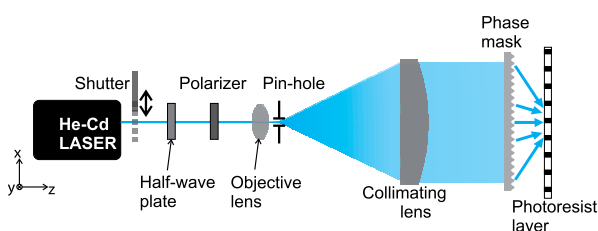


Fig. 2. Scheme of the multiple-beam interferometric setup.

4 DESIGN OF THE PHASE MASK

Based on a theoretical model of multiple-beam interference, a special phase mask with period 800 nm in both directions was prepared (Fig.3a). Modulation depth was designed to provide optimum diffraction efficiencies of all 21 transmitted orders to form a sparse interference pattern with high contrast (Fig.3b). Diffraction efficiencies were calculated using the 2D rigorous coupled wave analysis (RCWA). Designed phase mask was fabricated using sequential two-beam IL on a photoresist (AZ MiR 701)-coated SF2 glass substrate.

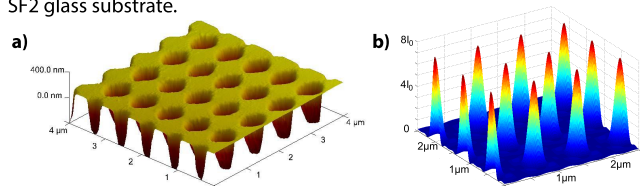


Fig. 3. a) AFM scan of the surface of the prepared phase mask with 800 nm period and 595 nm modulation depth and b) calculated interference pattern formed by all 21 diffraction orders transmitted by such mask.

5 FABRICATION PROCEDURE

The photoresist layer exposed in multiple-beam interferometer was wet developed in AZ 726 developer so that a periodic array of nanoholes was obtained (Fig. 4, left). A thin gold layer was then evaporated in vacuum on top of the structure. In order to obtain an array of separated gold nanodisks (Fig. 4, right), the photoresist layer was lifted-off in acetone.

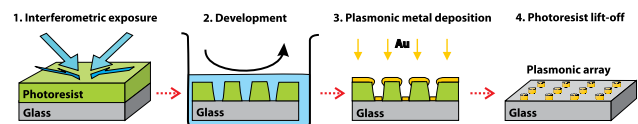


Fig. 4. Scheme of the fabrication procedure.

6 CHARACTERIZATION

Prepared plasmonic arrays were characterized morphologically using scanning electron microscope (SEM). Measured nanodisk diameters were from about 150 nm to 270 nm depending on the applied exposure dose.

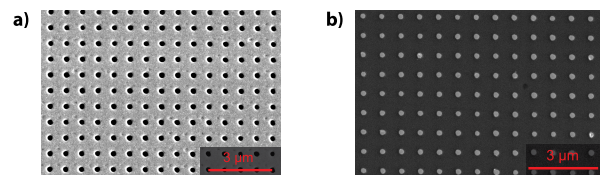


Fig. 5. SEM photographs of the fabricated sparse plasmonic arrays: a) gold-coated nanostructured photoresist; b) array of nanodisks (diameter ~215nm, height 30 nm, period 800nm) after lift-off of the sacrificial photoresist layer.

7 CONCLUSIONS

A novel method for fabrication of sparse plasmonic arrays is presented. It provides following **features and benefits**:

- ◆ **Fabrication of large areas (several mm²) of perfectly periodic 2D sparse plasmonic arrays**
- ◆ **Rapid patterning: photoresist exposure ~15 minutes**
- ◆ **Nanoparticle size < 20% of the array period**
- ◆ **Complex periodic patterns attainable by consecutive interferometric exposures**