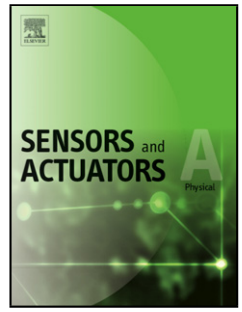
Accepted Manuscript



Title: One-step nanoimprinted Bragg grating sensor based on hybrid<!–<query id="Q1">No abstract and biographies are provided, please check</query>–> polymers

Authors: M. Förthner, M. Girschikofsky, M. Rumler, F. Stumpf, M. Rommel, R. Hellmann, L. Frey

PII: S0924-4247(18)30772-6
DOI: https://doi.org/10.1016/j.sna.2018.09.053
Reference: SNA 11028

To appear in: *Sensors and Actuators A*

Received date: 7-5-2018
Revised date: 31-7-2018
Accepted date: 21-9-2018

Please cite this article as: Förthner M, Girschikofsky M, Rumler M, Stumpf F, Rommel M, Hellmann R, Frey L, One-step nanoimprinted Bragg grating sensor based on hybrid polymers, *Sensors and amp; Actuators: A. Physical* (2018), https://doi.org/10.1016/j.sna.2018.09.053

One-step nanoimprinted Bragg grating sensor based on hybrid polymers

M. FÖRTHNER[1,4,*], M. GIRSCHIKOFSKY[3], M. RUMLER[1,4], F. STUMPF[2,4], M. ROMMEL[2], R. HELLMANN[3], L. FREY[1,2,4]

[1]*Chair of Electron Devices, University Erlangen-Nuremberg, Erlangen 91058, Germany*
[2]*Fraunhofer Institute for Integrated Systems and Device Technology (IISB), Erlangen 91058, Germany*
[3]*University of Applied Sciences Aschaffenburg, Aschaffenburg 63743, Germany*
[4]*Graduate School in Advanced Optical Technologies (SAOT), Erlangen 91052, Germany*
**Corresponding author: michael.foerthner@fau.de, Chair of Electron Devices, Cauerstrasse 6, Erlangen 91058, Germany*

Highlights:

- Surface relief Bragg gratings (SBGs) can be fabricated in OrmoComp® hybrid polymers within one step using UV-SCIL
- Focused ion beam milling is an efficient and viable option for the prototyping of SBGs
- SBG sensors exhibit an excellent temperature sensitivity which is 10 times higher than for glass fibers
- OrmoComp® based SBG sensors can be applied for refractive index sensing in liquids and gases

Bragg grating sensors are used for real-time analysis of gases or liquids. Complex processing methods are typically required for the sensor fabrication. A reduction of process steps and costs during their fabrication is essential in order to broaden the field of application. Within this work, we demonstrate an innovative process for a one-step fabrication of integrated Bragg grating sensors and their successful application for temperature and refractive index sensing. UV-enhanced substrate conformal imprint lithography (UV-SCIL) is used to replicate surface relief Bragg grating (SBG) sensors on a full wafer scale. Multiple chips of a planar waveguide system including couplers and junctions were etched into a silicon wafer. Nanostructured SBGs were locally added on the waveguides by focused ion beam processing. The sensor structures were replicated by UV-SCIL into a commercially available hybrid polymer (OrmoComp®). Reflection measurements with different Bragg gratings were performed and compared to simulations. The results reveal narrow-band Bragg reflections, coinciding with the simulations. Further, the temperature dependence of the SBGs was investigated. The imprinted grating structures featured a very high temperature sensitivity of -202 pm/°C. The sensor response to a varying refractive index of the surrounding medium was determined for index matching liquids and aqueous solutions.

1. Introduction

$$\boldsymbol{\lambda_B = 2 \cdot n \cdot \Lambda} \qquad (1)$$

Here, λ_B is the reflected Bragg wavelength, n the RI of the waveguide for the guided mode and Λ the grating period.

Possible fields of application for SBGs are temperature sensing, RI sensing or the detection of mechanical deformations [1, 2]. The according sensor sensitivities directly depend on its material properties. If external forces are present, mechanical material properties such as the Young's modulus are of relevance. Otherwise, any thermally induced shift of the Bragg wavelength $\Delta\lambda_B$ depends on the thermo-optical coefficient α (TOC) or the coefficient of thermal expansion ε (CTE) and can be described as follows:

$$\boldsymbol{\Delta\lambda_B = \lambda_B \cdot (\alpha + \varepsilon) \cdot \Delta\vartheta} \qquad (2)$$

Here, $\Delta\vartheta$ describes the temperature change. The TOC is defined by $\alpha = \partial n/(\partial\vartheta \cdot n)$, and the CTE as $\varepsilon = \partial\Lambda/(\partial\vartheta \cdot \Lambda)$ [2, 6]. A change of the RI directly affects λ_B, according to equation (1).