TECHNISCHE UNIVERSITÄT
ILMENAU

50. Internationales
Wissenschaftliches Kolloquium

September, 19-23, 2005

Maschinenbau von Makro bis Nano / Mechanical Engineering from Macro to Nano

Proceedings

Fakultät für Maschinenbau /
Faculty of Mechanical Engineering

Startseite / Index:
http://www.db-thueringen.de/servlets/DocumentServlet?id=15745

Impressum

Herausgeber:	Der Rektor der Technischen Universität Ilmenau Univ.-Prof. Dr. rer. nat. habil. Peter Scharff
Redaktion:	Referat Marketing und Studentische Angelegenheiten Andrea Schneider Fakultät für Maschinenbau Univ.-Prof. Dr.-Ing. habil. Peter Kurtz, Univ.-Prof. Dipl.-Ing. Dr. med. (habil.) Hartmut Witte, Univ.-Prof. Dr.-Ing. habil. Gerhard Linß, Dr.-Ing. Beate Schlütter, Dipl.-Biol. Danja Voges, Dipl.-Ing. Jörg Mämpel, Dipl.-Ing. Susanne Töpfer, Dipl.-Ing. Silke Stauche
Redaktionsschluss: (CD-Rom-Ausgabe)	31. August 2005
Technische Realisierung: (CD-Rom-Ausgabe)	Institut für Medientechnik an der TU Ilmenau Dipl.-Ing. Christian Weigel Dipl.-Ing. Helge Drumm Dipl.-Ing. Marco Albrecht
Technische Realisierung: (Online-Ausgabe)	Universitätsbibliothek Ilmenau ilmedia Postfach 10 05 65 98684 Ilmenau
Verlag:	isle Verlag ISLE, Betriebsstätte des ISLE e.V. Werner-von-Siemens-Str. 16 98693 Ilmenau

ISBN (Druckausgabe):	3-932633-98-9	(978-3-932633-98-0)
ISBN (CD-Rom-Ausgabe):	3-932633-99-7	(978-3-932633-99-7)

Startseite / Index:
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Technische Universität Ilmenau
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Hot embossing of optical waveguides

ABSTRACT

A simple and cost-effective way of manufacturing photonic components, such as optical waveguides, is described. Using standard MEMS technology, nickel tools can be manufactured and replicated in polymers by hot embossing. In combination with UV modification of the polymer, this process is suitable for cost-effective manufacturing of optical components.

HOT EMBOSSING OF OPTICAL COMPONENTS

In recent years, hot embossing of microcomponents has become a routinely used replication technology for thermoplastic polymers. The principal process steps can be described as follows [1]: A polymer film is inserted into the moulding machine, a micro-structured tool (mould insert) in an evacuated chamber is pressed with high force into the film that has been heated above its softening temperature, and the mould insert is filled by the plastic material which replicates the microstructures in detail. Then, the setup is cooled and the mould insert is withdrawn from the plastic. Low flow rates and slow moulding speeds ensure that even the smallest details in the nanometer range are replicated perfectly. Hot embossing is particularly suited for structuring plane plates and foils, as only a small amount of plastic has to be moulded. In contrast to injection moulding, the polymer flows a very short way from the foil into the microstructure during hot embossing. As a result, very little stress is induced into the polymer and the moulded parts are well suited as optical components, such as waveguides and lenses. Another advantage is the simple setup of the machine, which results in very short setup times due to the easy exchangeability of the mould insert or polymer material.

POLYMERS FOR TELECOMMUNICATION APPLICATIONS

An evolving market for polymer components is telecommunication, where the expansion of high-capacity optical transmission techniques into price-sensitive areas requires a major reduction of costs of optical components [2, 3]. Waveguides, beam splitters, and couplers have to be fabricated using a mass production technology, such as polymer replication, to make technologies like fibre-to-the-home available at acceptable costs. To meet the market requirements, materials as well as replication technologies have to be modified and enhanced.

FABRICATION METHOD

As waveguides and similar structures only require small structure heights to manufacture mono-mode components, we spin-coated a 15 µm layer of SU8 resist onto a silicon substrate with a metal starting layer and patterned it using standard UV lithography. From this template, the replication tool was electroplated with nickel. Final thickness of the tools is in the range of 300 µm, which is much thinner than that of tools made by micromechanical processes or X-ray LIGA [4]. The final components were replicated in poly(methylmetacrylate) by hot embossing. The polymer was then modified by a deep UV light flood exposure in order to increase its refractive index at the surface. First tests indicate that the height of 15 µm is sufficient to decouple the rip waveguide mode from the substrate mode. Radii smaller than 300 µm can be achieved when using this process.

Use of such comparatively thin replication tools (stampers) for hot embossing allows for a rapid manufacturing of polymer components. In case direct lithography is applied for patterning, a new design can be manufactured within several days. Furthermore, this technology is not only suited for research and development, but also for production. New stampers can be made easily from a master by electroplating, a process which is well established in the production of optical discs [5]. As the replication parameters are essentially the same, no major changes are necessary to adapt the process to higher quantities.

References:

[1] M. Heckele, W. Bacher, and K.D. Müller: *Hot embossing – the molding technique for plastic microstructures.* Microsyst. Technol. Vol 4, 122-4 (1998)

[2] L. Eldada and L.W. Shacklette: *Advances in polymer integrated optics.* IEEE J. Sel. Topics Quantum Electron. Vol 6, no 1, pp 54 – 68 (2000)

[3] Rabus, D. G., Henzi, P., Mohr, J.: *Photonic Integrated Circuits by DUV-induced Modification of Polymers*. IEEE Photon. Technol. Lett. 3, 591-593 (2005)

[4] Henzi, P., Rabus, D. G., Wallrabe, U., Mohr, J.: *Low Cost Singlemode Waveguide Fabrication Allowing Passive Fibre Coupling using LIGA and UV flood exposure.* Proceed. SPIE Photonics Europe, 26–30 April 2004, Strasbourg, France, 64-74 (2004)

[5] M.T. Gale: *Replication*, in *Micro-Optics: Elements, Systems and Applications*, H.P. Herzig, Ed., Taylor and Francis, London (1997)

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