Efficient Coupling Interfaces in Photonic Systems Enabled by Printed Freeform Micro-Optics

C. Koos[1,2,3], W. Freude[1,2], S. Randel[2], P.-I. Dietrich[1,2,3], M. Blaicher[1,2], Y. Xu[1,2], M. R. Billah[1,2], T. Hoose[1,2], M. Trappen[1,2], and A. Hofmann[4]

[1] *Institute of Photonics and Quantum Electronics (IPQ), Karlsruhe Institute of Technology (KIT), 76131 Karlsruhe, Germany*

[2] *Institute of Microstructure Technology (IMT), Karlsruhe Inst. of Technology (KIT), 76344 Eggenstein-Leopoldshafen, Germany*

[3] *Vanguard Photonics GmbH, 76344 Eggenstein-Leopoldshafen, Germany*

[4] *Institute for Automation and Applied Informatics (IAI), Karlsruhe Institute of Technology (KIT), 76344 Eggenstein-Leopoldshafen, Germany*

E-mail: christian.koos@kit.edu

ABSTRACT

In this presentation, we give an overview of our recent progress in exploiting direct-write two-photon lithography for additive 3D fabrication of freeform micro-optical elements. These elements can be printed with highest precision in direct contact with the facets of photonic integrated circuits or optical fibers, thereby greatly simplifying alignment and improving coupling efficiency. The approach offers new perspectives for a wide variety of applications, ranging from advanced photonic multi-chip modules for high-speed communications and optical sensing to highly efficient astro-photonic systems. We are currently working on transferring the concept from laboratory demonstrations to industrial manufacturing.

Keywords: photonic integrated circuits, silicon photonics, hybrid integration, photonic wire bonding, micro-optics, two-photon lithography, astro-photonics.

SUMMARY

Photonic integrated systems are key to a wide variety of applications, ranging from optical communications and high-speed signal processing to metrology and sensing and further to chemical analysis and life sciences. Over the last years, tremendous progress has been made in large-scale on-chip integration of optical devices, and several platforms have reached industrial maturity. However, off-chip connections still represent a major challenge that affect not only chip-to-chip and fiber-to-chip interfaces, but also the integration of optical chips into free-space micro-optical systems.

In this talk, we will give an overview of our recent progress towards harnessing additive fabrication on the nanoscale to overcome these challenges. We have previously demonstrated that direct-write two-photon lithography is perfectly suited for connecting photonic integrated circuits (PIC) by three-dimensional (3D) free-form single-mode waveguides, so-called photonic wire bonds [1] - [4]. This approach may build the base of advanced optical communication engines that combine silicon photonic modulators with InP-based laser-sources in highly integrated optical multi-chip modules (MCM) [4]. More recently, we have expanded the concept of in-situ printing of optical elements, exploiting two-photon laser lithography for highly precise fabrication of lenses in direct contacts with the facets of photonic chips [7] [8] and optical fibers [9]. This approach does not only allow for low-loss coupling of PIC to free-space beams in a wide variety of optical assemblies, but also opens new opportunities in other areas such as astrophotonics, where efficient coupling between free-space beams and optical fibers is essential [9].

ACKNOWLEDGEMENTS

This work was supported by the BMBF joint projects PRIMA (grant 13N14630) and PHOIBOS (grant 13N12574), by the European Research Council (ERC Consolidator Grant 'TeraSHAPE', # 773248), by the Deutsche Forschungsgemeinschaft in the framework of the collaborative research center "WavePhenomena" (CRC 1173), by the H2020 Photonic Packaging Pilot Line PIXAPP (# 731954), by the Alfried Krupp von Bohlen und Halbach Foundation, by the Karlsruhe Nano-Micro Facility (KNMF), and by the Helmholtz International Research School for Teratronics (HIRST).

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