Title:
Integrated optics for optical coherence tomography and surface topography characterization

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Abstract:
Photonic integration allows to miniaturize systems for optical coherence tomography (OCT) and for optical surface topography characterization (STC). The small size and the low cost of photonic integrated circuits (PIC) widens the application area in medical diagnostics and in industrial process control significantly. Medical applications include ophthalmology, dermatology and endoscopy. Industrial applications are focused on non-contact STC, robotics, machinery assembly, and on measuring material properties.

We report on two OCT systems fully integrated on a silicon-on-insulator (SOI) chip. Objects in distances of a few millimeter from the chip edge are imaged with a depth resolution of 11 µm and a dynamic range of 53dB. When using a remote fibre-connected OCT measurement head, the depth resolution is 30 µm, and the dynamic range increases to 60dB. Optimizations in design and technology are expected to improve these results significantly.

For an STC system, we use synthetic wavelength interferometry employing two spectrally flat optical frequency combs, which are generated by 40 GHz modulators. Distance measurement errors are less than 10 µm over a dynamic range of up to 37dB. We further designed a miniaturized distance sensor PIC comprising couplers, tunable power splitter and photodetectors on an SOI chip. With acquisition times of only 14 and target distances up to 4.5mm, the measurement error stays below 5 µm. A co-integration of the comb generators is also possible.

Wolfgang Freude received the Dipl.-Ing. (M.S.E.E.) and the Dr.-Ing. (Ph.D.E.E.) degrees in Electrical Engineering in 1969 and 1975 from the University of Karlsruhe. He is Professor at the Institute of Photonics and Quantum Electronics, a Member of the Network of Excellent Retired Scientists, and a Distinguished Senior Fellow at Karlsruhe Institute of Technology (KIT). His research activities are in the area of optical and wireless high-data rate transmission, high-density integrated-optics with a focus on silicon photonics, photonic crystals and semiconductor optical amplifiers, and in the field of low-energy opto-electronic devices and protocols for optical access networks.

He has authored and co-authored more than 270 papers, co-authored a book entitled “Optical Communications” (Berlin, Springer-Verlag 1991, in German), and authored or co-authored the following five book chapters: “Multimode Fibres” (Handbook of Optical Communications, Berlin, Springer-Verlag 2002, in German), “Microwave Modelling of Photonic Crystals” (Photonic Crystals – Advances in Design, Fabrication, and Characterization, Berlin, Wiley-VCH 2004), “Linear Semiconductor Optical Amplifiers” (Fibre Optic Communication – Key Devices, Berlin, Springer-Verlag 2012), “Last-Mile Technologies: New WDM Access Proposals, Devices and Experiments” (Lasers and Electro-Optics Research and Technology, Nova Science Publishers 2013), and “Optical OFDM and Nyquist Multiplexing” (Optical Fiber Telecommunications VI B. Systems and Networks, Amsterdam, Elsevier 2013).

Prof. Freude is an Honorary Doctor of the Kharkov National University of Radioelectronics, Kharkov, Ukraine, and a member of VDE/ITG, IEEE, and OSA. Among others, he serves in the Technical Programme Committee “Photonic Networks and Devices” (OSA Advanced Photonics Congress, since 2013), and was Member and Chair of the Subcommittee “Micro- and Nano-Photonic Devices” for CLEO 2011–2013. Until 2010 he was Vice Chair of the IEEE Germany Photonics Society Chapter.