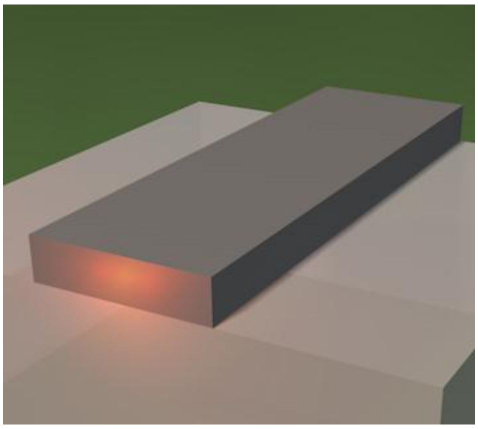
Ghent University, imec and collaborators extend the spectrum of frequency comb light sources towards the mid-infrared using silicon photonics technology

Mid-IR frequency combs enable high resolution spectroscopy for sensitive and accurate gas sensing

Ghent and Leuven (Belgium) – 10/03/2015 – Publishing in Nature Communications [1], scientists from Ghent University and imec have joined forces with the Max Planck Institute in Garching to realize a frequency comb light source in the mid-IR wavelength band. These frequency comb light sources with an extended spectrum can be used for real-time, extremely high resolution spectroscopy, e.g. to measure the presence and concentration of gas molecules in analytes.

A frequency comb source is a light source with a spectrum containing thousands of laser lines. The development of these sources has been revolutionary for fundamental science. It has allowed the construction of a link between the optical part of the electromagnetic spectrum and the radio frequency part. As such, it has allowed researchers to determine optical frequencies with an unprecedented precision. Amongst others, frequency comb light sources have been used in optical clocks enabling precise time keeping. The enormous impact of frequency comb light sources on science was highlighted in 2005, when the Nobel Prize for physics was awarded to Prof. T. Haensch and Prof J. Hall for their work on optical frequency metrology using frequency combs.

Lately, frequency combs have been used to target more real life applications. In several experiments, it has been shown that the specific properties of the sources can be used to do fast, high-resolution spectroscopy over a broad spectrum. However, traditional comb sources are not at the right wavelength spectrum for doing spectroscopy.



The strong confinement in the silicon photonic nanowire waveguide enhances the light matter interaction. The strong interactions allow to extend a frequency comb towards the mid-infrared

Ghent University, imec, the Max Planck Institute for Quantum Optics in Garching and the Auckland University in New Zealand have developed mid-infrared frequency combs, working in the mid-infrared molecular fingerprinting region of the electromagnetic spectrum. In this wavelength region, many molecules have specific absorption bands that can be used in spectroscopy to determine the presence and concentration of these molecules in samples. The researchers successfully realized the broad frequency combs, by combining the strong light-matter interaction in silicon with its broad transparency window. By fabricating so-called nanowire silicon photonics waveguides to confine the light in a very small area waveguide, they further enhanced the strong light-matter interaction allowing them to broaden the spectrum of the frequency combs into the mid-infrared. The achievements were possible through the use of a unique pump laser source, previously developed by ICFO, Spain. The results are an important step towards a small-footprint chip scale mid-infrared frequency comb source. Such sources could act as sensitive cheap gas sensors in the mid-infrared. These would be important for example for environmental monitoring for measuring air-pollution or in medical diagnostics as a cheap tool to do breath analysis. It is worth noting that the reported work has been the result of collaboration between three grants of the European Research Council (ERC), i.e. Multicomb, Miracle and InSpectra.

[1] B. Kuyken, T. Ideguchi, S. Holzner, M. Yan, T. W. Hansch, J. Van Campenhout, P. Verheyen, S. Coen, F. Leo, R. Baets, G. Roelkens, N. Picque, An octave spanning mid-infrared frequency comb generated in a silicon nanophotonic wire waveguide, Nature Communications, 6(6310), (2015). http://www.nature.com/ncomms/2015/150220/ncomms7310/full/ncomms7310.html

This press release can be downloaded at http://www2.imec.be/be_en/press/imec-news/imec-UGent-silicon-photonics-nature-communications.html

About the Photonics Research Group

The Photonics Research Group in the Department of Information Technology of Ghent University is active in the field of photonic integration - more specifically silicon photonics - and its applications in information and communication technology, in sensing and in life sciences.

The group puts its *research focus* on new concepts for photonic integrated devices and circuits and on the associated technologies and design methodologies. This includes passive and active waveguide-based photonic components, based on CMOS-compatible materials and processes as well as hybrid approaches combining silicon with other functional materials. The activities center around the telecom wavelength of 1.55 micrometer but are expanding both to longer wavelengths (mid-IR) and shorter wavelengths (visible). The infrastructure of the group includes cleanroom facilities for in-house fabrication of components as well as a variety of CAD-tools and measurement labs. The group is associated with the nano-electronics research center imec in Leuven and uses the CMOS-oriented research facilities of imec for research on silicon photonics.

About Ghent University

Ghent University (UGent) consists of 117 departments across 11 faculties and offers high-quality research-based educational programs in virtually every scientific discipline. UGent distinguishes itself as a socially committed and pluralistic university in a broad international perspective. The motto of the university is ‘Dare to Think’. The university’s appeal is growing every year, with about 41,000 students in 2014, of whom 11% (students) and 35% (PhD students) are international. Numerous research groups, centres and institutes have been founded over the years, becoming world-renowned in disciplines such as biotechnology, aquaculture and photonics.

Ghent University is the only Belgian university in the top 100 of both the Shanghai (70) and Times ranking (85). The University has participated in more than 200 research projects in the EU’s Sixth Framework Programme (2002-2006) and in 260 projects in the Seventh Framework Programme, of which 26 ERC grants and 26 Marie Curie Fellowships. Ghent University coordinated 42 collaborative projects in FP7. The university provides excellent training opportunities to both young and experienced researchers, and is one of the fastest growing European universities in terms of research capacity and productivity.

About imec

Imec performs world-leading research in nanoelectronics. Imec leverages its scientific knowledge with the innovative power of its global partnerships in ICT, healthcare and energy. Imec delivers industry-relevant technology solutions. In a unique high-tech environment, its international top talent is committed to providing the building blocks for a better life in a sustainable society. Imec is headquartered in Leuven, Belgium, and has offices in the Netherlands, Taiwan, US, China, India and Japan. Its staff of over 2,080 people includes more than 670 industrial residents and guest researchers. In 2013, imec's revenue (P&L) totaled 332 million euro. Further information on imec can be found at www.imec.be.

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About Max Planck Institute and the Max Planck Institute for Quantum Optics

The Max Planck Society is Germany's most successful research organization. Since its establishment in 1948, no fewer than 18 Nobel laureates have emerged from the ranks of its scientists, putting it on a par with the best and most prestigious research institutions worldwide. The more than 15,000 publications each year in internationally renowned scientific journals are proof of the outstanding research work conducted at Max Planck Institutes – and many of those articles are among the most-cited publications in the relevant field.

The currently 82 Max Planck Institutes conduct basic research in the service of the general public in the natural sciences, life sciences, social sciences, and the humanities. Max Planck Institutes focus on research fields that are particularly innovative, or that are especially demanding in terms of funding or time requirements.

Research at the Max Planck Institute of Quantum Optics concentrates on the interaction of light and matter under extreme conditions. One focus is the high-precision spectroscopy of hydrogen. In the course of these measurements Prof. Theodor W. Hänsch developed the frequency comb technique for which he was awarded the Nobel Prize for Physics in 2005. Other experiments aim at capturing single atoms and photons and letting them interact in a controlled way, thus paving the way towards future quantum computers. Theorists on the other hand are working on strategies to communicate quantum information in a most efficient way. They develop algorithms that allow the safe encryption of secret information. MPQ scientists also investigate the bizarre properties quantum-mechanical many-body systems can take on at extremely low temperatures (about one millionth Kelvin above zero). Finally light flashes with the incredibly short duration of several attoseconds (1 as is a billionth of a billionth of a second) are generated which make it possible, for example, to observe quantum-mechanical processes in atoms such as the 'tunnelling' of electrons or atomic transitions in real time.