Chip-scale tunable laser to enable bandwidth-on-demand in advanced optical networks

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Researchers from A*STAR's Institute of Microelectronics (IME) and Nanyang Technological University (NTU) have demonstrated the smallest wavelength-tunable laser fabricated by microelectromechanical system (MEMS) technology. The laser features a wide tuning range which enables telecommunications providers to cost-effectively expand system capacity in advanced optical networks to support high data packets at ultra fast speed. By having one laser, instead of several, that can generate light over a range of wavelengths, the network infrastructure is greatly simplified, and inventory and operational costs are dramatically reduced, thus strengthening the capability of telecommunications providers to deliver bandwidth-on-demand services at higher profit margins.

To keep up with increasing consumer demands for faster internet connectivity and greater network coverage, service providers need to revamp their network architectures. In fibre-optic communications, advanced wavelength division multiplexing (WDM) networks typically rely on single wavelength laser sources, making them expensive, time-intensive, energy-inefficient and logistically impractical for service providers to increase their system capacity.

On the other hand, commercial tunable lasers require multiple components in their set-up in order to achieve the necessary wide tuning range, thereby contributing to the bulkiness of these lasers and rendering them unsuitable for system integration.

To tackle these challenges, the joint team from IME and NTU has demonstrated an on-chip integrated laser, the smallest reported tunable laser fabricated by MEMS technology that can generate light from 1531.2 nm to 1579.5 nm of the near-infrared region, relevant to optical telecommunications. Compared to MEMS tunable laser based on external cavity design, the new laser significantly improves the coupling efficiency of 50% to more than 75% to offer wide tuning range using processing steps that are more streamlined and amenable to mass production.

Presented at the prestigious 2013 International Electron Devices Meeting (IEDM) in the USA, the design uses simple packaging and provides ease of fabrication for mass production. This miniature on-chip system can also be readily integrated into high-density photonic circuits to achieve smaller form-factor. These distinct functionalities and highlights make the laser an attractive light source for next generation optical telecommunications, as well as in other spectroscopy applications.

Dr Cai Hong, the IME scientist who is leading the research project, commented, "Our laser exploits the superior light converging ability of the rod lens and parabolic mirror of the 3D micro-coupling system to achieve both wide wavelength tuning range and small form factor. In external cavity tunable lasers, wide tuning range is traditionally at the expense of small form factor."

Professor Liu Ai Qun, from the School of Electrical and Electronic Engineering, NTU, said: "This new chip is very attractive to communications and biomedical device companies because of its small size and low cost. Our prototype, a 1 cm by 1 cm microchip, is the smallest tunable laser which can be easily manufactured as it is ten times smaller than most commercially available tunable laser devices. The key innovation was that our tunable laser is integrated onto a microchip using MEMs technology, made possible only through NTU's strong expertise

in MEMs, backed by a decade of solid research into single-chip solutions."

"This breakthrough signifies the successful partnership enjoyed by IME and NTU, leveraging on each other's strengths which led to the successful design, fabrication, packaging and characterisation of this new chip which is expected to impact industries which require tunable laser technology such as in optical fiber communications," added Prof. Liu, who is also Programme Director at VALENS, an NTU research centre which focuses on bio-instrumentation, devices and signal processing, and has collaborations with many international industry partners.

Professor Dim-Lee Kwong, Executive Director of IME, said, "The tunable laser is a timely solution to address a key technological hurdle that is holding back the outreach of affordable, dynamic and versatile optical network services to consumers. We expect this breakthrough to augment IME's capabilities in silicon photonics to enable product developers and relevant industries to get a head start in the optical networking space."

More information: Hong Cai et al., "Demonstration of a Single-Chip Integrated MEMS Tunable Laser with 48-nm Wavelength Range", International Electron Devices meeting 2013, December 9 – 11, 2013, Washington D.C., USA.

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