Amplifier with 10-fold bandwidth opens up for super lasers

April 9 2025

The amplifier developed by Chalmers researchers is compact, measuring just a few centimeters, yet it can process 10 times larger amounts of data per second than current optical communication systems. Credit: Chalmers University of Technology | Vijay Shekhawat

Rapidly increasing data traffic is placing ever greater demands on the capacity of communication systems. In an article titled "Ultra-broadband optical amplification using nonlinear integrated waveguides" published in *Nature*, a research team from Chalmers University of Technology, in Sweden, introduce a new amplifier that enables the transmission of 10 times more data per second than those of current fiber-optic systems.

This amplifier, which fits on a small chip, holds significant potential for various critical laser systems, including those used in medical diagnostics and treatment.

The advancement of AI technology, the growing popularity of streaming services, and the proliferation of new smart devices are among the factors driving the expected doubling of data traffic by 2030. This surge is heightening the demand for communication systems capable of managing vast amounts of information.

Currently, optical communication systems are employed for the internet, telecommunications, and other data-intensive services. These systems utilize light to transmit information over long distances. The data is conveyed through laser pulses that travel at high speeds through optical fibers, which are composed of thin strands of glass.

To ensure that information maintains a high quality and isn't overwhelmed by noise, optical amplifiers are essential. The data transmission capacity of an optical communication system is largely determined by the amplifier's bandwidth, which refers to the range of light wavelengths it can handle.

"The amplifiers currently used in optical communication systems have a bandwidth of approximately 30 nanometers. Our amplifier, however, boasts a bandwidth of 300 nanometers, enabling it to transmit 10 times more data per second than those of existing systems," explains Peter Andrekson, Professor of Photonics at Chalmers and lead author of the study.

Small, sensitive and powerful

The new amplifier, made of silicon nitride, features several small, spiral-shaped, interconnected waveguides that efficiently direct light with minimal loss. By combining this material with an optimized geometric design, several technical advantages have been achieved.

"The key innovation of this amplifier is its ability to increase bandwidth 10-fold while reducing noise more effectively than any other type of amplifier. This capability allows it to amplify very weak signals, such as those used in space communication," says Andrekson.

Additionally, the researchers have successfully miniaturized the system to fit on a chip just a few centimeters in size.

"While building amplifiers on small chips is not a new concept, this is the first instance of achieving such a large bandwidth," adds Andrekson.

Contributes to earlier detection of diseases

The researchers have integrated multiple amplifiers onto the chip, allowing the concept to be easily scaled up as needed. Since optical amplifiers are crucial components in all lasers, the Chalmers researchers' design can be used to develop laser systems capable of rapidly changing wavelengths over a wide range. This innovation opens up numerous applications in society.

"Minor adjustments to the design would enable the amplification of visible and infrared light as well. This means the amplifier could be utilized in laser systems for medical diagnostics, analysis, and treatment. A large bandwidth allows for more precise analyses and imaging of tissues and organs, facilitating earlier detection of diseases," says

Andrekson.

In addition to its broad application potential, the amplifier can also help make laser systems smaller and more affordable.

"This amplifier offers a scalable solution for lasers, enabling them to operate at various wavelengths while being more cost-effective, compact, and energy efficient. Consequently, a single laser system based on this amplifier could be utilized across multiple fields. Beyond medical research, diagnostics, and treatment, it could also be applied in imaging, holography, spectroscopy, microscopy, and material and component characterization at entirely different wavelengths," explains Andrekson.

Further insights into the amplifier's potential

Light at different wavelengths serves various applications. The researchers have demonstrated that the amplifier functions effectively within the optical communication spectrum, ranging from 1,400 to 1,700 nanometers. With its extensive bandwidth of 300 nanometers, the amplifier can potentially be adapted for use at other wavelengths.

By modifying the waveguide design, it is possible to amplify signals in other ranges, such as visible light (400–700 nanometers) and infrared light (2,000–4,000 nanometers). Consequently, in the long term, the amplifier could be utilized in fields where visible or infrared light is essential, such as disease diagnosis, treatments, visualization of internal organs and tissues, and surgical operations.

More information: Peter Andrekson, Ultra-broadband optical amplification using nonlinear integrated waveguides, *Nature* (2025). DOI: 10.1038/s41586-025-08824-3. www.nature.com/articles/s41586-025-08824-3

Provided by Chalmers University of Technology

Citation: Amplifier with 10-fold bandwidth opens up for super lasers (2025, April 9) retrieved 4 October 2025 from https://phys.org/news/2025-04-amplifier-bandwidth-super-lasers.html

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.