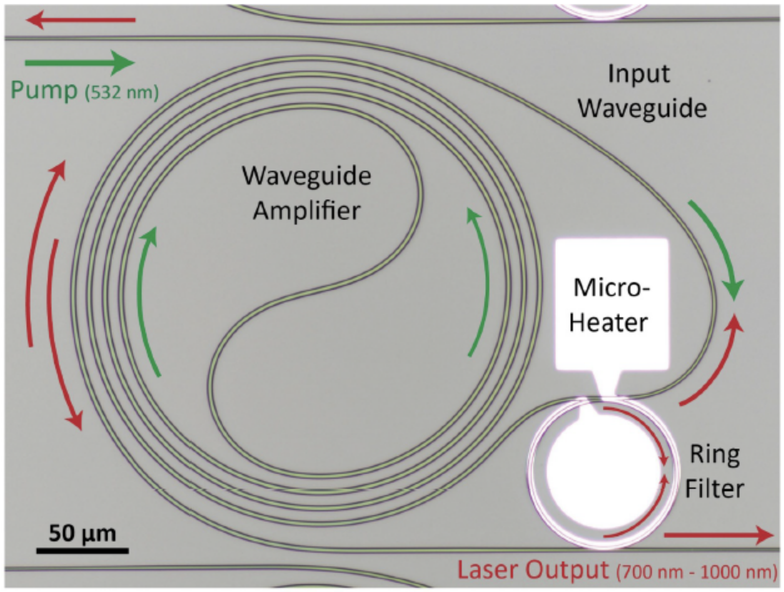
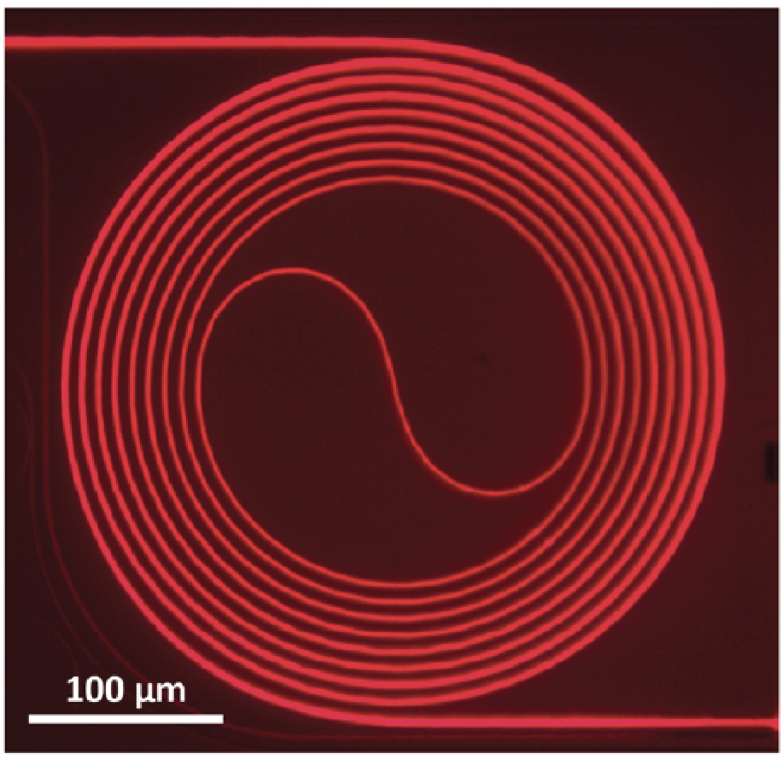
Docket #: S23-369

Diode-pumped photonic integrated titanium-sapphire waveguide amplifier

Stanford researchers have developed ultra-wideband amplification of near infrared signals for the first time on a photonic integrated circuit. Previously, optical amplification on photonic integrated circuits has been limited to wavelengths longer than 1000 nm, which has restricted use in biological applications. Furthermore, tabletop titanium-sapphire are large, cost, and require high optical pump powers. The Stanford developed diode-pumped photonic integrated titanium-sapphire waveguide amplifier incorporates the critical near-infrared window for biological tissue, which is pivotal for medical imaging and diagnostic equipment, as well as provides an on-chip solution for applications such as quantum technology, LiDAR and beyond.

The device consists of a nanophotonic crystalline thin-film titanium-sapphire optical waveguide co-integrated with a semiconductor diode-laser used to pump the titanium-sapphire waveguide. The nanophotonic titanium sapphire waveguide amplifies optical signals with wavelength ranging from 700 nm to 1000 nm. The titanium-sapphire waveguides do not absorb when the material is not pumped, and passive propagation losses are smaller than 0.45 dB/cm. These titanium-sapphire waveguides outperform currently available optical gain waveguides, and meets the needs of a wide range of applications in photonic integrated circuits





Ti:Sapphire waveguide amplifier as stand-a-lone chip optical amplifier (Top) and
Ti:Sapphire waveguide amplifier prototype (Bottom)
(Image courtesy the Nanoscale and Quantum Photonics Lab)

Stage of Development – Proof of Concept Prototype

Applications

- On chip, high performance, ultra-wideband lasers and amplifiers for:
    - Quantum computing, simulations, sensing, and networks
    - Data communications
    - Positioning, navigation, and timing (PNT) systems
    - LiDAR
    - Augmented and virtual reality
    - Biomedical applications, such as optical coherence tomography (OCT), medical devices, proton therapy, microscopy, spectroscopy, imaging, surgery, etc.

Advantages

- **Compact, photonic integrated circuit**
- **First time, ultra-wideband** amplification of near infrared signals on a photonic integrated circuit
- **Lower cost** than existing table-top systems

Publications

- Myers, A. (2024, June 26). Chip-scale titanium-sapphire laser puts powerful technology in reach. *Stanford News*. https://news.stanford.edu/stories/2024/06/a-chip-scale-titanium-sapphire-laser
- Yang, J., Van Gasse, K., Lukin, D. M., Guidry, M. A., Ahn, G. H., White, A. D., & Vu?kovi?, J. (2024). Titanium: sapphire-on-insulator integrated lasers and amplifiers. *Nature, 630*(8018), 853-859.

Patents

- Published Application: WO2025085856

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