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Towards practical photonic integrated optical parametric amplifiers

Optical amplification is a key component in modern laser technology, including long-range fiber communication systems and data center interconnects. Metrology, imaging, and sensing systems – all require low-noise amplification of weak signals across different optical frequencies. For years, semiconductor optical amplifiers and rare-earth-doped fiber amplifiers, especially EDFAs, have been the workhorses of laser systems all over the globe. These days, with extreme data transmission rates, it becomes necessary to search for new types of optical amplifiers – more compact, with better noise properties, and, most importantly, capable of amplifying optical signals across a wide wavelength range. Among other solutions, photonic integrated optical parametric amplifiers (OPAs) seem to be a promising option [1-7]. Over the past few years, we have developed OPAs in photonic integrated circuits and demonstrated their potential for practical use in next-generation optical systems. From the first demonstration of optical fiber-to-fiber gain in silicon nitride [1], OPAs advanced to 35 dB gain in gallium phosphide waveguides [2] and 850 nm of gain bandwidth in periodically poled lithium tantalate waveguides [3]. We have shown how these amplifiers can be used for frequency comb amplification or in communication systems.

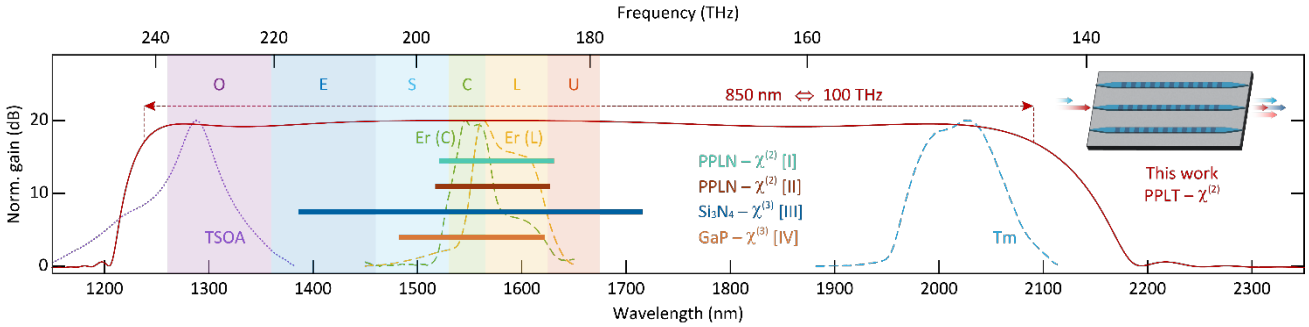

Figure 1: gain windows of various optical amplifiers. The amplification bandwidth of the recently developed cascaded optical parametric amplifier based on a periodically poled thin-film lithium tantalate waveguide is shown in red and covers more than 850 nm, or nearly 100 THz. Colored bars indicate bandwidths of recently demonstrated state-of-the-art photonic integrated OPAs (I – Ref. [6], II – Ref. [7], III – Ref. [5], IV – Ref. [2]).

References

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