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Erbium-doped Si_3N_4 Photonic Integrated Circuits

Erbium ions are the gain medium of choices for fiber amplifiers that have revolutionized long-haul optical communications and laser technology [1]. Erbium ions could equally provide a basis for efficient optical amplification in photonic integrated circuits [2] but has remained impractical due to insufficient output power. We overcame this challenge and demonstrated a photonic integrated circuit-based erbium amplifier reaching 145 mW output power and more than 30 dB small-signal gain - on par with commercial fiber amplifiers and beyond state-of-the-art III-V heterogeneously integrated semiconductor amplifiers. Specially, we applied ion implantation [3] to ultralow-loss Si_3N_4 photonic integrated circuits [4], which show promising application potential in low-noise laser amplification, broadband soliton microcomb amplification by 100-fold for low-noise photonic microwave generation, and wavelength-division multiplexed coherent optical communications [5]. More recently, this new class of Er-doped Si_3N_4 photonic integrated circuits enable the miniaturization of tunable CW lasers on a chip approaching fiber-laser coherence, which achieved a minimum intrinsic linewidth of 50 Hz and > 40 nm wavelength tuning range [6].

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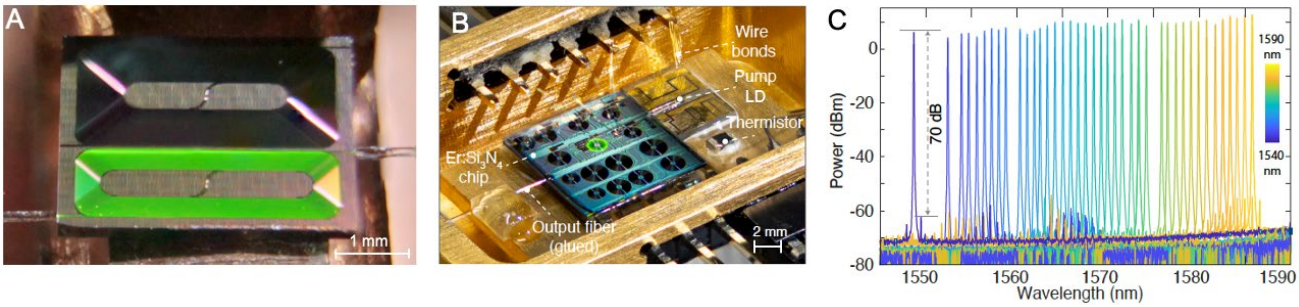

Figure 1: Er-doped silicon nitride photonic integrated circuit-based devices. (A) An Er-doped waveguide amplifier. (B) An Er-doped waveguide laser. (C) Optical spectra of the laser output with wavelength tunability.