Photonic Integrated Technologies for Low-SWaP, Narrow- Linewidth, and Tunable Laser Systems

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Primary CNF Tools Used: AJA Sputter, DISCO Dicing Saw, Hamatech Hot Piranha, Heidelberg DWL2000, JEOL JBX-9500FS E-beam Lithography System, KLA P7 Profilometer, MOS Clean Bench & Tanks, MRL B3 LPCVD LTO, MRL B4 LPCVD Nitride, MRL E4 LPCVD CMOS Nitride, Oxford 100 ICP Dielectric, Oxford 80 RIE, PT Takachi HDP-CVD, Suss MA6|BA6 Aligner, Unaxis 770 Deep Silicon Etch, YES EcoClean Asher, YES Asher, Zeiss Ultra SEM, Woollam RC2 Spectroscopic Ellipsometer, Keyence VHX- 7100 Digital Microscope

Abstract:

As quantum technologies transition from laboratories to the world, their successful deployment critically relies on the size, weight, and power (SWaP) of the laser sources fueling them. Due to the stringent optical requirements of most of these systems, they still predominantly use bulky lasers made of free-space components. With the emergence of high-performance, chip-scale lasers based on photonic integrated circuits (PICs) [1], practical quantum systems that are compact and scalable are now within reach. However, to successfully realize a PIC-based laser module that meets both optical and functional requirements, a system-level approach for co-designing the optical source (gain medium and PIC), the driver electronics, and the control software needs to be adopted.

Summary of Research:

Our research comprises the design, fabrication, characterization, and packaging of PIC-based laser systems. The PIC components include the laser external cavity and any other desired light processing units to manipulate and deliver the light.

Conclusions and Future Steps:

We have successfully demonstrated a complete and compact PIC-based laser system around 780 nm wavelength targeting quantum applications. Our work was featured in the conference publications listed in References [2- 4]. Future steps include improving the current system, expanding to other wavelengths, and adding more optical components for light manipulation and delivery.

References:

[1] M. Corato-Zanarella, A. Gil-Molina, X. Ji, M. Chul Shin, A. Mohanty, M. Lipson, "Widely tunable and narrow-linewidth chip-scale lasers from near-ultraviolet to near-infrared wavelengths," Nat. Photon. 17, 157–164 (2023).

[2] M. Corato-Zanarella, M. Lommel, D. Mayzlin, J. Nojic, A. Eras, C. Nölleke, B. Globisch, C. Haimberger, "Low-SWaP, Narrow-Linewidth, and Tunable Laser System For The Next Generation Of Quantum Technologies", 2025 Conference on Lasers and Electro-Optics Europe & European Quantum Electronics Conference (CLEO/Europe-EQEC), Munich, Germany (2025).

[3] J. Nojic, A. Eras, L. Winkler, D. Mayzlin, M. Corato-Zanarella, M. Lommel, C. Nölleke , "Narrow-linewidth, Fully Integrated Chip-based Laser System in the Red Spectral Range", 2025 Conference on Lasers and Electro-Optics Europe & European Quantum Electronics Conference (CLEO/Europe-EQEC), Munich, Germany (2025).

[4] S. Dadras, M. Corato-Zanarella, A. Heiniger, C. Haimberger, "PIC-based tunable diode lasers for fieldable quantum applications", Proc. SPIE PC13563, Photonics for Quantum 2025, PC1356314 (18 July 2025); https://doi.org/10.1117/12.3065992.ff

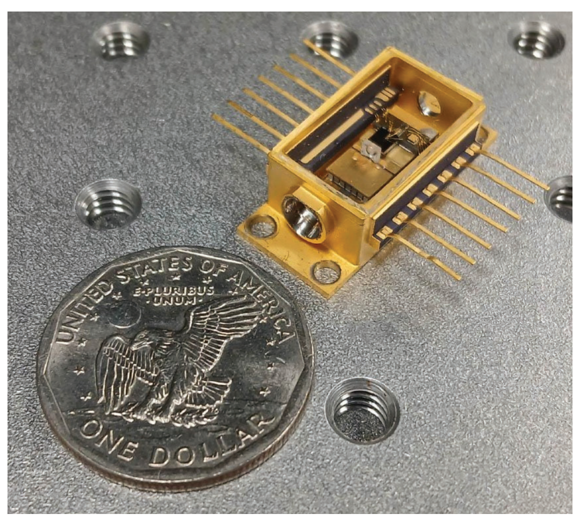

Figure 1: Low-SWaP, PIC-based laser.

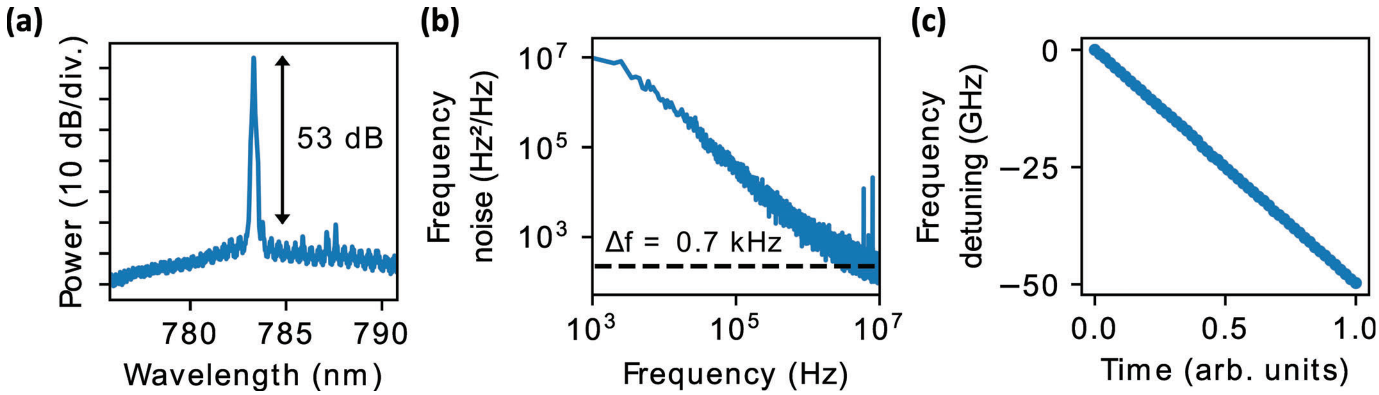

Figure 2: Example performance metrics of a PIC-based laser. (a) Side-mode suppression ratio. (b) Frequency noise. (c) Mode hop-free tuning range.