亮点报道：掺铒薄膜铌酸锂波导放大器实现＞10 dB 片下净增益

DOI: 10.12086/oee.2026.261004.h03

薄膜铌酸锂 (TFLN) 因其优异的电光和非线性特性，被视为光子集成芯片的理想平台。然而，由于 TFLN 波导端口与外接光纤或光纤透镜的折射率和模场失配较大，导致较高的端面耦合损耗使得目前已实现的掺铒薄膜铌酸锂波导放大器片下净增益 (从光纤到光纤) 很低甚至为负值，大大制约了其实际应用。

华东师范大学物理与电子科学学院程亚教授及其团队公开报道了一款基于薄膜铌酸锂平台的最高片下净增益掺铒波导放大器 (EDWA)。利用反锥形波导与氮氧化硅包层的结构，通过精确控制波导模式的绝热渐变，使光场能够平滑地从亚微米厚度的铌酸锂波导中演化到厚度 3 μm 的氮氧化硅波导中，进而实现薄膜铌酸锂波导端口与超高数值孔径光纤的高效模式匹配。该模斑转换器的耦合效率超过 75%，单端耦合损耗低至 −1.2 dB。将高耦合效率的模斑转换器与掺铒波导放大器单片集成，通过对 5.5 cm 长的掺铒铌酸锂波导双向泵浦，在 1532 nm 波长附近实现了>10 dB 的片下净增益，噪声系数低至 6.8 dB，在输出光纤中测量到的最高放大功率超过 20 mW。

本研究利用基于绝热模斑转换结构的波导端面耦合器，实现了波导放大器的片下高增益与高功率放大，为高密度光子集成系统提供了关键解决方案。

Highlights: Erbium-doped thin-film lithium niobate waveguide am-plifier achieves >10 dB on-chip net gain

DOI: 10.12086/oee.2026.261004.h03

Due to the significant refractive index and mode-field mismatch between TFLN waveguides and external optical fibers or fiber lenses, high facet coupling losses have resulted in low or even negative on-chip net gain (fiber-to-fiber) in previously reported erbium-doped TFLN waveguide amplifiers. This limitation has greatly hindered their practical applications.

Researchers employed a structure combining inverse-tapered waveguides with a silicon oxynitride (SiON) cladding. By precisely controlling the adiabatic tapering of the waveguide mode, the optical field is smoothly transformed from a submicron-thick LN waveguide into a 3-μm-thick SiON waveguide, thereby achieving efficient mode matching between the thin-film lithium niobate (TFLN) waveguide facet and ultra-high numerical aperture (UHNA) fibers. This mode-field converter achieves a coupling efficiency exceeding 75%, with a single-facet coupling loss as low as −1.2 dB. Compared to conventional end-face polished butt-coupling methods, the coupling efficiency is improved by more than sevenfold. This configuration achieved narrow-linewidth continuous-wave lasing with a maximum fiber-coupled output power of 2.1 mW.

This study employs an adiabatic mode-field converter-based waveguide facet coupler to achieve high net gain and high-power amplification in waveguide amplifiers, providing a critical solution for high-density photonic integrated systems.

Opto-Electronic Science, 2025, **4**(9): 250004.
https://www.oejournal.org/article/doi/10.29026/oes.2025.250004
英文报道摘自 https://www.eurekalert.org/news-releases/1091274