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Low Back-Reflection Optical Coupling Using 3D printed Facet-Attached Micro-Lenses (FaML)

Minimizing parasitic back-reflection is essential when optically coupling photonic chips or fibers. Reflections at interfaces—such as fiber-to-chip transitions or mismatched waveguides—can re-enter the system, introduce noise, destabilize lasers through optical feedback, and degrade overall signal quality. Even low reflection levels can significantly increase bit-error rates and reduce reliability in high-performance photonic systems. To mitigate these effects, we present a coupling strategy based on 3D-printed facet-attached microlenses (FaMLs). With careful design, these microlenses effectively suppress unwanted reflections while offering tunability, lateral alignment tolerance, and preservation of laser characteristics. Using this approach, we demonstrate — for the first time with an integrated external-cavity feedback circuit — a 1000-fold reduction in the intrinsic linewidth of comb tones from a quantum-dash mode-locked laser (QD-MLLD), a result not attainable with conventional coupling methods.

References

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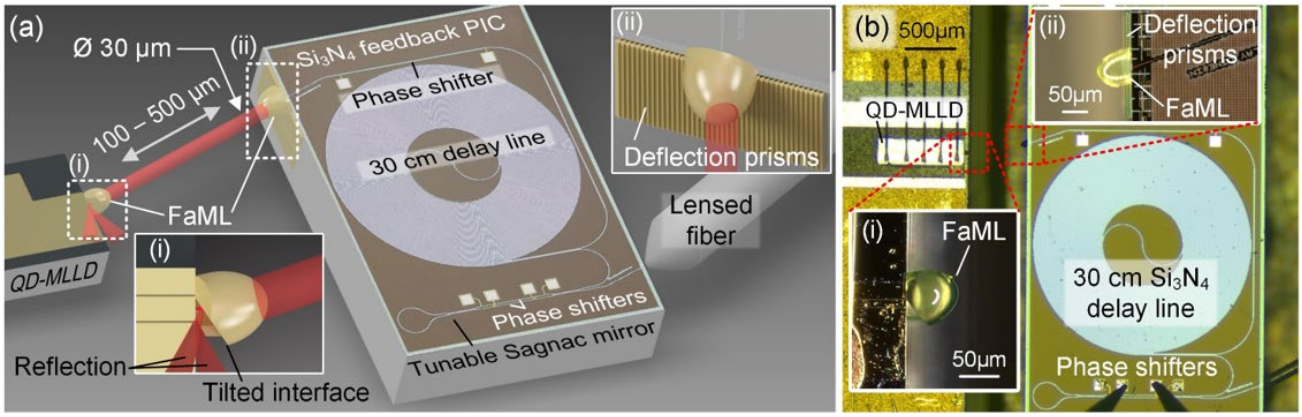

Figure 1: (a) Conceptual schematic of optical coupling between a quantum-dash mode-locked laser (QD-MLLD) and a Si3N4 feedback photonic integrated circuit (PIC), using a pair of strongly curved, asymmetrical facet-attached microlenses (FaMLs, shown in green) designed to minimize parasitic back-reflection. On the laser side, a tilted FaML interface (Inset i) suppress back-reflection while preserving the facet's reflectivity. To mitigate parasitic backscattering of unwanted beam sidelobes from the rough sidewall of the Si3N4 chip, we incorporate dedicated prism-like structures that deflect stray beams, see Inset (ii). (b) Microscope image of the system. The coupling distance can be precisely adjusted by a translation stage. A lensed fiber on the right collects the output light. Inset (i): FaML printed on the QD-MLLD facet. Inset (ii): FaML with deflection prisms on the Si3N4 facet.