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Photonic integration of GaAs-based lasers for quantum, spectroscopic, and biosensing applications

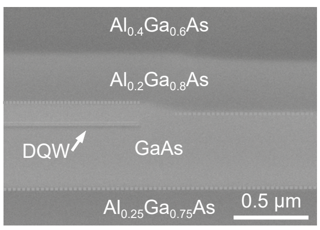
FBH is one of the world's leading research institutions in the design and fabrication of gallium arsenide (GaAs)-based diode lasers. Building on this expertise, the institute is developing methods to explore new wavelengths for photonic integrated circuits (PICs), aiming to enable novel compact laser sources with improved functionality and performance. Two main approaches are being pursued to achieve this.

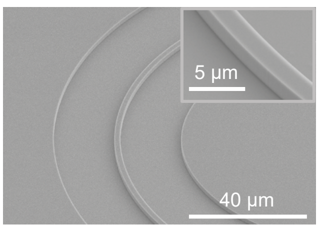
The first approach relies on the monolithic integration of GaAs-based PICs, enabled by selective quantum well removal and two-step epitaxy, to create active and passive waveguides. The platform also supports both shallow and deeply etched waveguides, allowing for low propagation losses and tight waveguide bends. The wavelength range addressable for this approach covers 950 nm to 1180 nm.

The second approach uses the heterogeneous integration of GaAs chiplets onto passive waveguide platforms via micro-transfer printing (MTP), such as low-loss silicon nitride PICs. The MTP process enables submicron precise positioning of laser or amplifier chiplets from a III-V source wafer on a target wafer containing the passive waveguide circuit. In principle, this approach can be applied to the full GaAs wavelength range, from 630 nm to 1180 nm.

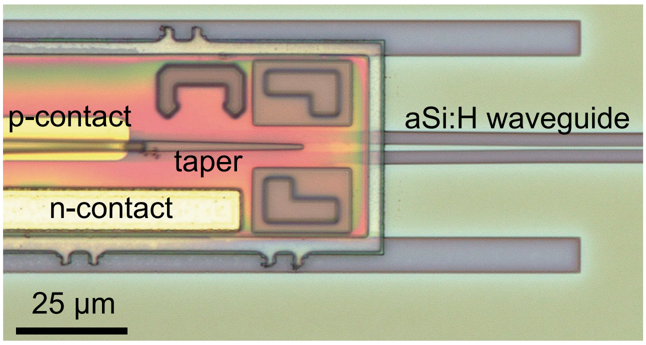
Example 1: Monolithic ring resonator-coupled laser

- emission wavelength around 1064 nm
- low passive waveguide losses of less than 2 dB/cm
- high-Q ring resonators ($Q > 2.5 \cdot 10^5$)
- output power > 10 mW; SMSR > 40 dB
- wide tunability based on Vernier filters possible
- typical applications: compact sources for OCT & LIDAR





SEM pictures of (left) an active–passive interface in cross section and (right) a deep-etched Euler U-bend segment in top view.



Amplifier chiplet printed on intermediate waveguide.

Example 2: Evanescently coupled heterogenously integrated amplifier chiplets

- emission wavelength at 890 nm and 950 nm
- high coupling efficiency to intermediate waveguide
- novel epitaxial design with InGaP n-contact & GaAs sacrificial layers
- can be processed as standard RW laser for testing
- typical applications: swept laser sources for OCT & narrow-linewidth lasers for quantum applications

Profile

The Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik (FBH) researches electronic and optical components, modules and systems based on compound semiconductors. In the field of III-V electronics, it manufactures high-frequency devices and circuits for communications, power electronics, and sensor technology. Moreover, FBH develops light sources from the visible to the UV spectral range: high-power diode lasers, UV light sources, and hybrid laser systems. Applications range from medical technology, materials processing and sensors to optical communications in space and integrated quantum technology. In close cooperation with industry, its research results lead to cutting-edge products.

The institute is a member of the Leibniz Association and part of Research Fab Microelectronics Germany (FMD).