Nano-engineered high-confinement AlGaAs waveguide devices for nonlinear photonics

The combination of nonlinear and integrated photonics enables applications in telecommunication, metrology, spectroscopy, and quantum information science. Pioneer works in silicon-on-insulator (SOI) has shown huge potentials of integrated nonlinear photonics. However, silicon suffers two-photon absorption (TPA) in the telecom wavelengths around 1550 nm, which hampers its practical applications. To get a superior nonlinear performance, an ideal integrated waveguide platform should combine a high material nonlinearity, low material absorption (linear and nonlinear), a strong light confinement, and a mature fabrication technology. Aluminum gallium arsenide (AlGaAs) was identified as a promising candidate for nonlinear applications since 1994. It offers a large transparency window, a high refractive index (n ≈ 3.3), a nonlinear index (n2) on the order of 10^{-17} m^2/W, and the ability to engineer the material bandgap to mitigate TPA. In spite of the high intrinsic nonlinearity, conventional deep-etched AlGaAs waveguides exhibit low effective nonlinearity due to the vertical low-index contrast. To take full advantage of the high intrinsic linear and nonlinear index of AlGaAs material, we reconstructed the conventional AlGaAs waveguide into a high index contrast layout that has been realized in the AlGaAs-on-insulator (AlGaAsOI) platform. We have demonstrated low loss waveguides with an ultra-high nonlinear coefficient and high Q microresonators in such a platform. Owing to the high confinement waveguide layout and state-of-the-art nanolithography techniques, the dispersion properties of the AlGaAsOI waveguide can be tailored efficiently and accurately by altering the waveguide shape or dimension, which enables various applications in signal processing and generation, which will be reviewed in this paper.