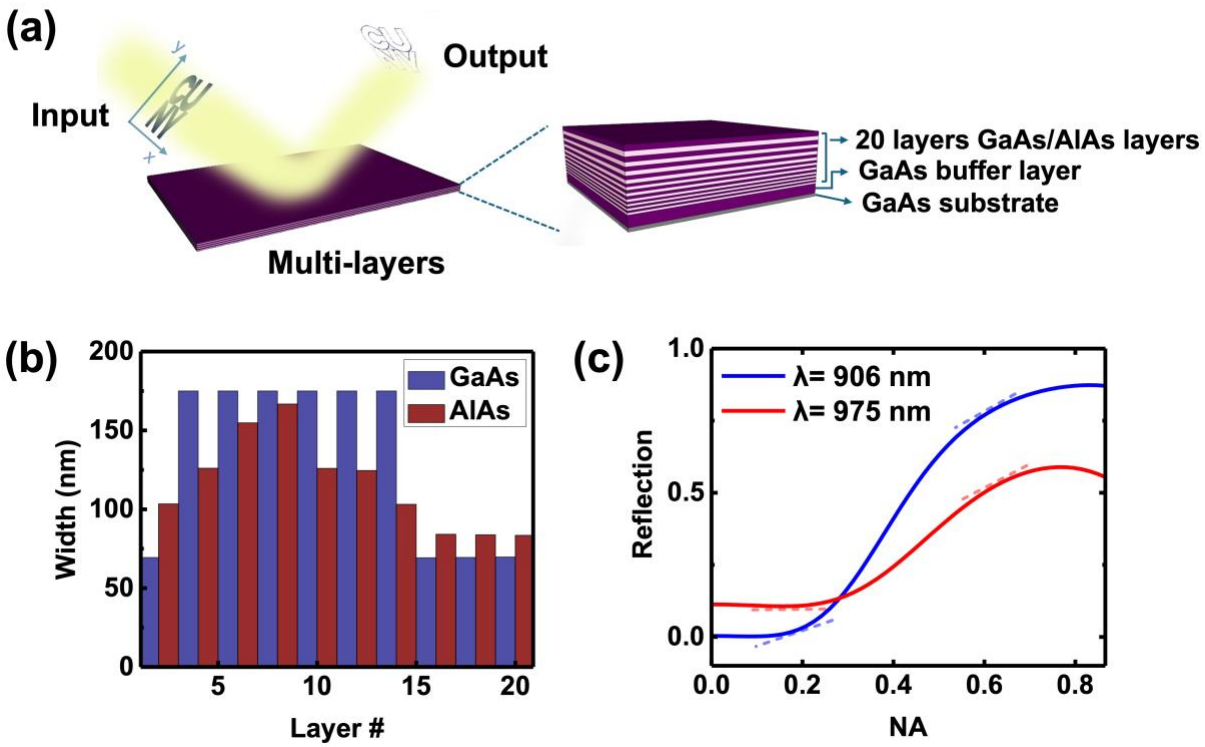
Title:

Real-Time Multi-Wavelength Edge Detection Using MBE-Grown GaAs/AlAs Thin Films

Abstract:

We present an MBE-grown GaAs/AlAs multilayer structure optimized for optical edge detection at multiple wavelengths. This 20-layer aperiodic stack is designed to selectively manipulate spatial frequency components of incident light, enhancing high-frequency features while suppressing low-frequency intensity variations. The fabrication via molecular beam epitaxy ensures precise layer thickness, high-quality interfaces, and minimal deviations from the design thicknesses. Simulated and experimental angle-resolved reflectance measurements confirm a strong numerical aperture (NA)-dependent reflectance transition, demonstrating the feasibility of high-contrast edge enhancement in imaging applications. The multilayer interference structure provides an energy-efficient, real-time optical processing solution with multi-wavelength operation, scalable for integration into advanced imaging and computational optics. Our findings underscore the potential of MBE-grown multilayer stacks as compact, hardware-based alternatives to conventional digital and metasurface-based edge detection techniques.



(a) Schematic diagram of edge enhancement through multilayer interference(left) and 3D schematic of the fabricated multilayer stack(right). (b) Thickness distribution of individual GaAs and AlAs layers, showing

variations optimized for spectral response. (d) Simulated reflectance as a function of numerical aperture (NA), demonstrating the angular-dependent optical response