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A Novel Self-Aligned Process to Fabricate High-Index-Contrast Ridge Waveguide Lasers

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ABSTRACT

A self-aligned fabrication process for high-index-contrast (HIC) ridge waveguide (RWG) lasers is implemented by combining deep dry etching with O_2-enhanced wet thermal oxidization. The thermal oxide grown on the deeply-etched RWG sidewalls and base provides electrical isolation from the contact metallization resulting in a simplified, self-aligned process. The elimination of a second photolithography step with its potential for alignment error also largely reduces the challenges present in fabricating sub-micron devices with good ohmic contacts by conventional, low-cost photolithography and dry etch processes. The high-quality AlGaAs native oxides, formed by a wet thermal oxidation process modified through the addition of <1% O_2 to the N_2 carrier gas, provide good electrical passivation and a structure which eliminates current spreading. High-power, high-efficiency RWG lasers fabricated in an AlGaAs/InAlGaAs/GaAs graded-index separate confinement heterostructure (GRINSCH) demonstrate the superiority and feasibility of this fabrication process. A native-oxide-defined straight laser (w=7 μm, L= 452 μm) operates cw (300 K, unbonded, p-side up) with a threshold current of Ith=21.5 mA (J_{th}=679.5 A/cm^2) and slope efficiency of 1.19 A/W (differential quantum efficiency = 78%) at a wavelength of ~813 nm. The resulting HIC semiconductor/oxide interface with Δn~1.7 leads to a high lateral optical confinement factor, enabling curved geometry waveguide devices with bending radii as small as 2 μm in theory. Operation of a half-ring laser having a record small bend radius of 10 μm is demonstrated.

Keywords: high-index-contrast, ridge waveguide laser, thermal oxidation, self-aligned process, surface passivation

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