

## Reduced Thickness Strain-Free GaN/InAlN Short Period Superlattice Bottom Cladding for 450 nm Laser Diodes

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This work presents the theoretical idea of utilizing strain-free GaN/InAlN short period superlattices (SPSL) as the reduced thickness bottom cladding for the InGaN laser diode (LD) emitting at 450 nm. We have replaced 700 nm  $n\text{-Al}_{0.065}\text{Ga}_{0.935}\text{N}$  bottom cladding with 100 stacks of  $n\text{-GaN}/n\text{-In}_{0.18}\text{Al}_{0.82}\text{N}$  SPSL having thickness of 1 nm each, as shown in Fig 1. The refractive index of  $\text{In}_{0.18}\text{Al}_{0.82}\text{N}$  is 2.3603 which is far lower than the conventional  $\text{Al}_{0.065}\text{Ga}_{0.935}\text{N}$  cladding  $\sim 2.477$ . Thus, 200 nm SPSL layers are sufficient to achieve the optical field confinement equivalent to the conventional structure. As shown in Fig 2 and 3, the optical field confinement factor in the waveguide of reference LD is 3.28%, with 200 nm SPSL it is 3.43%. However, the strain due to  $\text{Al}_{0.065}\text{Ga}_{0.935}\text{N}$  cladding is  $-0.9321 \times 10^{-3}$  which has been eliminated due to the lattice matched GaN/InAlN SPSL. The L-I characteristic of both the laser diodes remains unchanged, however, the slight increase in resistance at higher applied bias has been observed. The computations are carried out in SiLENSe 5.12 tool.

p-Contact (p-GaN)	50 nm	Mg: $3 \times 10^{19}$				
p-Cladding ( $\text{p-Al}_{0.065}\text{Ga}_{0.935}\text{N}$ )	400 nm	Mg: $1 \times 10^{19}$				
p-Guiding (p-GaN)	100 nm	Mg: $1 \times 10^{19}$				
Electron Blocking Layer ( $\text{p-Al}_{0.15}\text{Ga}_{0.85}\text{N}$ )	30 nm	Mg: $3 \times 10^{19}$				
Undoped InGaN Guiding ( $\text{In}_{0.08}\text{Ga}_{0.92}\text{N}$ )	60 nm	u: $5 \times 10^{17}$				
Barrier ( $\text{In}_{0.08}\text{Ga}_{0.92}\text{N}$ )	8 nm	u: $5 \times 10^{17}$				
QW ( $\text{In}_{0.17}\text{Ga}_{0.83}\text{N}$ )	2.6 nm	u: $5 \times 10^{17}$				
Undoped InGaN Guiding ( $\text{In}_{0.08}\text{Ga}_{0.92}\text{N}$ )	80 nm	u: $5 \times 10^{17}$				
n-Guiding (n-GaN)	100 nm	Si: $5 \times 10^{18}$				
n-Cladding ( $\text{n-Al}_{0.065}\text{Ga}_{0.935}\text{N}$ )	700 nm	Si: $5 \times 10^{18}$				
Bottom Contact (n-GaN)	2 $\mu\text{m}$	Si: $5 \times 10^{18}$				
Substrate						

n-In <sub>0.18</sub> Al <sub>0.82</sub> N	1 nm	Si: $5 \times 10^{19}$	X 100
n-GaN	1 nm	Si: $5 \times 10^{19}$	

Thin SPSL bottom cladding structure

Reference LD structure

Figure 1 Epitaxial Structure of Reference LD and SPSL cladding

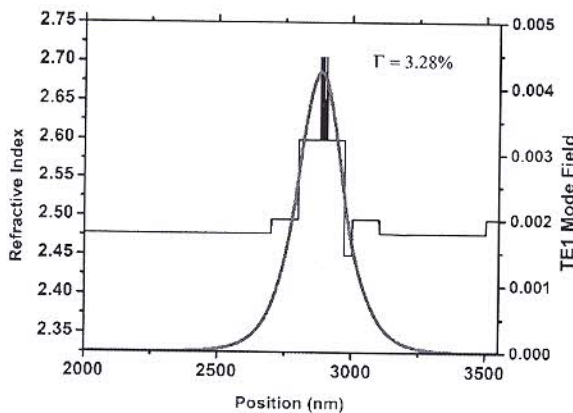


Figure 3 TE1 Mode optical field confinement in reference LD

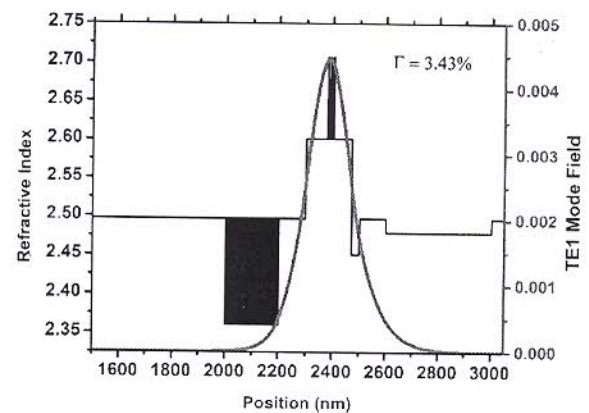


Figure 2 TE1 Mode optical field confinement in SPSL cladding LD