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Invited

Fabrication and Device Characterization of Buried Ridge II-VI Blue-Green Laser Diodes

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1. Introduction

Short wavelength laser diodes have attracted much attention since the first demonstration of II-VI based devices in 1991 . Driven by applications like optical data storage, improvements in the growth of II-VI materials have led to significant advancements in device performance [1].

Laser diodes used in optical data storage systems must meet several demanding criteria including minimal astigmatism, low threshold current, single lateral optical mode, linear light-current characteristics, and the capability of emitting over 30 mW of transverse CW optical power.

This presentation will describe the fabrication and device characterization of index guided II-VI laser diodes [2] for high performance applications such as optical recording.

2. Fabrication

Electrical contact is made to the p-type semiconductor via a Pd/Au metallization. Index-guided devices are defined by Xe+ ion-milling a narrow 4-5 μm ridge about 1 μm into the p-type quaternary. One micron of ZnS is then thermally evaporated onto the device. Photoresist used to define the laser ridge during the ion-milling is subsequently removed, lifting off the ZnS above the stripe. The evaporated ZnS serves as an electrical insulator and lateral index-guiding layer. Figure 1 is an cross-section illustration of the completed device.

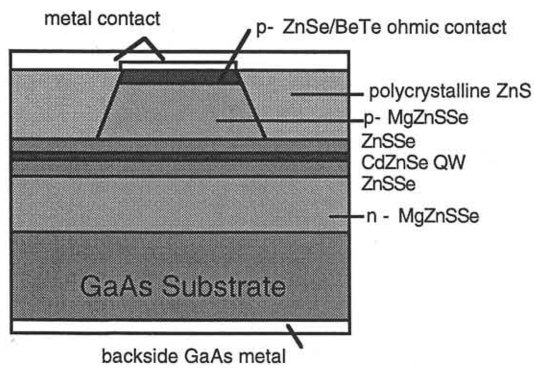

Fig. 1 Cross-section schematic of index-guided II-VI laser diode. Polycrystalline ZnS is thermally evaporated after ridge is defined in ion-milling step. The ridge width, not drawn to scale, is approximately 5 μm wide.

Laser cavities are created by cleaving the sample into bars approximately 1 millimeter long. The bars are subsequently facet coated with MgF_2/ZnS quarter-wave reflectors.

3. Characterization

Figure 2 shows the optical output power and device voltage as a function of current. The threshold current density for this particular device was 233 A/cm^2. Without facet coatings the device threshold is 450 A/cm^2. The device voltage at threshold is 5.9 volts. Operating voltages are often much lower for other devices, typically 4 volts.

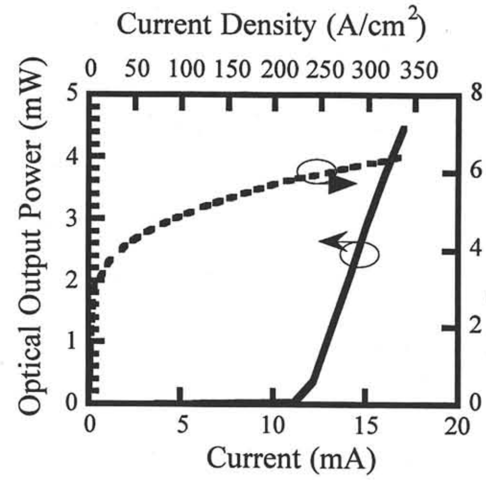

Fig. 2 Optical power and device voltage as a function of injection current for an index-guided laser. The threshold current and voltage are 11.8 mA and 5.9 volts respectively.

Reductions in stacking fault densities, to less than 10^4/cm^2, have resulted in increased device lifetimes. Facet coated index-guided devices with stacking fault densities near 9000 cm^{-2} lasted for more than 50 hours at 1 mW optical power. The lifetimes of these index-guided devices tend to be longer than larger gain-guided structures because, in part, the number of stacking fault defects in the active area is less. Other contributing factors, such as lower operating current and less heating, slow device degradation.

Device criteria for optical data storage systems are demanding. The design of index-guided lasers can impact several of these parameters including astigmatism, beam shape, operating current, and high output power capabilities. We will present an overview of parameters important to optical data storage with measurements from index-guided devices some of which are listed in Table I. Lifetime is certainly a critical issue but it is apparent that other key operating characteristics will impact when commercially viable devices can be introduced.

Table I List of II-VI laser diode performance characteristics that pertain to optical data storage systems. All measurements were made on 5 μm wide index-guided devices operating epi-up at room temperature. The wavelength, unless otherwise noted is 515 nm.

Parameter	Symbol	Limits*	Measured Values	Units
Power Output - CW		30	42	mW
Threshold Current	I_{th}	30-60	20	mA
Operating Current	I_{op}	110	40	mA
Operating Voltage	V_{op}		4-5	V
Differential Efficiency	η	.6-1.0	0.75	mW/mA
Pulse Power		55	100	mW
Wavelength	λ		485-550	nm
Resistance	R	10	50	W
Inductance	L	10	12	nH
Capacitance	C	30-60	30	pF
Astigmatism		0-10	7	μm
Transverse mode		1	1	mode
Polarization ratio		20:1	50:1	
λ temperature shift	$\Delta\lambda_p$	10	4.2	nm
Characteristic temperature	T_0	100	150	°K
Relative Intensity Noise	RIN	-125	-122	dB/Hz

* Limits are representative values of 670 nm lasers used for optical data storage

Acknowledgments

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