Tunable VCSEL For Optical Communication

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Contents

- Introduction
- c-VCSEL structure and tunable mechanism
- Tuning performances
- Other tunable diode lasers
- Summary
VCSEL Basics

(a) Edge emitting laser

(b) VCSEL

VCSEL: Lasers that emit light from their surface in contrast with regular 'edge emitters'
VCSELs vs. Conventional Lasers

- VCSELs emit a uniform, narrow, circular laser beam instead of elliptical beam emitted by edge-emitter.
- VCSELs can be tested on-chip, before the wafer is diced while edge emitters must be tested individually.
- VCSELs dissipate less electrical power and heat, so they don't require temperature control.
- VCSELs are very efficient at turning electricity into photons.
History of VCSELs:
1977- first idea and initial demonstration
1988- first CW VCSEL
1999- new structures and applications
• VCSELs at wavelength of 750 to 850 nm are based AlGaAs/GaAs.
• GaInAsP-InP VCSELs with wavelength of 1300 to 1700 nm, where fibers have lower attenuation and dispersion.
• GaInNAs/GaAs structure (1150 nm) are currently investigating.
Why tunable VCSEL?

Multi-wavelength communication demanding one laser with varying wavelength.

- Only One longitudinal wavelength within the gain spectrum.
- Changing of optical thickness controls the laser wavelength.
- Position of the layer with thickness variation relative to the active region is crucial to maximize the wavelength variation.
Operating Mechanism
Performance (1)

Tuning range: continuously tunable in 1530-1610 nm.
Performance (2)

- Threshold current: about 2 mA
- Output Power: up to 0.3 mW for 9 µm aperture device.
The tuning speed: less than 200 $\mu$s.
Other Tunable Semiconductor lasers

- Temperature tuning distributed feedback (DFB) lasers. But only 5 nm of tuning range is possible.
- Multi-section distributed Bragg reflector (DBR) laser. Tuning is discontinuous.

Continuous tuning vs. step tuning.
Conclusion

- The integration of MEMS and VCSEL produced fast and reliable wavelength-tunable laser.
- The c-VCSEL can be batch processed and tested.
- Combined with the new communication techniques, long-wavelength tunable VCSELs are expected to bring the most cost-effective, flexible service to the fast growing market.