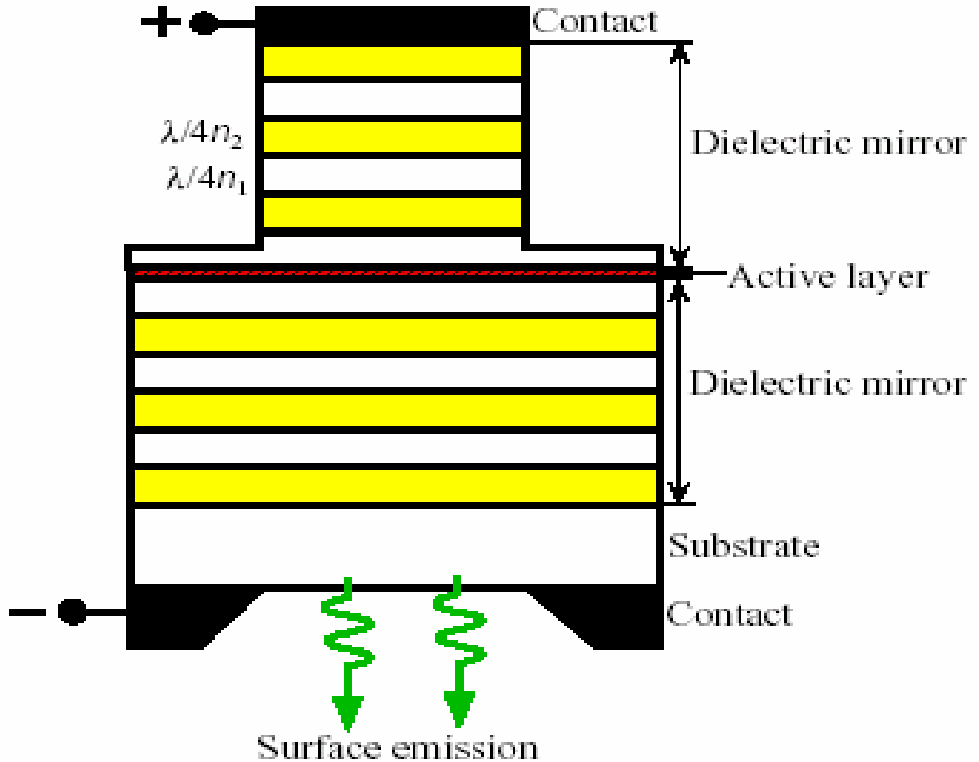
Overview of the VCSEL

Characteristics of VCSEL
VCSEL Structure
VCSEL Fabrication

Structure of VCSEL



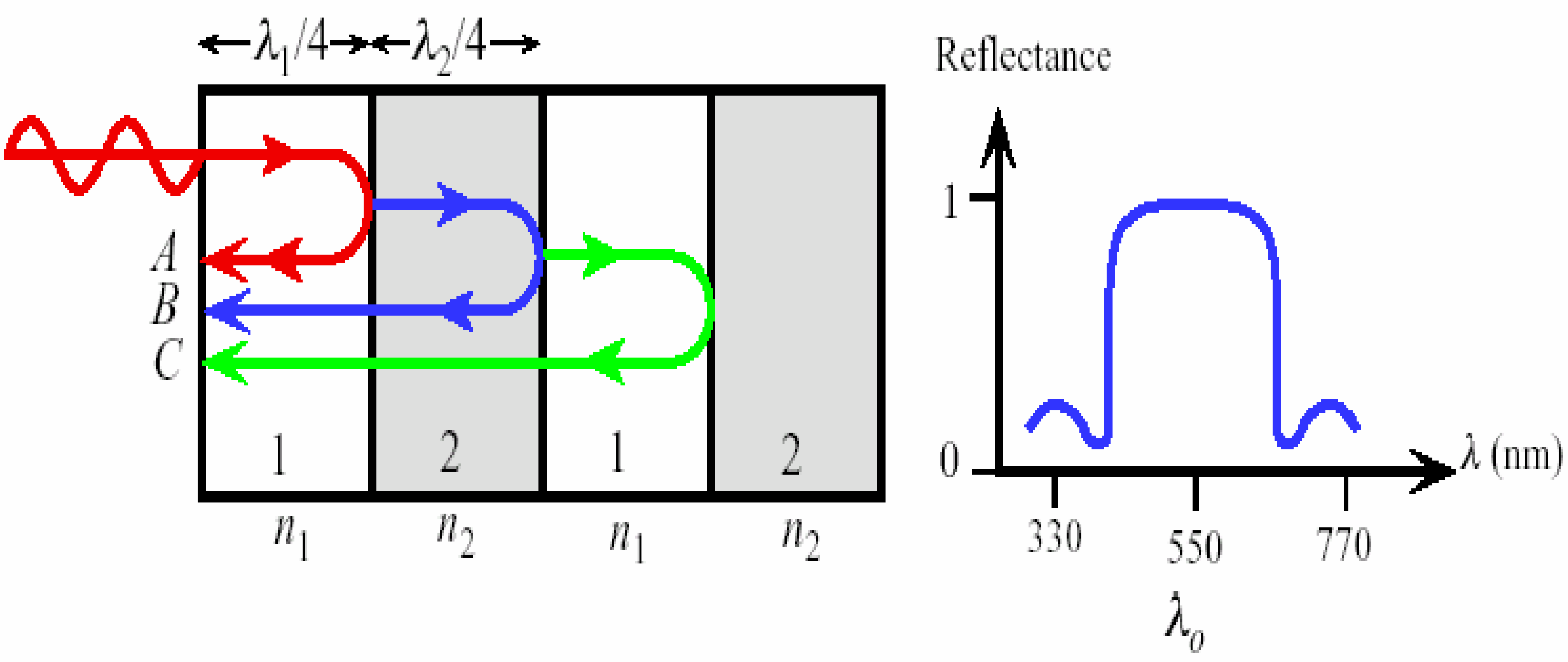
simplified schematic illustration of a vertical cavity
urface emitting laser (VCSEL).

Characteristics of VCSEL

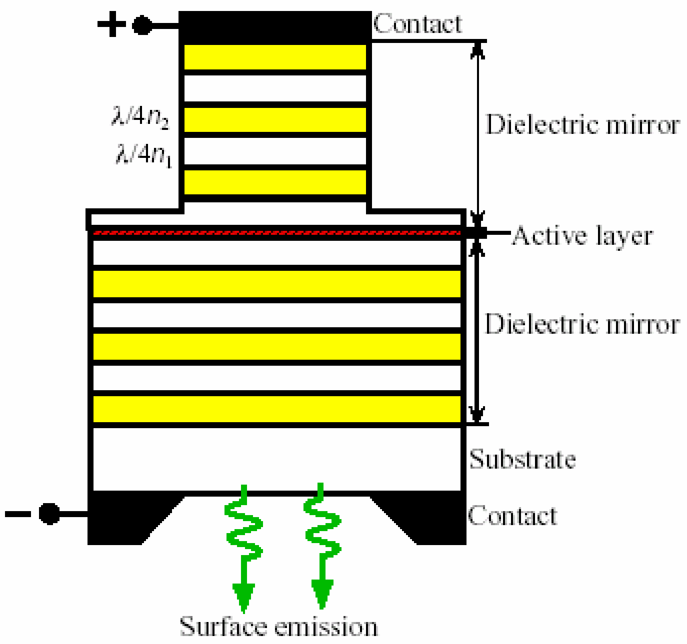
VSCEL use the Bragg reflector instead of the facet mirror to be perpendicular

Shorter cavity length

How Does the DBR Work?



Schematic illustration of the principle of the dielectric mirror with many low and high refractive index layers and its reflectance.



simplified schematic illustration of a vertical cavity
urface emitting laser (VCSEL).

$n1*d1+n2*d2=$ Half Wavelength

Why Use VSCEL?

- Advantages of VCSEL
  - Lower divergence
  - Could be used by IC fabrication
  - Could perform the wafer level testing before packaging, that is reduced the cost of manufacturing.
  - Could be treated as the 2D arrays to do the calculation
  - Circular cross-section that can be easily coupled.
  - Low current needed due to small active volume

Lower divergence

- Compare to the lateral emission laser, the VSCEL Laser has lower divergence due to the geometry

Used by IC fabrication

- By using the IC fabrication process, we can get low-cost and huge amount product.

Could perform the wafer level testing

- Several wafer level testing could be done in the manufacturing process that could reduce the producing cost.

Arrays

- By integrating lots of individual components into an array, we could treat it as a "computer"

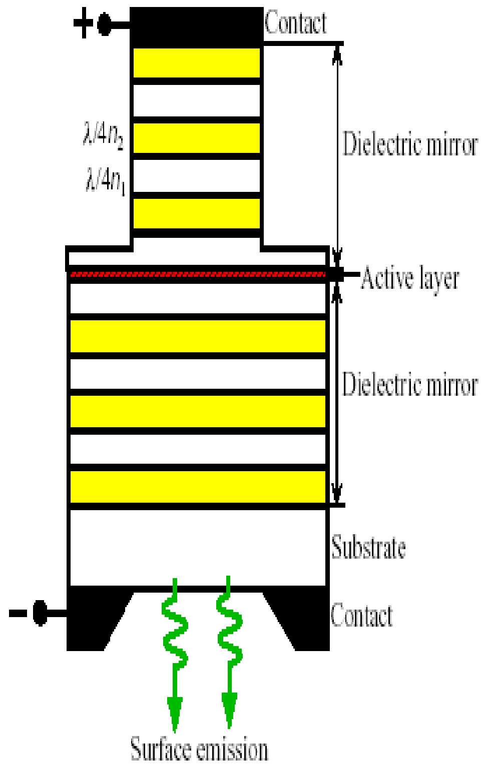
Can be easily coupled.

- Due to the circular geometry, we can get lesser coupling loss than the conventional laser

Low current needed

- Thinner active region, needs fewer current to drive
- Less power consuming

Structure of VCSEL



simplified schematic illustration of a vertical cavity urface emitting laser (VCSEL).

1. 2 kinds of high n mirror confine the Fabry-Perot Cavity

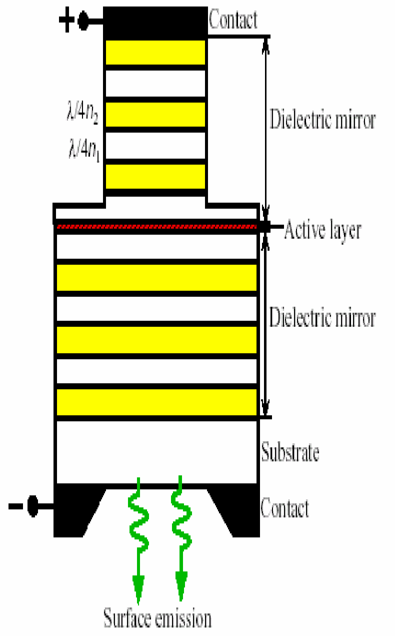
2.The reflectance is higher than 99%

3.The issues in the mirrors:

   1. Maximize the index contrast
   r= (n1-n2)/(n1+n2)

   2. transparent to the laser

Structure of VCSEL

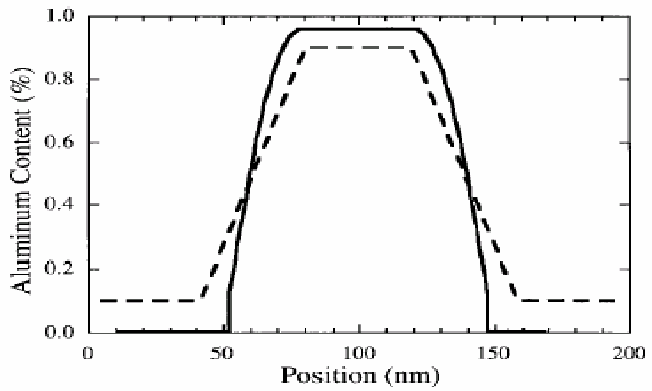


simplified schematic illustration of a vertical cavity
urface emitting laser (VCSEL).

What happened to the mirror ?

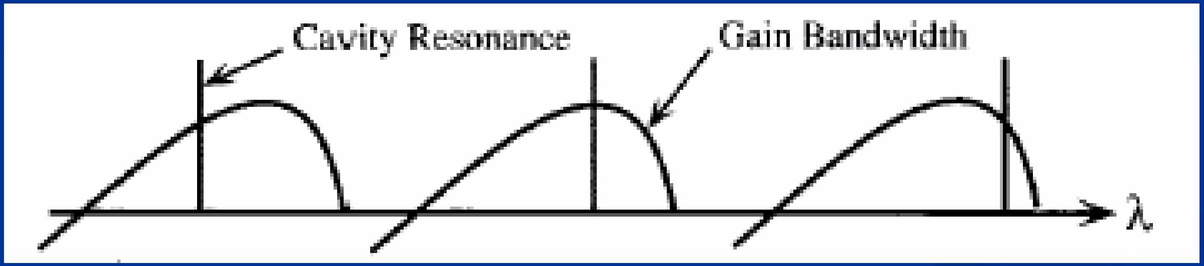
current transport through the VCSEL is an issue
why: hetrojuction links as series resistance

solution: composition grading



Structure of VCSEL

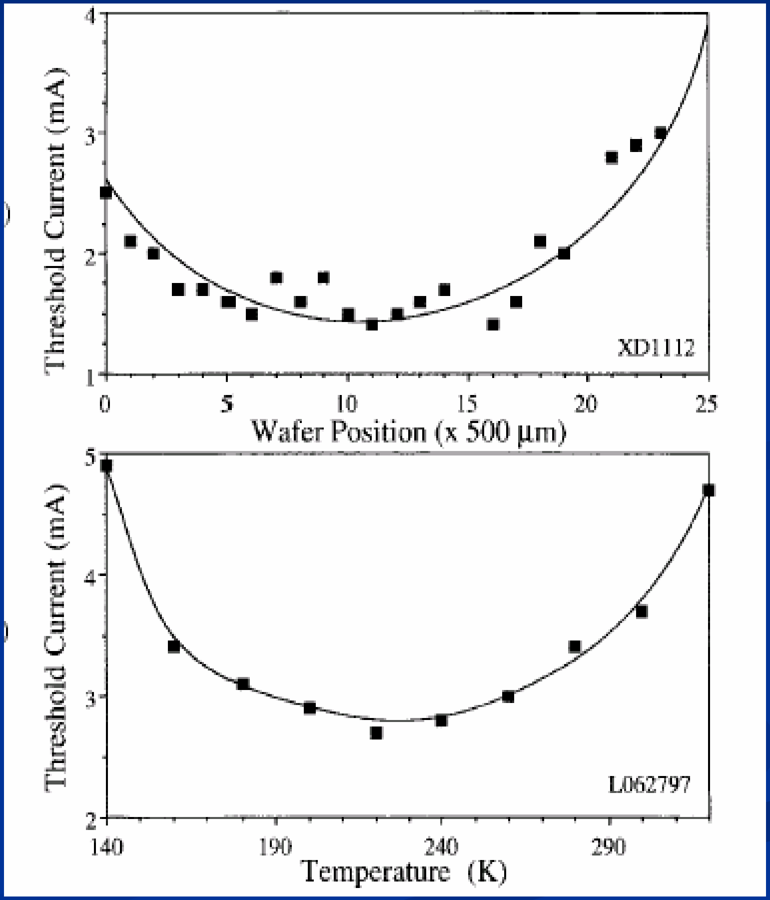
- The Location in the wafer influent the performance?



spectral alignment between the cavity resonance and the laser gain bandwidth in a VCSEL, which can be influenced by wafer thickness nonuniformity and substrate temperature.

Structure of VCSEL

- The Location in the wafer influent the performance?
- We can see that the threshold current is the function of thickness and the temperature

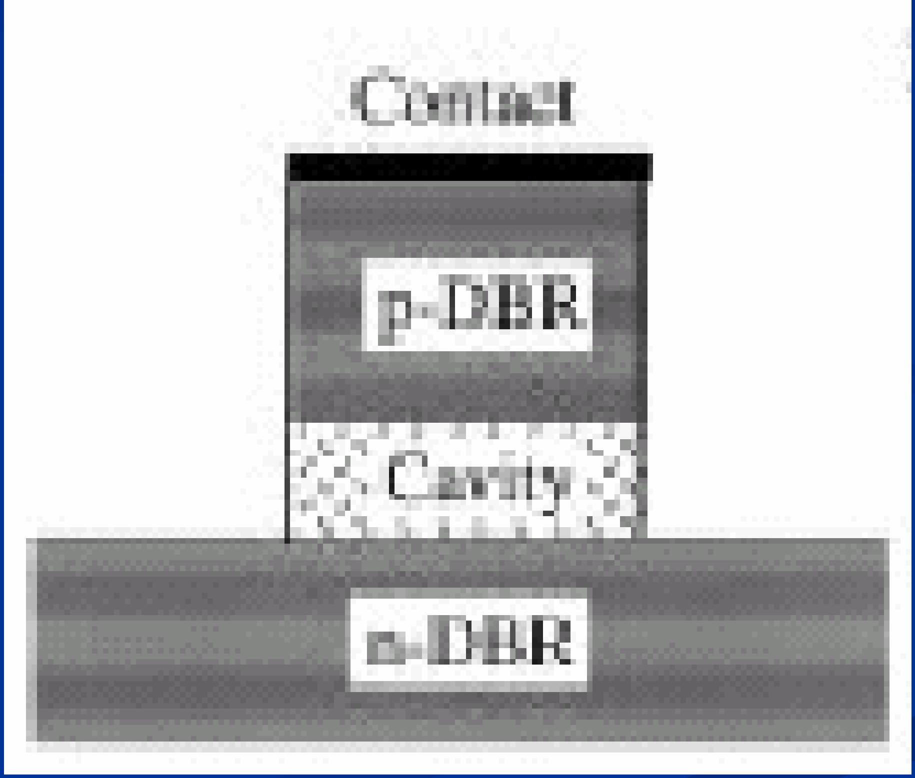


Three different fabrication methods

- (a) Etched air-post VCSEL's.
- (b) Ion-implanted VCSEL's.
- (c) Selectively oxidized VCSEL's. (most commonly used)

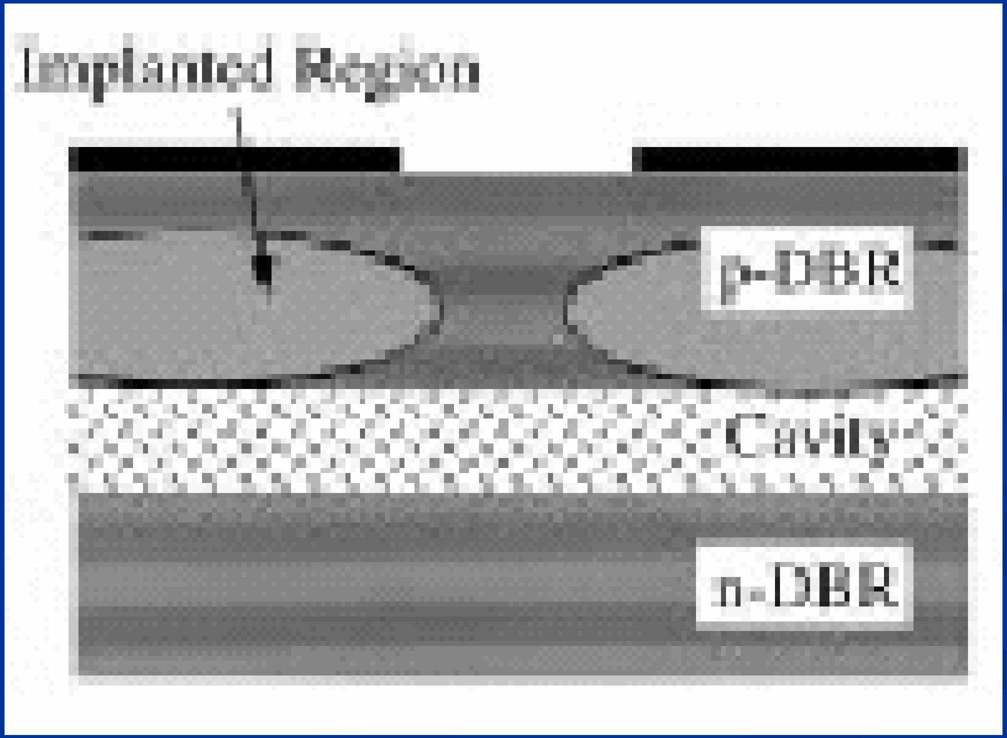
Etched air-post VCSEL's

- advantages: simple fabrication; index guided optical confinement .
- disadvantages: high optical loss; restricted thermal dissipation.



Ion-implanted VCSEL's

- it defines a current path but no transverse optical confinement is provided

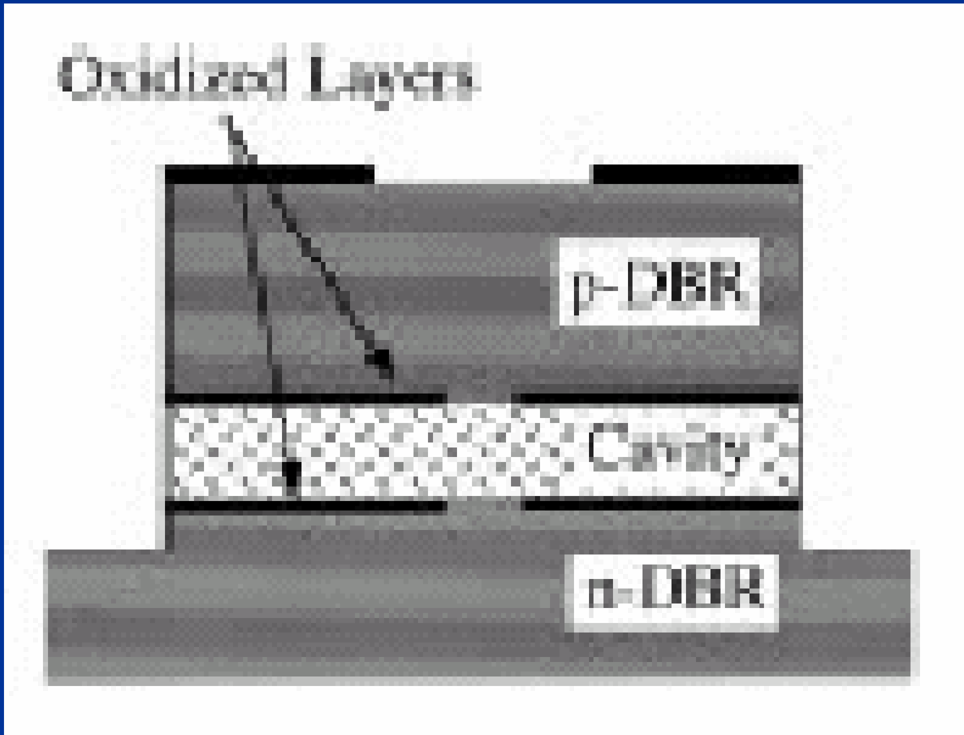


Ion-implanted VCSEL's

- Advantages :
  - good performance
  - better reliability
  - simple fabrication method needed
- Disadvantages :
  - thresh hold current could vary by different wavelength
  - turn-on delay is obvious.

Selectively oxidized VCSEL's

- both optical and electrical confinement that defines the laser cavity.
- the oxide of the AlGaAs is robust, inert to chemical reactions, good insulating material and lower n.



Selectively oxidized VCSEL's

- advantages :
  - the oxide (with smaller n) provided index-guided lateral confinement that makes the current flows better and reduces the heat.
  - it has wider wavelength range (640nm< λ < 1550nm)
  - could be commercialized (CHEAP!!)

- Disadvantages :
  - needs improved device reliability
  - needs more robust oxidation fabrication process.

The Future VSCEL:

- increasing power in the fundamental mode
- Longer wavelength for sensor application
- Shorter wavelength for display
- VSCEL array for optical signal processor, interconnects, and image processing