Finisar®

Fiber Optic Solutions
for High-Speed Networks

Tunable Lasers
---- Technologies, Cost, and Applications

Wen Li

Next Generation EPON Industry Connections
IEEE802 Plenary, March 18, 2014
Beijing, China

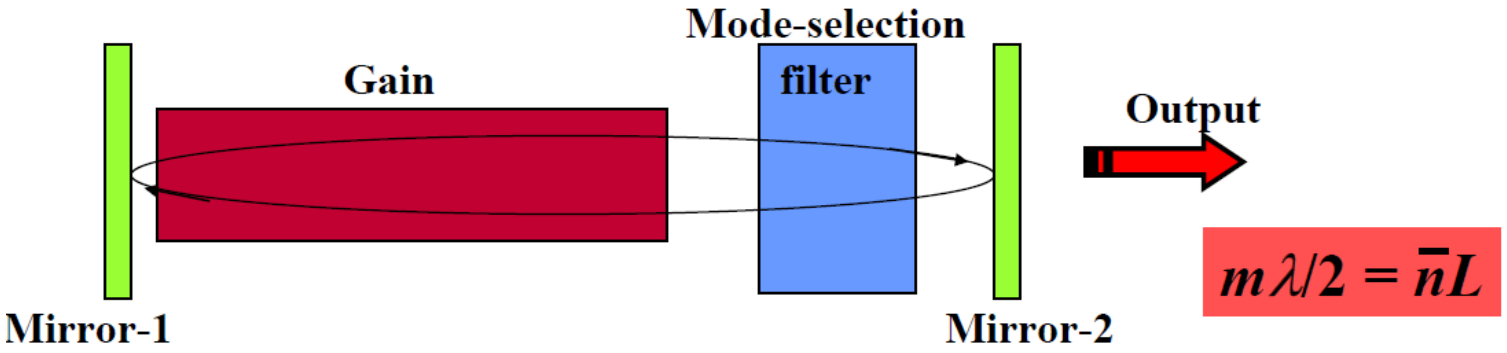
Why Tunable Lasers?

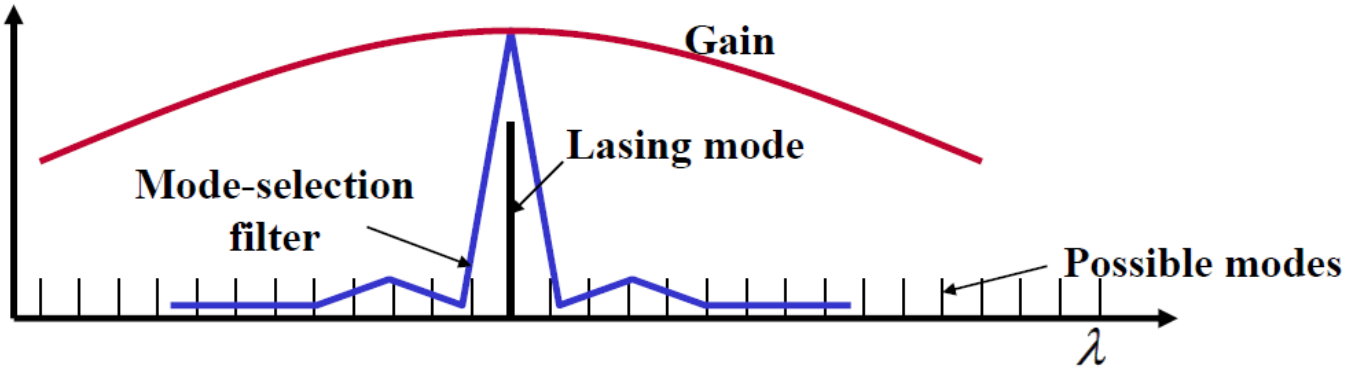
- One time provisioning—inventory and sparing
- Field re-provisioning—new services without hardware change or truck roll
- Reconfigurable Optical Add/Drop Multiplexers (ROADM)—Drop and add any channel without demux/mux
- Wavelength conversion—Eliminates wavelength blocking without OEO line cards
- Photonic Switching—Eliminates many OEO line cards
- Wavelength Routing—Use passive optical core

Larry A. Coldren, “Tunable Semiconductor Lasers”

“Colorless” ONU is desired for simplicity and low OPEX

Single-frequency Laser



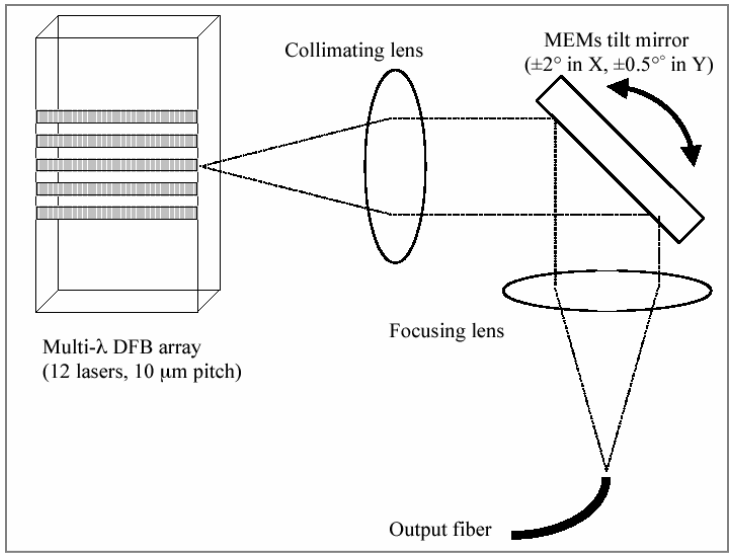


Larry A. Coldren, “Tunable Semiconductor Lasers”

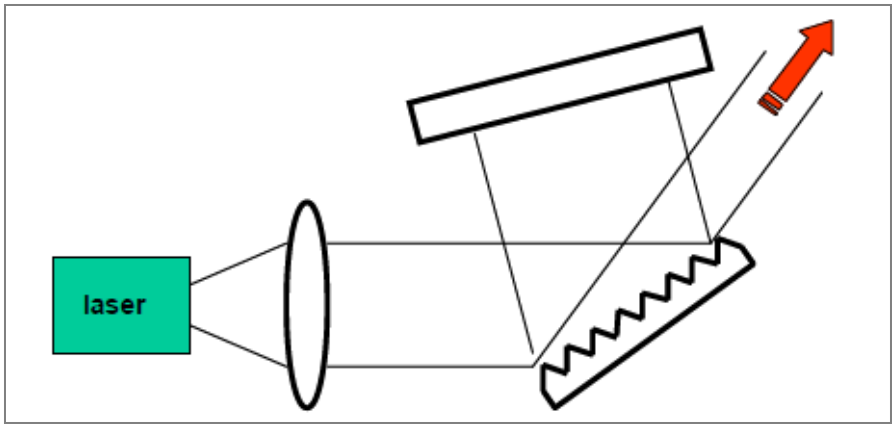
Tunable Laser Overview

Tunable technologies

- **Temperature** (narrow band)
- **Mechanical**
  - Laser array (DFB) + MEMS mirror
  - External cavity laser (ECL) for test and measurement



DFB array + MEMs



ECL tunable Laser

- **Vernier Effect**
  - Current control (2 Bragg gratings + Active section + Phase section)
  - SG-DBR, MG-Y DBR, DSDBR

Vernier Effect

- Vernier effect is normally used in high resolution measurements
- Vernier effect is exploited in laser system to achieve wide tunability (Finisar, JDSU, Emcore etc.)

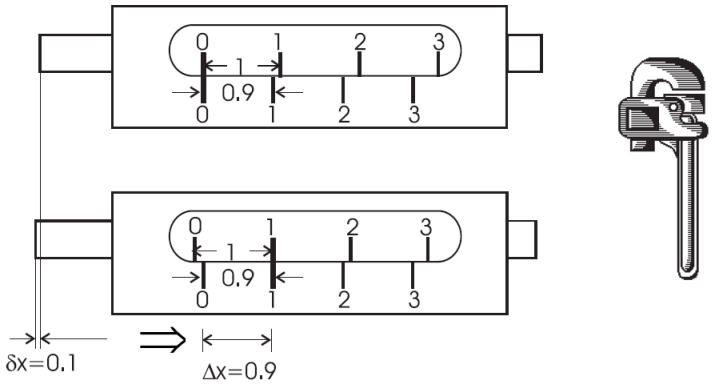


Figure 7.1 A Vernier using two scales with a 10% pitch difference. A shift of one scale by δx leads to a shift of the point where the scales coincide by $\Delta x = 9\delta x$.

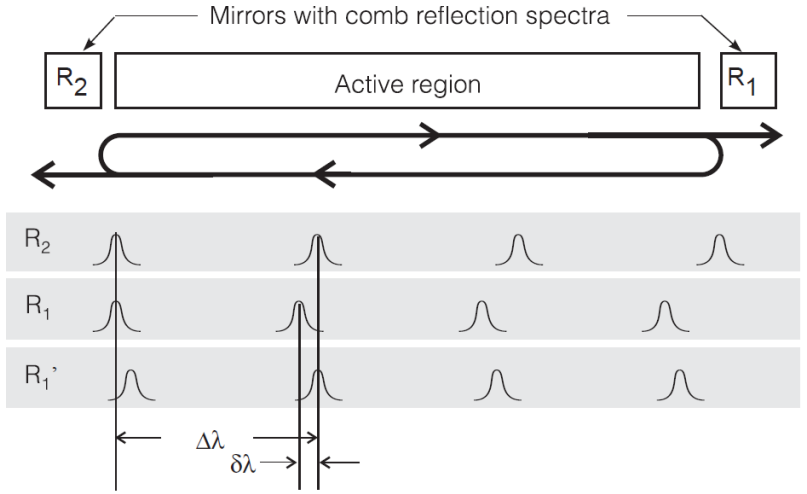
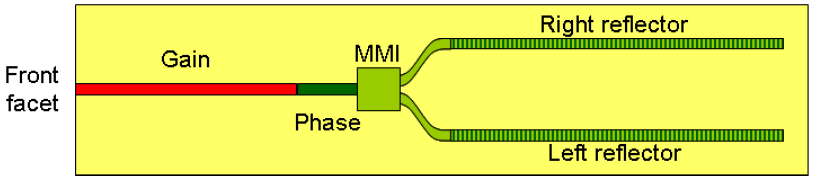
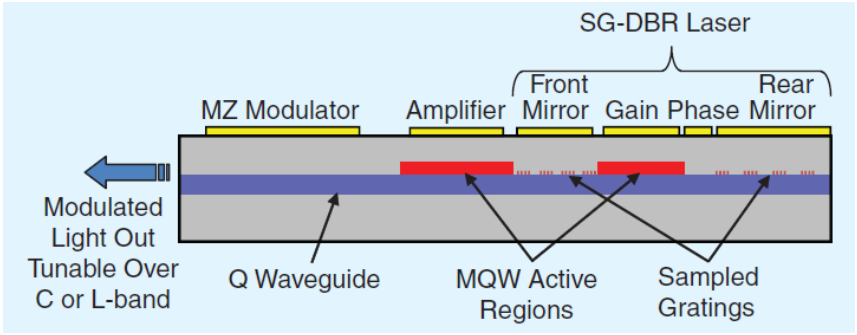


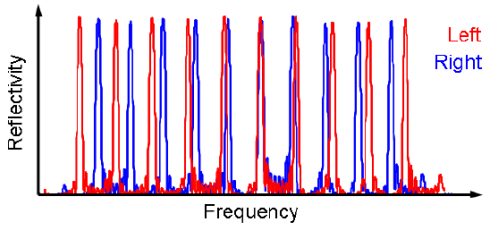
Figure 7.2 Laser structure where each end reflectivity has a comb characteristic. Sufficient cavity gain for lasing is only available where the reflection peaks coincide.

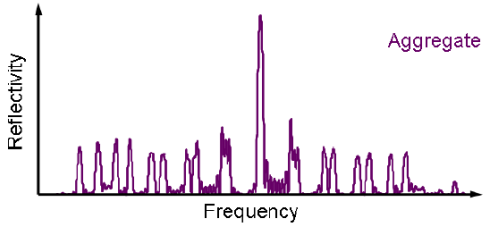
Buss, Amann, Blumenthal, “Tunable laser diodes and related optical sources ”

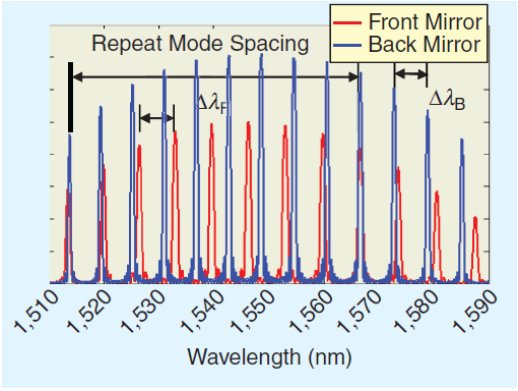
Examples of Lasers using Vernier Effect











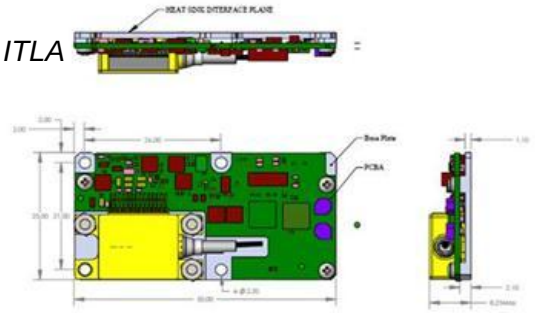
Finisar, “Controlling the S7500 CW Tunable Laser”,
Coldren, “Semiconductor Laser Advances”

Tunable Products

- Mature Product Line
  - Monolithically integrated SOA and MZ modulator
  - Test automation (chip, TOSA and module)
  - Manufacturing yield/efficiency significantly improved
- Lower cost for Access Applications
  - Volume
  - Relaxed specifications
  - New designs (chip/packaging…)

Tunable TOSA

Mini ITLA

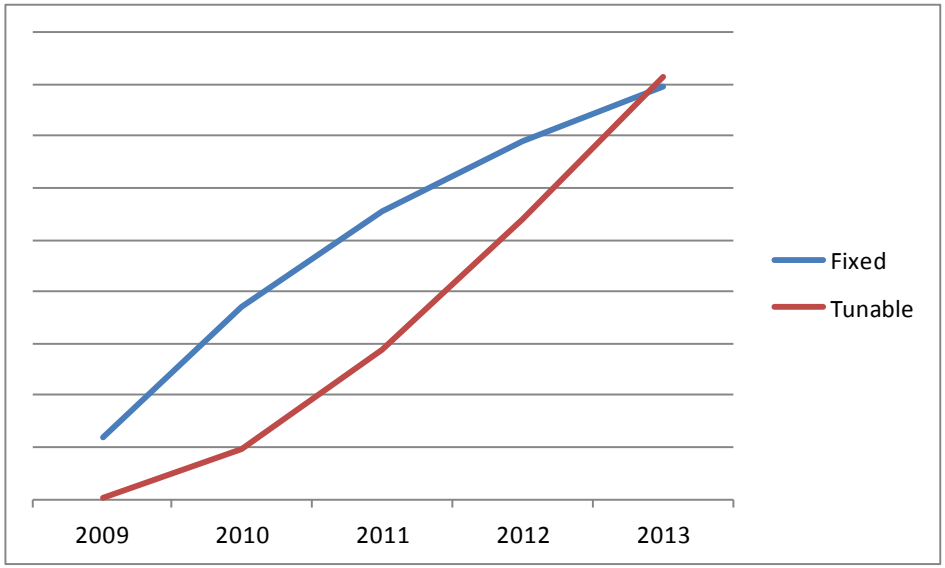


Tunable XFP

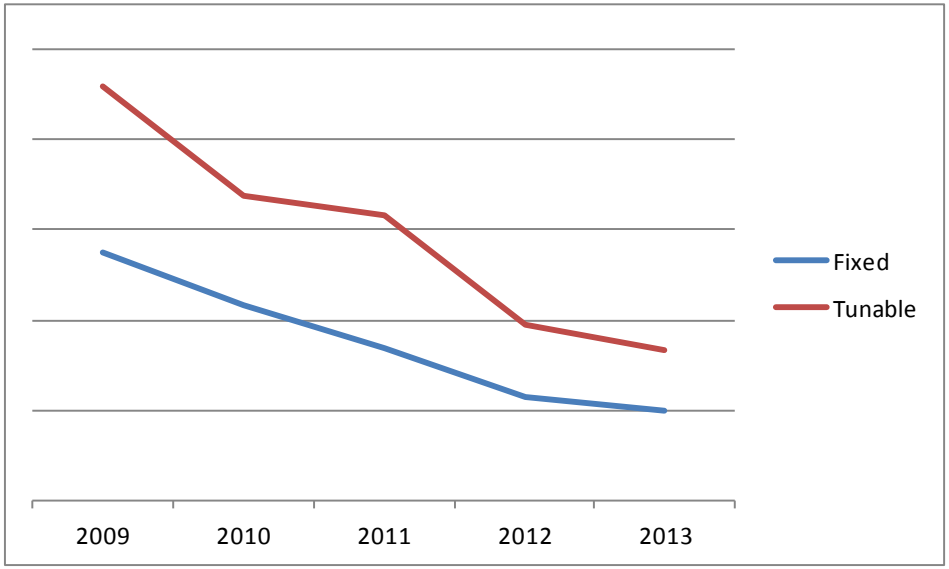
Tunable SFP+

10G DWDM Volume and Cost Trend (relative)

Total unit shipped
(All distance & form-factors)



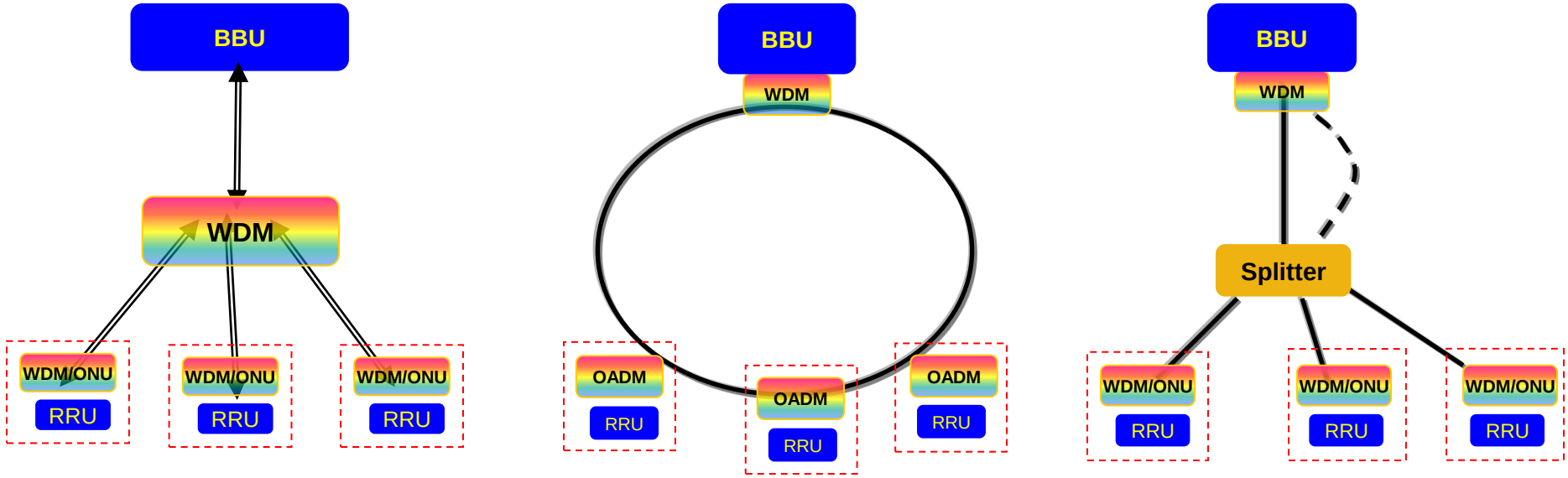
Cost
(All distance; XFP)



Tunable XFP cost is <2x of EML based fixed DWDM XFP

Tunable for Radio Access Networks

- Access has immediate demand for tunable optics
  - Heavy investment in 4G LTE
  - Mobile front-haul / C-RAN
  - Business access / Long-reach access
- Different architectures need to be considered



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Thank you!

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