A HISTORY OF PICs AND VCSELs:
Tribute to the Career of Larry Coldren

Milan Mashanovitch (UCSB Ph.D. 2004)
Freedom Photonics LLC
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Early life – Mifflintown, Pennsylvania

- Larry was born on first day of baby boom, January 1, 1946 in Mifflintown, central Pennsylvania...
- He grew up on a large farm...
According to Larry, living at a farm, there was always equipment to fix, and structures to build.... So he became proficient with mechanical and civil engineering
- Enlisting brother for help in execution

So, when choosing a major at Bucknell University, he decided on electrical engineering
- “I did not know anything about it”

Double major in Physics and Electrical Engineering

Summer internships at IBM
Employment with Bell Labs and Stanford M.S. and Ph.D.

- Larry graduated with honors from Bucknell in 1968
- Fellowship offer from MIT vs employment offer from Bell Laboratories
  - Military systems division, working on development of early version of missile defense and anti-EMP
- Larry chose Bell Laboratories, in part due to the moment in history and Vietnam war
  - Masters needed to work at Bell
  - 1 year program with Stanford
- At the end of master program, offered to continue to Ph.D. on a Bell Lab stipend
  - Recession and budget cuts made it favorable to defer hiring
- Extra 3 years of Ph.D. work
Early work at Bell Labs, and IEEE Fellow Status

- After his PhD, at Bell Labs, Larry joined Bell Labs research
- Larry worked on surface acoustic wave devices
  - Used for signal processing, storage of high-data rate signals
- Result of this work – timing recovery filter, deployed in TAT-8
- In 1982, Larry was elected a Fellow of IEEE for his work with acoustic waves (not lasers!)
- This work was very fabrication intensive, involving precision lithography and dry etching
Getting into diode lasers

- A lot of work on growth of III-V materials and laser fabrication happening at Bell Labs
- Larry had an RIE system in his lab, and was a “processing guy”
- RIE etching of InP and III-V using chlorine – original work
- Having worked on acoustic filters, and etching slots, the idea was hatched – can we make a single mode (tunable) laser with coupled cavities? A PIC was born….

Monolithic two-section GaInAsP/InP active-optical-resonator devices formed by reactive ion etching

L. A. Coldren, B. I. Miller, K. Iga, and J. A. Rentschler
Bell Telephone Laboratories, Holmdel, New Jersey 07733

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Move to UCSB and UCSB work

- 1982 breakup of AT&T brought the winds of change to Bell Labs
- Larry decided to pursue a career in academia
- Despite many choices, settled on UC Santa Barbara, an up-and-coming University, hoping to make it better (1984)
- Large investment and recruitment efforts at UCSB continued, fueled, in great part via SDI
- Larry was working on lasers, fabrication technology, and phase and other modulators
- Vertical resonant cavity modulator work led to a world changing idea that enabled commercialization of VCSELs (1987)
- Optical Concepts -> Gore Photonics
Widely tunable lasers and PICs

- 1988 – patent on a multisection tunable laser with differing multielement mirrors
  - Vernier effect for wide tuning
- Initial results – 3 section Vernier device
  - 1992, ISLC
- 4 section SGDBR laser – 1993

![Diagram of a multielement laser with InP and quaternary waveguide](image)

- Commercialization by Agility – 1998, acquisition by JDSU in 2005
SGDBR – wide tuning, high power and reliability

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Photonic Integrated Circuit work at UCSB – SGDBR+ and *X devices

- EMLs, ILMZs, wavelength converters, coherent receivers,

IEEE PHOTONICS TECHNOLOGY LETTERS, VOL. 11, NO. 6, JUNE 1999

Widely Tunable Sampled Grating DBR Laser with Integrated Electroabsorption Modulator

Beck Mason, Greg A. Fish, Steven P. DenBaars, and Larry A. Coldren, Fellow, IEEE

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And large scale integration....
The Book of Diode Lasers

- Standard textbook for graduate diode lasers and photonic integration circuit courses
- 2 editions, translations into Japanese and Chinese languages
- So popular, that it is available for free illegal download on all relevant web sites
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