

Coldren Legacy: VCSEL Respectability

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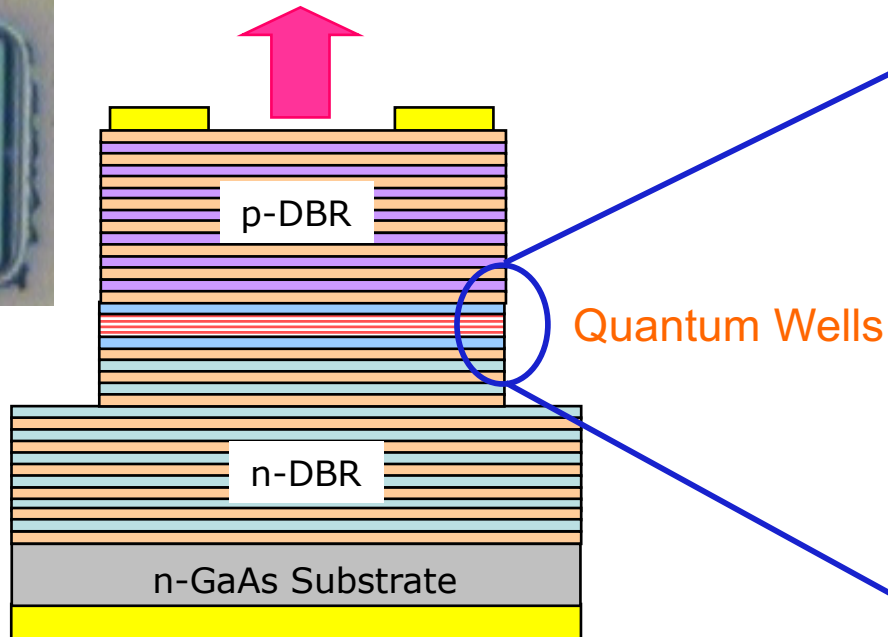
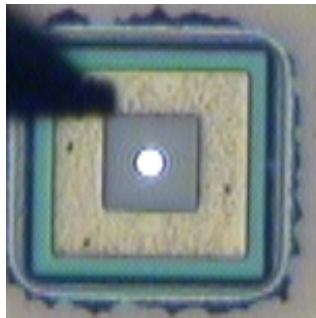
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Vertical Cavity Surface Emitting Lasers

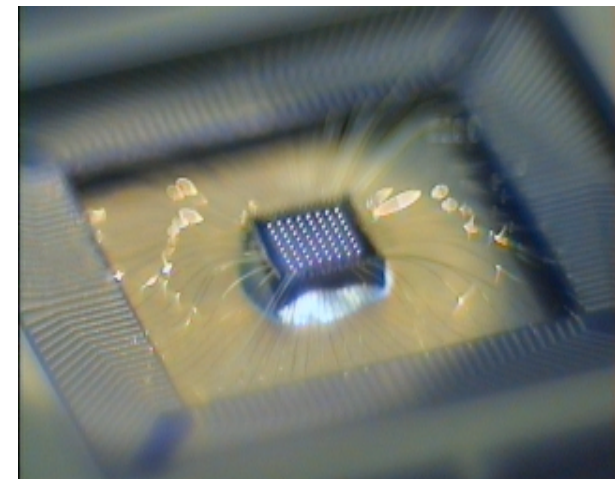


Distributed Bragg Reflector

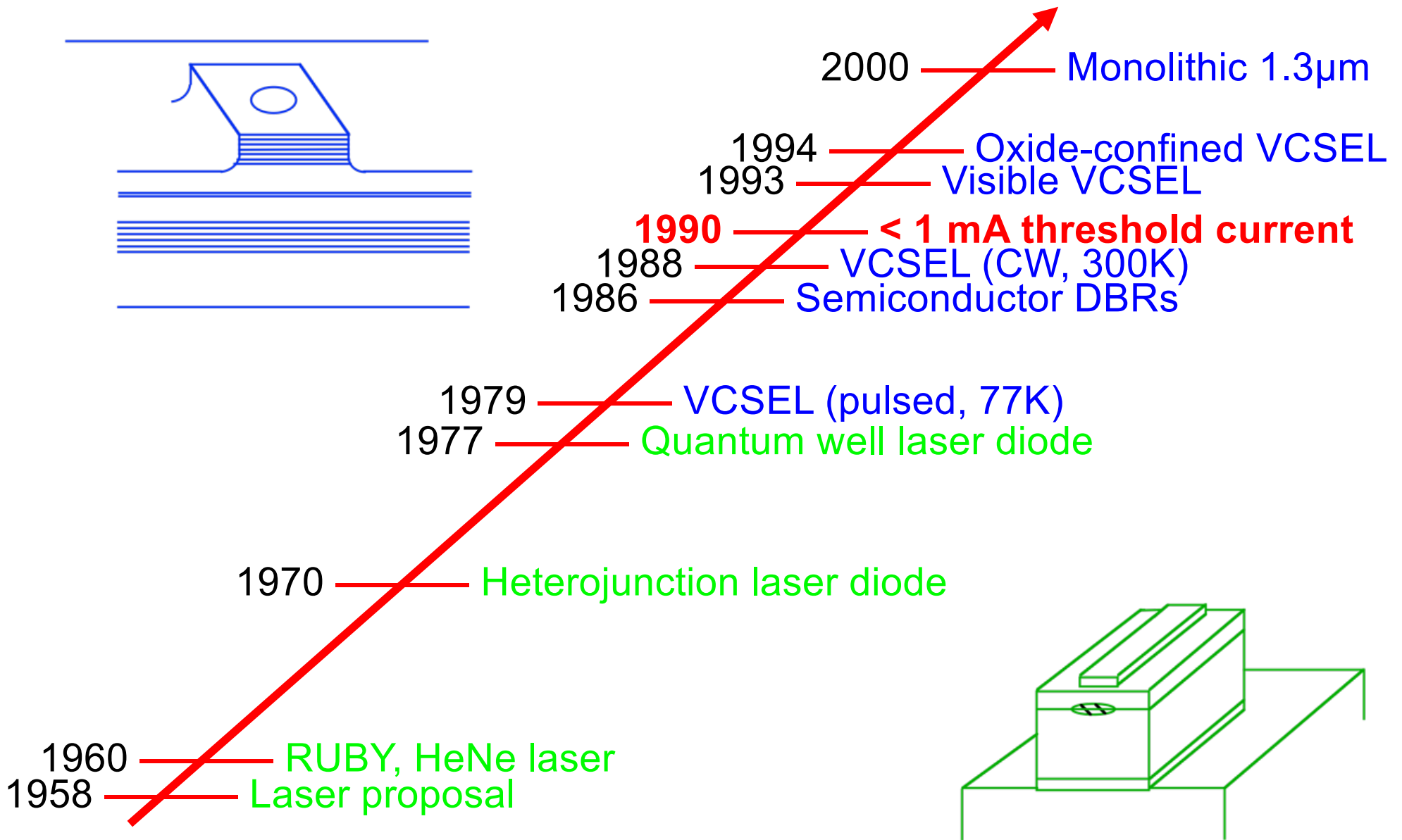
Distributed Bragg Reflector

VCSELs:

- Invented by Prof. Kenichi Iga in 1977
- Infrared and visible microcavity lasers
- Technology for optical communication & sensing
- > 20M manufactured/year
- > 1B deployed around the world



Semiconductor Laser Development



Critical Milestone in VCSEL Development

Applied Physics Letters 57, (16) pp. 1605 (1990)

Submilliamp threshold vertical-cavity laser diodes

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We report for the first time room-temperature, continuous-wave operation of individual vertical-cavity laser diodes with submilliampere threshold currents. A single quantum well active region emitting at 979 nm surrounded by GaAs/AlAs Bragg reflector mirrors was used. Threshold currents were as low as 0.7 mA. A record low linewidth-power product of 5 MHz mW and a linewidth as narrow as 85 MHz was measured. High yield and good uniformity were demonstrated.

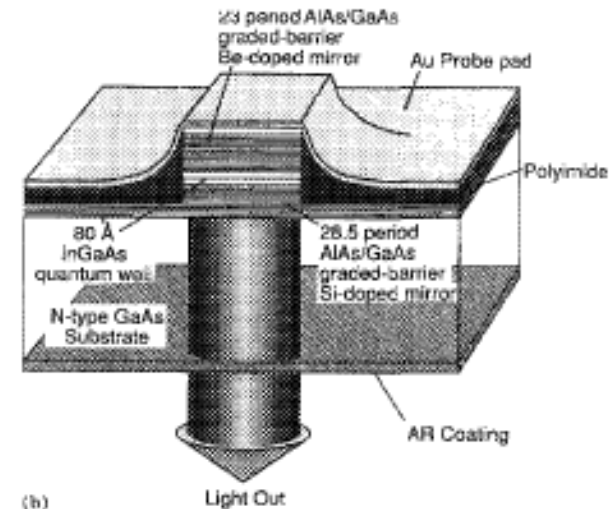
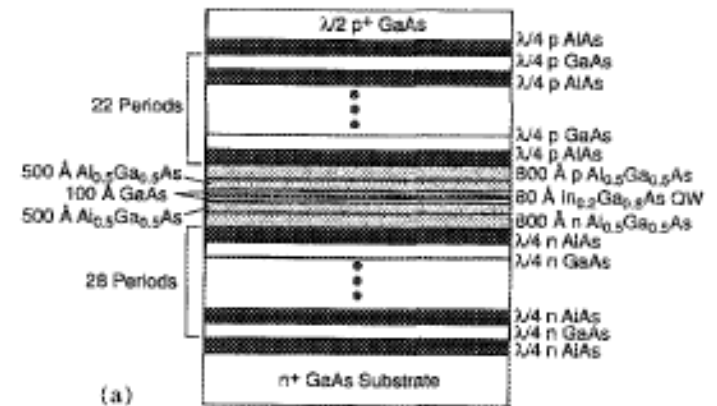
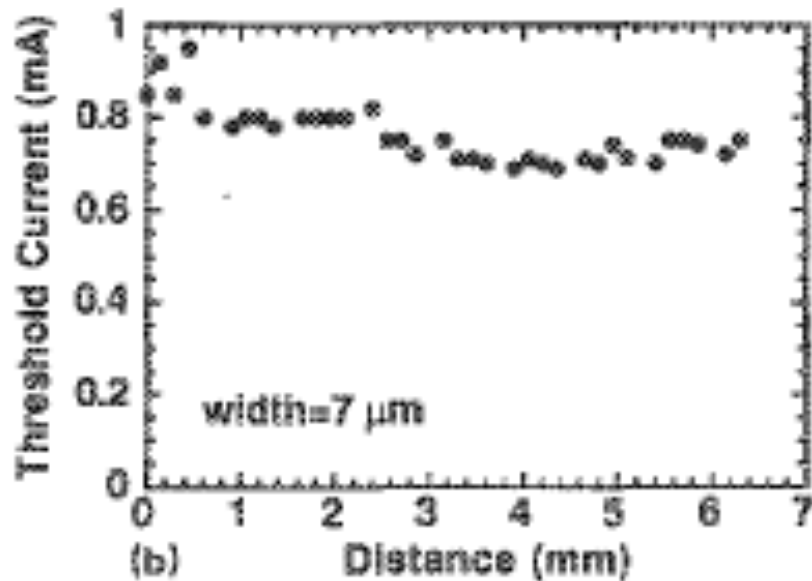
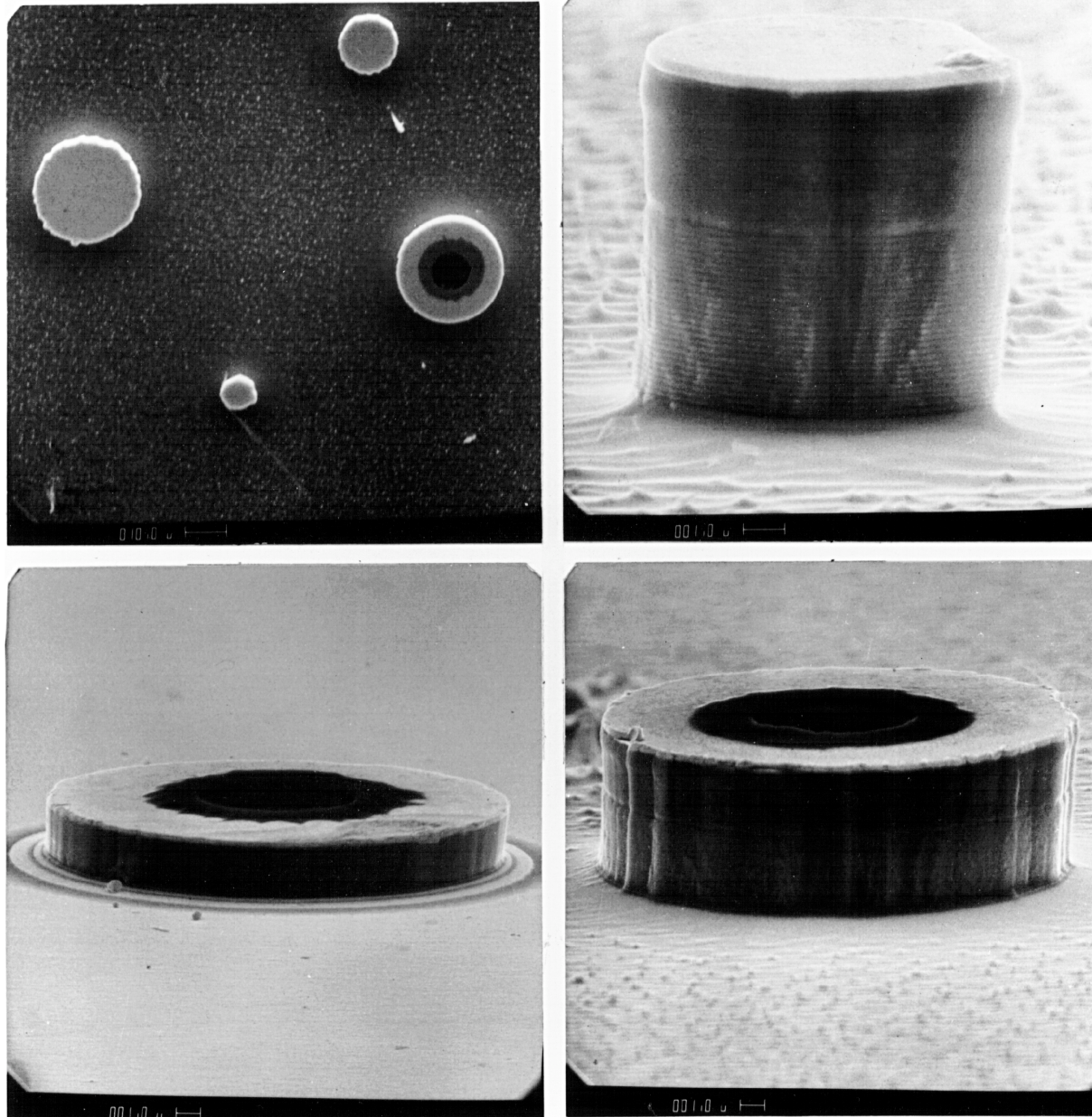


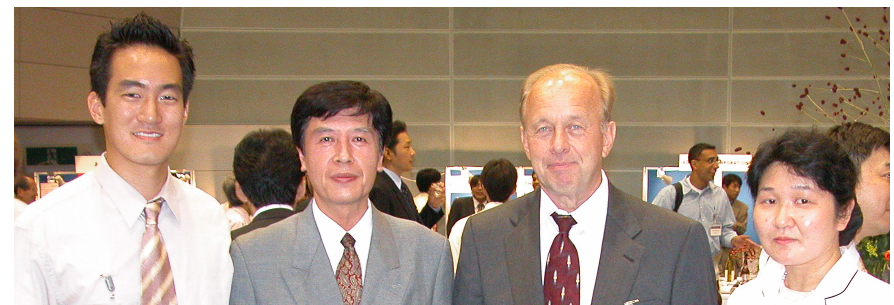
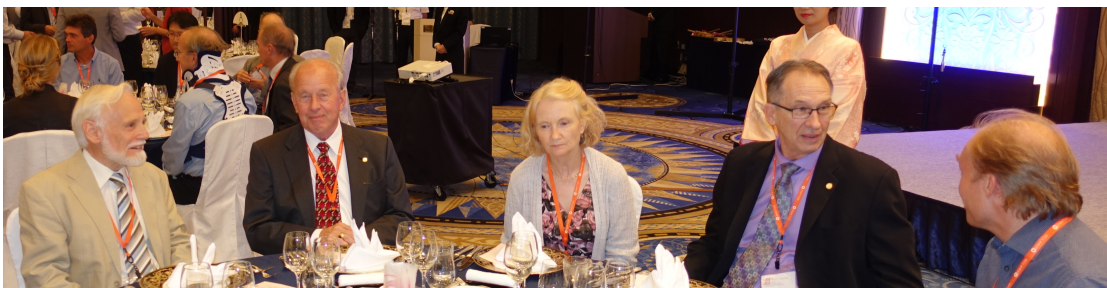
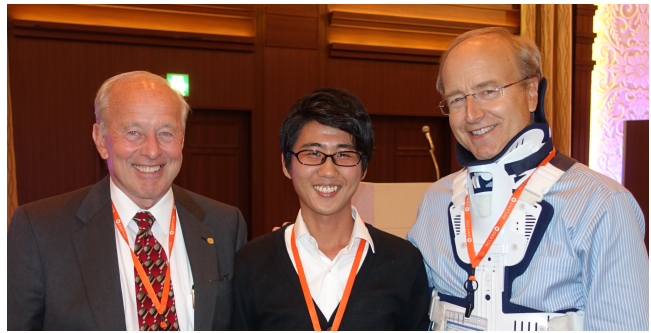
FIG. 1. (a) Layer structure used for surface-emitting lasers. Interfaces in the mirrors are linearly graded. (b) Planarized surface-emitting laser with light emitted through the substrate.

Etched Air-Post VCSEL at Bell Labs



K. D. Choquette, G. Hasnain, Y. Wang, J. Wynn, R. S. Freund, and A. Y. Cho, "GaAs Vertical-Cavity Surface Emitting Lasers Fabricated by Reactive Ion Etching," *IEEE Photon. Technol. Lett.* **3**, 859-862 (1991).

Larry @ International Semiconductor Laser Conference



Coldren Legacy

Great students,
Seminal textbook,
Successful companies,
Impactful research . . .

