

From Niagara Falls to Yellow Stone - 40 Years of VCSEL: Larry and Me -

2018.3.16 UCSB Larry Coldren Symposium



Kenichi IGA

**Tokyo Institute of Technology
Prof. Emeritus/Previous President**

Since 1881



RIE Laser

L. A. Coldren,,,, K. Iga
Appl. Phys. Lett., vol. 37, no. 8,
pp. 681-683, Oct. 1980.

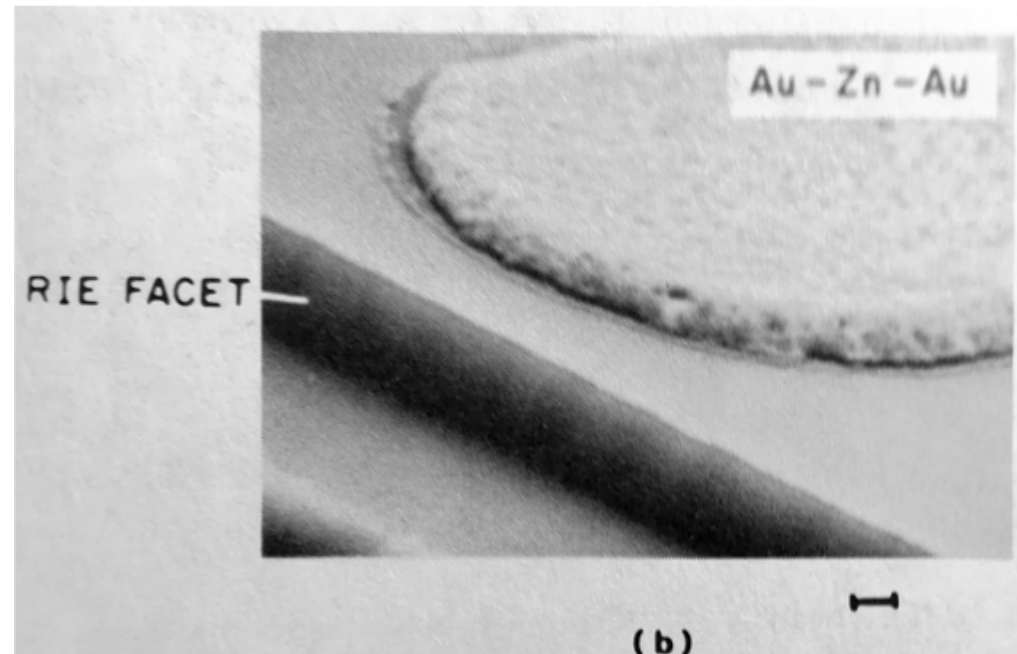
Once rejected !

Reviewer said:

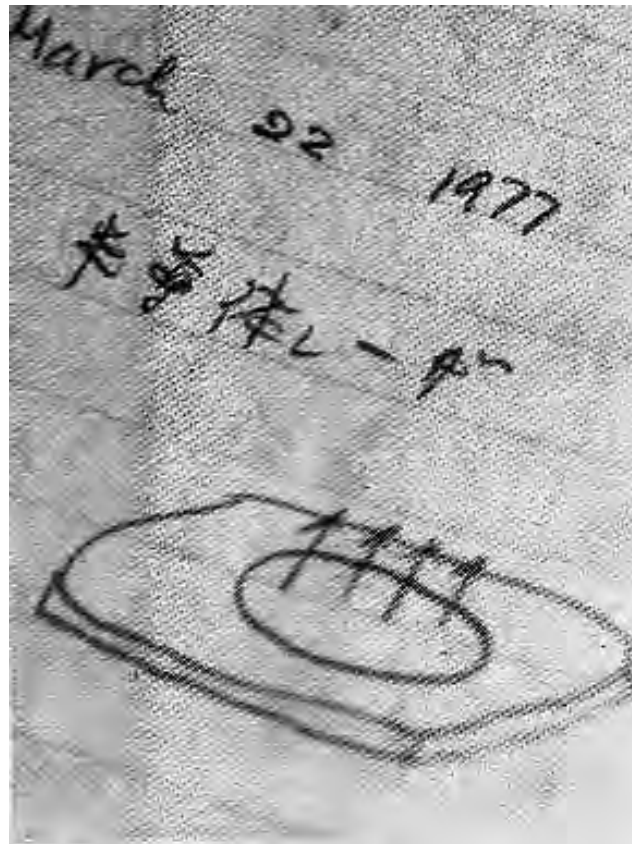
“RIE etched facet looks
like **Niagara Falls.**”

“These guys did a
Friday afternoon experiment.”

This experiment is followed by
2-section and 3-section lasers.



VCSEL: Initial Idea 1977.03.22



VCSEL Idea

Yellow Stone Nat'l Park



VCSEL Video Demo



After Genichi Hatakoshi, Toshiba

VCSEL Benchmarks

Iga's Group

1977. 03.22 The first idea, on Lab Notebook

1978. 03.28 The first report of the idea#)

1978.11 #)The oral presentation at IEEE
LED Symposium

1978.11 The 2nd report of the idea

1979.12 The first report on VCSEL Oscillation

1982.05 6- μ m cavity length GaInAsP VCSEL

1986.10 6-mA I_{th} GaAs VCSEL

1988.07 GaAs/AlGaAs DBR VCSEL

1988.09 Detailed report on GaAs VCSEL

1988.12 The first room temperature CW

1992.08 Mechanically tunable VCSEL
demonstrated

World Groups

1979.09.13 Xerox patent, filed

1989.07 J. Jewell CW

1989 Coldren Periodic Gain

1990-95 sub-mA I_{th}

(Coldren, Ebeling, Deppe, et al.)

1995 MEMS tunable VCSEL
(Chang-Hasnain)

Device Research Conference 1990 in SB



**Chair: L. A. Coldren
Plenary Talk: K. Iga**

**After Five at Sand Pipers:
Iga, Bowers, Coldren (From the left)**

June 27, 1990



**A Wild Fire in Santa Barbara Area
(Photo by K. Iga)**

June 28, 1990

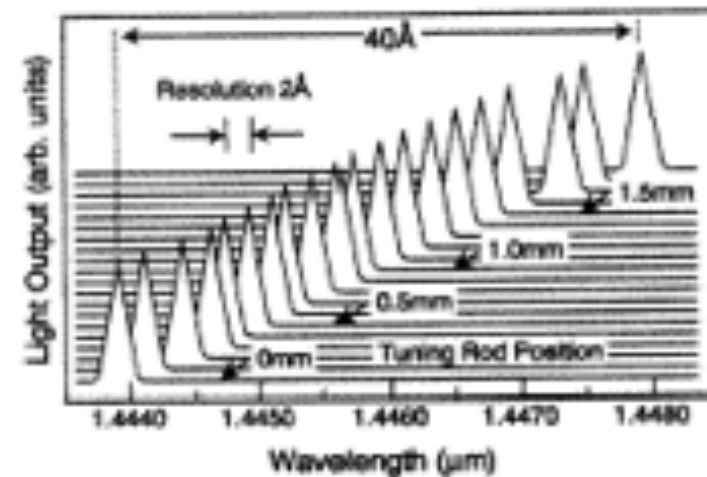
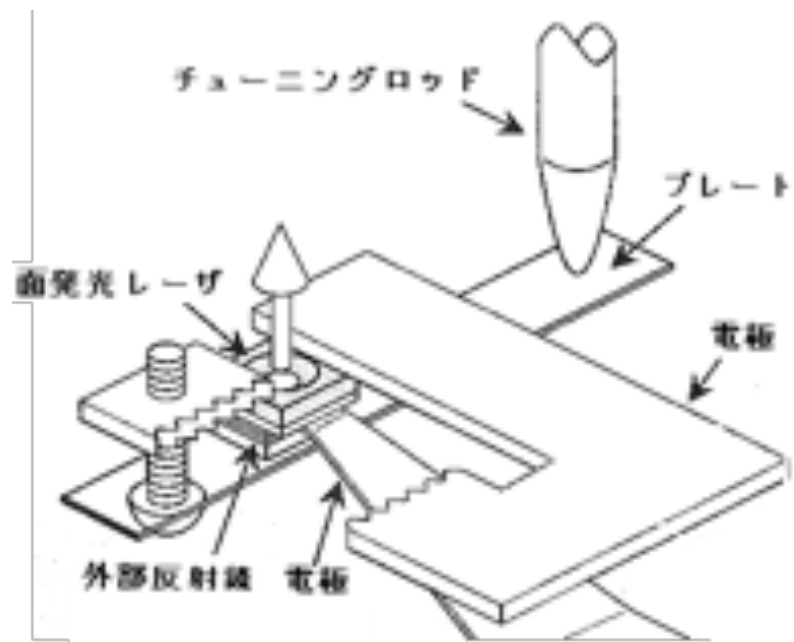
Competition of Threshold Reduction

1990-2000

Tokyo IT, UCSB, Bell Labs, Bell Core, USC,
U.TX, U. Ill, UCB, TNM, U. Ulm, TU Berlin,
TU München, U. Würzburg, Industries,,,,,,

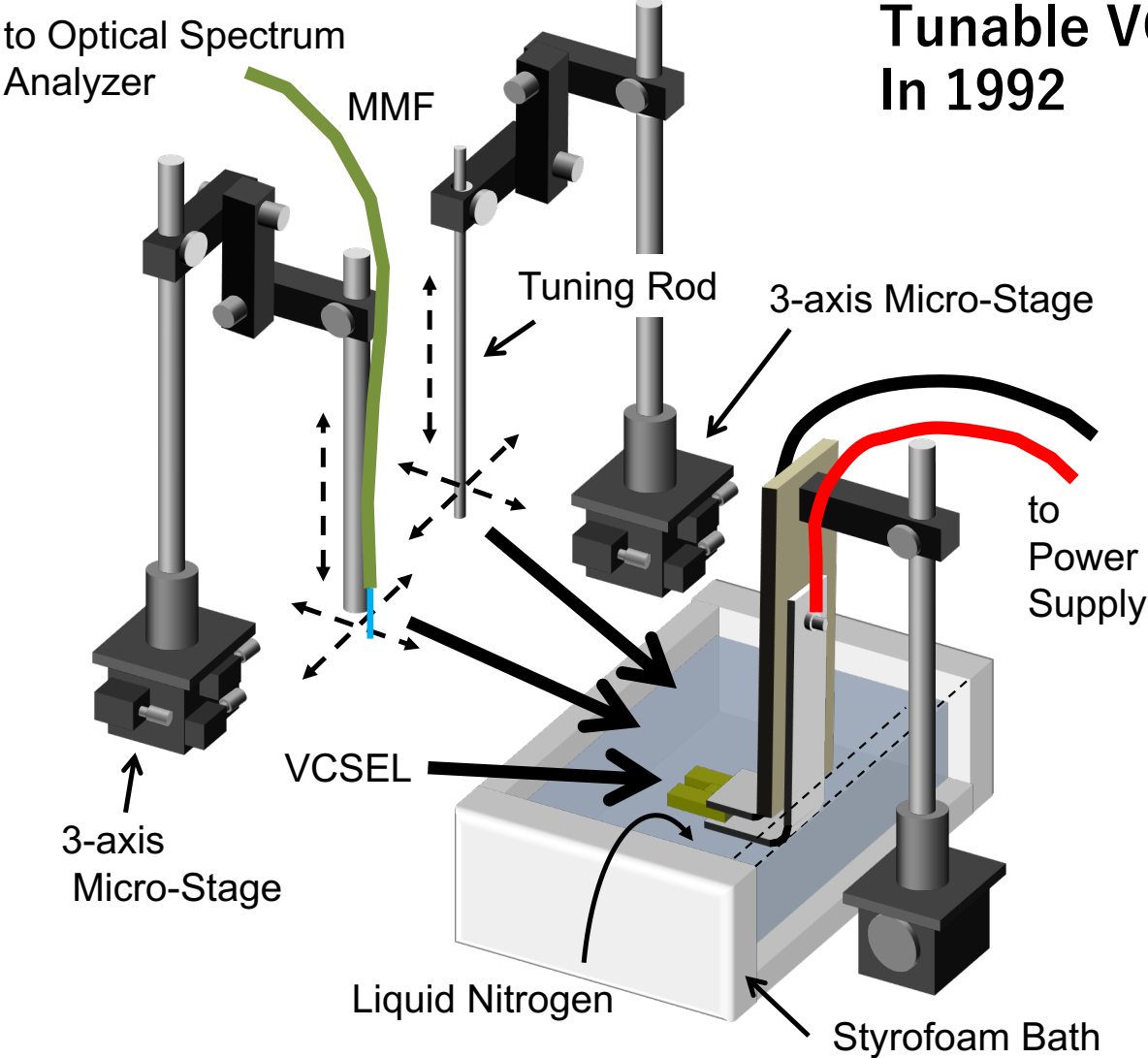
Quantum wells and dots, AIAs oxidation,
High quality conductive mirrors, ,,,,

First Mechanical Wavelength Tuning : 1992



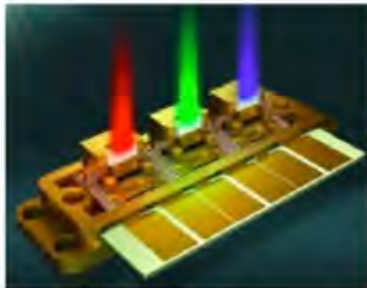
N. Yokouchi, T. Miyamoto, T. Uchida, Y. Inaba, F. Koyama, and K. Iga:
IEEE Photon. Technol. Lett., vol. 4, no. 7, pp. 701-703, Jul. 1992.

Tunable VCSEL Apparatus In 1992



VCSEL Applications

After OPTICIS



after Novalux



after Microsoft
(Ulm Photonics)

Sensing



after Apple

Recognition



after Fuji Xerox

Datacom

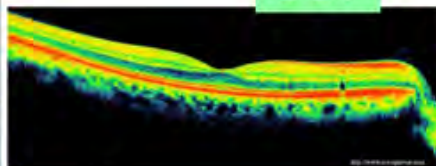
Printing

VCSEL Photonics

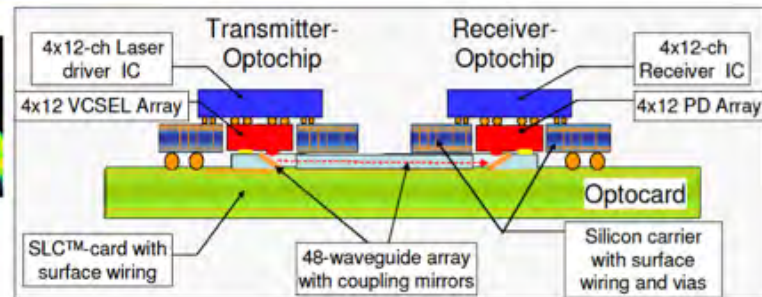
Display

Interconnects

OCT



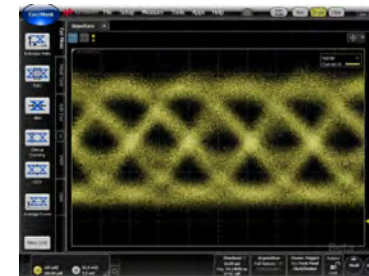
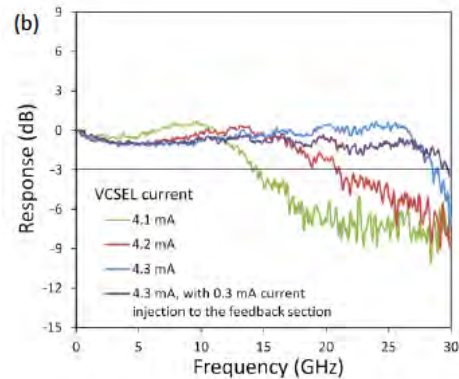
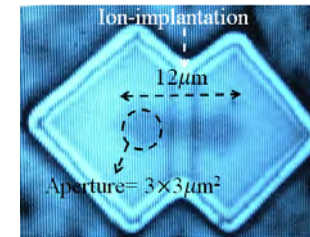
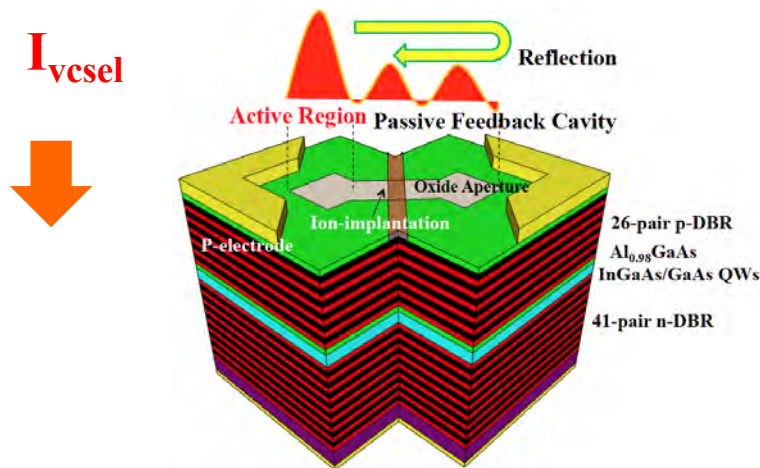
After [http://www.oct-optovue.com/](http://www.oct-<u>optovue.com/</u>)



after IBM/Agilent

Transverse-Coupled-Cavity VCSEL for High Speed Operations

Dalir and Koyama, APL, 2014



$f_{3dB} > 30$ GHz

48 Gbps

VCSEL_40th_Dec. 2017

Conclusion

VCSEL: Good for Health



Larry

Ken

23rd Microoptics Conference

MOC 2018

- Since 1987 operated by Microoptics Group, JSAP
 - 2018: Oct. 15-18 in Taipei, Taiwan
- Honorary Chairs: K. Iga, Ching-Jong Liao
- Chairs: K. Hamamoto, S. L. Lee
- Program Chair: C. F. Lin, K. Kato, S. H. Hsu
- Liaison Advisor: H. Nakajima
- Plenary Speakers:
 - Larry A. Coldren**, Lars Zimmermann,
Chihaya Adachi, Din-Ping Tsai
- Paper Submission: No later than June 1, 2018



Congratulations ! Larry for Happy Retirement





Kenichi IGA was born in Hiroshima in 1940. He received B.E., M.E., and Dr. Eng. degrees from the Tokyo Institute of Technology, in 1963, 1965 and 1968, respectively. From 1968, he joined P&I Laboratory of Tokyo Institute of Technology as Assistant Professor, became Associate Professor in 1974, and Professor in 1984. He served as Director of P&I Laboratory and University Library. From 1979 to 1980, he stayed at Bell Laboratories, Holmdel as Visiting Technical Staff Member.

He retired Tokyo Institute of Technology in March 2001 and was awarded by Professor Emeritus. Prof. Iga joined Japan Society for the Promotion of Science (JSPS) as Executive Director from April 2001 to September 2007. He served as the President of Tokyo Institute of Technology from October 2007 till September 2012.

Prof. Iga first proposed and pioneered the research of surface emitting laser (VCSEL) and microoptics. He is Fellow/Life Member of IEEE, the Fellow of OSA, IEICE of Japan, JSAP, Laser Society, respectively. He is Foreign Member of NAE of USA.

He received 1992 IEEE/LEOS William Streifer Award, 1998 IEEE/OSA John Tyndall Award, 2003 IEEE Daniel E. Noble Award, 2002 Rank Prize, 1998 Asahi Prize, 2001 Purple Ribbon Prize of Japan, 2003 Fujiwara Award, 2007 C&C Prize, and 2009 NHK Broadcast Cultural Award. In 2013, he was awarded 2013 Franklin Medal with the Bower Award and Prize in Science.