

CHEMICAL HERITAGE FOUNDATION

ROBERT T. JENKINS

Transcript of an Interview
Conducted by

David C. Brock and Hyungsub Choi

at

Los Altos and Discovery Bay, California

on

9 May and 24 July 2007

(With Subsequent Corrections and Additions)

ACKNOWLEDGMENT

This oral history is part of a series supported by grants from the Gordon and Betty Moore Foundation. This series is an important resource for the history of semiconductor electronics, documenting the life and career of Gordon E. Moore, including his experiences and those of others in Shockley Semiconductor, Fairchild Semiconductor, Intel, as well as contexts beyond the semiconductor industry.

This oral history is made possible through the generosity of the Gordon and Betty Moore Foundation.

CHEMICAL HERITAGE FOUNDATION
Oral History Program
FINAL RELEASE FORM

This document contains my understanding and agreement with Chemical Heritage Foundation with respect to my participation in the audio-recorded interview conducted by David C. Brock and Hyungsub Choi on 9 May and 24 July 2007.
I have read the transcript supplied by Chemical Heritage Foundation.

1. The audio recording, corrected transcript, photographs, and memorabilia (collectively called the "Work") will be maintained by Chemical Heritage Foundation and made available in accordance with general policies for research and other scholarly purposes.
2. I hereby grant, assign, and transfer to Chemical Heritage Foundation all right, title, and interest in the Work, including the literary rights and the copyright, except that I shall retain the right to copy, use, and publish the Work in part or in full until my death.
3. The manuscript may be read and the audio recording(s) heard by scholars approved by Chemical Heritage Foundation subject to the restrictions listed below. The scholar pledges not to quote from, cite, or reproduce by any means this material except with the written permission of Chemical Heritage Foundation.
4. I wish to place the conditions that I have checked below upon the use of this interview. I understand that Chemical Heritage Foundation will enforce my wishes until the time of my death, when any restrictions will be removed.

Please check one:

a. _____

No restrictions for access.

NOTE: Users citing this interview for purposes of publication are obliged under the terms of the Chemical Heritage Foundation Oral History Program to obtain permission from Chemical Heritage Foundation, Philadelphia, Pennsylvania.

b. _____

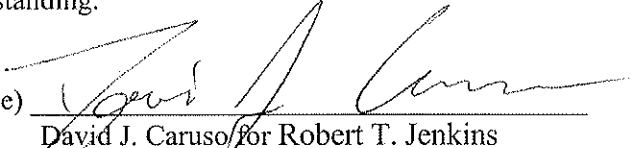
Semi-restricted access. (May view the Work. My permission required to quote, cite, or reproduce.)

c. _____

Restricted access. (My permission required to view the Work, quote, cite, or reproduce.)

This constitutes my entire and complete understanding.

(Signature) _____


David J. Caruso for Robert T. Jenkins
(Verbal agreement for Free Access)

(Date) _____

22 Jan 2010

This interview has been designated as **Free Access**.

One may view, quote from, cite, or reproduce the oral history with the permission of CHF.

Please note: Users citing this interview for purposes of publication are obliged under the terms of the Chemical Heritage Foundation Oral History Program to credit CHF using the format below:

Robert T. Jenkins, interview by David C. Brock and Hyungsub Choi at as Altos and Discovery Bay, California, 9 May and 24 July 2007 (Philadelphia: Chemical Heritage Foundation, Oral History Transcript # 0364).



Chemical Heritage Foundation
Oral History Program
315 Chestnut Street
Philadelphia, Pennsylvania 19106



The Chemical Heritage Foundation (CHF) serves the community of the chemical and molecular sciences, and the wider public, by treasuring the past, educating the present, and inspiring the future. CHF maintains a world-class collection of materials that document the history and heritage of the chemical and molecular sciences, technologies, and industries; encourages research in CHF collections; and carries out a program of outreach and interpretation in order to advance an understanding of the role of the chemical and molecular sciences, technologies, and industries in shaping society.

ROBERT T. JENKINS

Education

1965 B.S., California Institute of Technology
1966 M.S., California Institute of Technology

Professional Experience

1966-1967 Fairchild Semiconductor Research and Development Laboratories
Process Engineer

Intel Corporation

1968-1979 Variety of positions in Wafer Fabrication
1979 Manager, Microprocessor/Peripheral Manufacturing
1980-1985 General Manager, Peripheral Components Division
1986-1989 Vice President and General Manager,
Memory Components Division

1990-1999 Vice President and Director, Corporate Licensing
1996-1999 Chairman, Government Affairs Committee

2000-present California State University, Sacramento
Adjunct Professor, Communication Studies

Honors

Chairman, Board of the California Manufacturers and
Technology Association
Member, Board of Directors, Skyler Technology, Inc.
Member, Board of the Information Technology Industry Council
Member, Board of the American Electronics Association
President, Alumni Association of California Institute of Technology
President, The Associates (California Institute of Technology
support organization)
Member, Board of Trustees, California Institute of Technology

ABSTRACT

Robert T. Jenkins (Ted) grew up in Glendale, California, the suburb of Los Angeles in which his parents and grandparents had also grown up. His father was a welder, and Ted always liked to help him with his work. Together they built a swimming pool in their back yard. Jenkins also loved ham radio and cannot remember when he was not interested in electricity. He earned both his BS in engineering (there were no divisions within engineering at the time) and his MS from California Institute of Technology. While he was there he worked in the lab of Carver Mead, his advisor, and took a comprehensive business course from Horace Gilbert.

While Jenkins was in the lab Gordon Moore came to talk to Carver Mead, recruiting likely students for his company, Fairchild Semiconductor. He told Jenkins about his bipolar power transistor, and Ted became very interested. He went right from his master's degree to Fairchild, beginning in the process end of the linear integrated circuit group in Research and Development. All new employees were required to take a technology course at Fairchild, taught by Andrew Grove, Edward Snow, and Leslie Vadasz; Jenkins calls it "better than a PhD." At Fairchild, Jenkins and Garth Wilson developed and patented Schottky-barrier diode processes and devices. Half seriously, Carver Mead called the Schottky diode the Jenkins diode. Jenkins later used a Schottky diode in the design of Intel's first product, the i3101 64-bit TTL compatible RAM. Introduced in 1969, the device was nearly twice as fast as earlier TTL products.

When Jenkins had been at Fairchild for about two years, Robert Noyce and Gordon Moore left to found their own company, Noyce-Moore Electronics (or Moore-Noyce, which they thought sounded too much like "more noise," an inauspicious name for an electronics company), whose name they changed to Intel (INTEgrated ELectronics) later that year. Moore recruited a number of others from Fairchild, including Jenkins, who came in originally to help develop blue LED. He held a number of positions, working on wafers, until he was made manager of peripherals manufacturing. Intel's first product used Jenkins' Schottky diode, which doubled the speed and reduced the power consumed. Soon thereafter Jenkins became general manager of the whole peripheral components division. From there he moved to become a vice president and the general manager of the memory components division. He selected the Folsom site, within a day's drive from Santa Clara, for new fabrication plants, and explains that the Oregon site was chosen because it was not on the San Andreas Fault line. He spent his last ten years at Intel as a vice president and as director of corporate licensing. After retiring from Intel he reentered the academic world, becoming an adjunct professor at California State University at Sacramento and joining the Board of Trustees of California Institute of Technology.

INTERVIEWERS

David C. Brock is a senior research fellow with the Center for Contemporary History and Policy of the Chemical Heritage Foundation. As an historian of science and technology, he specializes in oral history, the history of instrumentation, and the history of semiconductor science, technology, and industry. Brock has studied the philosophy, sociology, and history of science at Brown University, the University of Edinburgh, and Princeton University (respectively and chronologically). His most recent publication is *Understanding Moore's Law: Four Decades of Innovation* (Philadelphia: Chemical Heritage Press), 2006, which he edited and to which he contributed.

Hyungsub Choi is the manager for Electronics, Innovation, and Emerging Technology programs at CHF. Choi earned a Ph.D. from the Johns Hopkins University in the history of science and technology. He earned an M.S. in history of technology at Georgia Institute of Technology and a B.S. in engineering from Seoul National University. Choi took over the center's electronic materials program in November 2006. He has published extensively on such subjects as the history of electronic manufacturing in post-World War II Japan, RCA's transistor production, and solid-state innovations.

TABLE OF CONTENTS

Early and College Years	1
<p>Lived in Glendale, California, ancestral home town. Helped his father, a welder, with any projects he was allowed to. Helped build swimming pool in back yard. Always liked physics and chemistry in school. Loved ham radio; mourned the demise of Morse code. Attended California Institute of Technology (Caltech) for both bachelor's and master's degrees. Worked in Carver Mead's laboratory. Decided against PhD, instead being recruited right into Fairchild Semiconductor by Gordon Moore.</p>	
Fairchild Semiconductor Years	6
<p>Received equivalent of PhD education from technology course at Fairchild, course taught by Andrew Grove, and from practical experience. Patented applications of Schottky diode.</p>	
Starting at Intel	17
<p>Recruited by Gordon Moore to Noyce-Moore Electronics, later called Intel; developed blue LED. Worked with IBM on early microprocessor chips. Microprocessor originally "good for traffic signals"; needed applications and software.</p>	
Fabrication Plants and Competition	40
<p>In charge of three fabs. Selected Folsom site. Became general manager of memory division. Trade agreement with Japan kept Intel competitive. From DRAM to EPROM to flash memory. Out of flash memory into licensing.</p>	
Reflections on Grove, Moore, and Intel	85
<p>Discussion of personalities of Andrew Grove and Gordon Moore. Discussion of Intel culture. Discussion of Intel's stock appreciation, number of patents.</p>	
Index	97

INDEX

- 1**
1101, 26, 27, 60
1103, 26, 27, 31, 37, 49, 50, 59
- 2**
2048, 49
2708, 66
- 3**
3101, 21, 23, 25
386, 72
- 4**
4004, 42
- 8**
8085, 39
8086, 39, 51, 81
8088, 39
8253, 40, 41
8255, 40, 41
- A**
Advanced Micro Devices, 45, 71, 72, 76,
83, 84
Affymetrix, 19
aluminum, 11, 12, 15, 22, 23, 24
AMD. *See* Advanced Micro Devices
American Telephone and Telegraph, 73, 75,
77, 78
Applied Materials, 32, 33, 85
argon, 3
AT&T. *See* American Telephone and
Telegraph
- B**
Baltimore, David, 93
Bardeen, John, 78
Barrett, Craig, 84
- Basic Input/Output System, 82
Bay, Tom, 9
BCD. *See* binary-coded decimal
Bell Laboratories, 68, 75, 77
binary-coded decimal, 7
BIOS. *See* Basic Input/Output System
bipolar, 5, 6, 7, 8, 11, 17, 19, 20, 21, 23, 24,
25, 31, 32, 48, 51, 57, 73, 87, 92
Bittman, Charles, 87
Boca Raton, Florida, 41, 64
Bohn, Richard, 23
Bower, Robert, 19
Brattain, Walter, 78
Burbank California, 2
Burroughs 220, 7
- C**
cadmium sulfide, 16
California Institute of Technology, 2, 4, 5,
6, 7, 18, 20, 43, 52, 90, 93, 95, 96
Caltech. *See* California Institute of
Technology
Carsten, Jack, 40, 43, 64, 65
Chou, Sunlin, 28, 48
Chua, H.T., 23
CMOS. *See* MOS
Cornet, Jean-Claude, 30
Costa Rica, 93
Cupertino, California, 50
- D**
Dallas, Texas, 4
Davidow, William H., 42, 43, 62, 89
device physics, 3, 57, 95
diffusion, 9, 12, 22, 24, 32, 55
diodes, 6, 11, 12, 13, 19, 22, 23, 28, 48, 92
Schottky diode, 11, 13, 22
DRAM, 35, 44, 45, 46, 50, 67, 69, 76, *See*
dynamic random access memory
Dunlap, Thomas, 74, 84
dynamic random access memory, 35, 53, 83

E

EPROM, 43, 45, 46, 47, 62, 66, 67, 71, 82
erasable programmable read-only memory.
See EPROM
Ernest Orlando Lawrence Berkeley National
Laboratory (LBNL), 34
eutectic, 11
Extrion Ltd., 28, 29

F

Faggin, Federico, 28, 48
Fairchild Semiconductor, 5, 6, 8, 9, 10, 11,
12, 13, 14, 15, 18, 19, 20, 35, 59, 68, 73,
86, 87, 89, 96
Federal Trade Commission, 71, 72
Fermi level, 3, 22
First Electrical Book for Boys, A, 1
Fitzgerald, Desmond, 17, 23
Flath, Eugene J., 19, 26, 27, 31, 33, 34, 36,
37
Folsom, California, 40, 42, 43, 61, 64, 65,
84
FORTRAN, 7
Frohman, Dov, 46
FTC. *See* Federal Trade Commission

G

Galilee Pacification Plan, 46, 47
gallium arsenide, 15
Gelbach, Edward L., 37, 92
germanium, 4, 15
gettering, 7, 25, 87
Gilbert, Horace N., 4, 95
Glendale High School, 1
Glendale, California, 1
gold doping, 8, 12, 13, 19, 22
Gopen, Howard, 39
Grove, Andrew S., 6, 10, 14, 15, 19, 22, 26,
27, 28, 40, 43, 62, 87, 89, 93
gunite, 1
Gunn, Henry M., High School, 19

H

Hartman, Thomas, 38

Hewlett Packard, 75
hFE, 22
HMOS. *See* MOS
Hogan, Clarence Lester, 14
Holmstrom, Robert, 32, 90
House, David, 39, 40, 43, 61, 64
Houston, Texas, 2
HP. *See* Hewlett Packard
Hughes Aircraft Company, 1, 18
Hugle Electronics, Inc., 33
hydrogen, 7, 11
Hyundai Motor Company, 76

I

IBM, 7, 39, 40, 41, 42, 56, 58, 60, 62, 63,
64, 65
integrated circuits, 7, 11, 19, 87
Intel, 3, 10, 13, 17, 19, 21, 27, 31, 39, 40,
41, 45, 46, 50, 51, 53, 58, 59, 60, 65, 66,
72, 73, 74, 80, 86, 88, 89, 91, 95, 96
International Rectifier, 4
International Trade Commission, 67, 68
ion implantation, 18, 28, 29, 51
Israel, 46
ITC. *See* International Trade Commission

J

Japan, 44, 70, 81, 82
Jarrett, James, 84
Jerusalem, Israel, 47

K

Kilby, Jack S., 8
Kirchoff's Laws, 5
Kulicke and Soffa, 33

L

L.A.. *See* Los Angeles, California
Law, Trevor, 35
light-emitting diodes, 14
Livermore, California, 31, 34, 35, 39, 49,
50, 51
Los Altos Hills, California, 6
Los Angeles, California, 1, 2

M

magnetics, 43
mask, 3, 8, 11, 15, 33, 36, 51, 55, 80
mask works, 80, 81
Massachusetts Institute of Technology, 20, 73
Matthews, Walter, 36
McCaldin, James O., 16, 18
Mead, Carver A., 3, 5, 6, 12, 13, 14, 17, 18, 93, 96
metal oxide semiconductor, 11, 19, 20, 21, 24, 25, 28, 32, 34, 46, 53, 60, 87, 90, 92
 complementary metal oxide semiconductor, 26, 27, 28, 30, 31, 33, 48, 51, 52, 54, 55, 58, 59, 60, 86
 n-metal oxide semiconductor, 31, 55, 60, 86
Metter, Jim, 34
Michener, James A., 46
Microma, 30, 48, 58
Millikan, Robert A., 4
Minuteman missile, 20, 73
MIT. *See* Massachusetts Institute of Technology
Monsanto Company, 17
Moore, Gordon, 5, 9, 10, 12, 21, 27, 32, 67, 73, 84, 85, 86, 89, 90, 91, 92, 93, 94
Morse code, 1
MOS. *See* metal oxide semiconductor
 HMOS, 48, 53, 54, 58, *See* metal oxide semiconductor
Motorola, 14, 78
Mount St. Helens, 36

N

National Semiconductor, 9, 14
N-channel, 28, 31, 48, 49, 51, 55, 67
NEC. *See* Nippon Electric Company
Nippon Electric Company, 81, 82
NMOS. *See* MOS
North American Aviation Science Center, 18
Noyce, Robert N., 8, 9, 10, 14, 96

O

Oregon, 28, 36, 38, 40, 44, 61
Otellini, Paul S., 40, 62
Ottawa, Canada, 25
oxide, 8, 11, 12, 15, 20, 22, 32, 47, 52, 55, 57, 58, 60, 90

P

Palo Alto, California, 4, 29
Parker, Gerhard, 6, 17, 22, 52, 86, 90
Pasadena, California, 2, 15
Pashley, Richard, 52, 54, 69, 86
Patterson, Tonia, 50
PC. *See* personal computer
P-channel, 20, 28, 31, 46, 48, 49, 51, 54, 55, 66
Perkin Elmer, 33, 36
personal computer, 35
Phoenix, Arizona, 4, 23
phosphorus, 21, 25, 26, 87
Pilling, David, 9
Poughkeepsie, New York, 39, 41, 63, 65

R

RAM, 45, 53, 63, 69
Rice University, 2
ring oscillator, 52, 54, 86
Rock, Arthur, 10, 85
Rowe, Thomas, 20, 21, 25, 28, 73
Rubylith, 21, 23, 36
Rudin, Marvin, 9

S

Sacramento, California, 40, 41, 88
Samsung, 44, 70
San Andreas Fault, 35
Santa Clara, California, 29, 37, 43, 64, 88, 93
Sarbanes-Oxley Act, 86
Schneer, George, 69
Scholastic Aptitude Test, 2
Schottky. *See* diodes
selenium, 5
SEMATECH, 45

SEMI, 45
semiconductors, 3, 16, 68, 79
Shockley, William, 78
silicon, 4, 5, 7, 11, 12, 15, 22, 23, 28, 32,
47, 48, 52, 59, 60, 85, 90, 91
Snow, Edward H., 6
Source, The, 46
Sporck, Charles E., 9
Stanford University, 28
surface physics, 10, 87
Syria, 47

T

Taiwan, 68
Tel Aviv, Israel, 47
Texas Instruments, 8, 37, 75, 78, 79, 91, 92
TI. *See* Texas Instruments
transistors, 7, 11, 20, 28, 30, 49, 81, 87, 95
TRW, Inc., 4

U

UCSB. *See* University of California, Santa
Barbara
University of California, Berkeley, 6, 28,
32, 90

University of California, Santa Barbara, 1
University of Southern California, 1
USC. *See* University of Southern California

V

Vadasz, Leslie L., 6, 30, 40, 92
Varian, Inc., 28
Veeco High Performance, Inc., 33

W

wafer, 8, 11, 12, 22, 25, 31, 32, 33, 34, 35,
36, 37, 49, 50, 51, 52, 53, 54, 57
N-type, 11, 16, 21, 28, 48, 54
P-type, 11, 21, 28
Whittier, Ronald J., 28, 69, 86
Widlar, Robert J., 9
Wilson, Garth H., 6, 13
Woodside, California, 4

Y

Yu, Albert, 90

Z

zinc sulfide, 15, 16