CHEMICAL HERITAGE FOUNDATION

ALAN J. HEEGER

Transcript of an Interview
Conducted by

Cyrus Mody

at

Santa Barbara, California

on

13 and 16 March 2006

(With Subsequent Corrections and Additions)

ACKNOWLEDGEMENT

This oral history is part of a series supported by the Center for Nanotechnology in Society (CNS), University of California, Santa Barbara, under the National Science Foundation Grant No. SES 0531184. Scholars and other people using this interview should acknowledge in all written publications. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the interviewee and interviewer and do not necessarily reflect the views of the National Science Foundation.

This oral history series is an important resource for the history of nanotechnology, documenting the lives and career of key scientists and engineers that shaped and contributed to the contemporary practice of science and technology.

Center for Nanotechnology in Society
University of California, Santa Barbara

Oral History Interview Agreement

A central mission of the Center for Nanotechnology in Society ('CNS') is to preserve and make known the history of nanotechnology and nanoscience.

In pursuit of its mission, the Center is conducting, or has conducted, an oral history interview with you ("the interviewee"). The purpose of this agreement is to allow the Center to make this interview available to scholars, teachers, students, and other members of the interested public; to use the contents of this interview in its exhibits, teaching modules and other publications; and to transfer the contents of this interview to other media or institutions, such as the American Institute of Physics and the Chemical Heritage Foundation, for purposes of access and/or preservation.

This agreement does not restrict the interviewee's own use of this interview in any way.

The interviewee grants to the CNS a perpetual, irrevocable, royalty-free right to copy, distribute, publish, and to use this interview in any written or electronic materials, or other media or formats now existing or hereafter devised. The interviewee authorizes CNS to create an abstract and index for this interview, and to create and distribute derivative works in accord with its mission.

Print Name of Interviewee: Alan Heeger

Signature of Interviewee: Alan J Heeger

Date: April 24 2006

Print Name of Interviewer: Cyrus Mody

Date(s) of Interview: March 13th and 16th, 2006

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.

ALAN J. HEEGER

1936	Born in Sioux City, Iowa on 22 January

Education

1957	B.S. with High Distinction, physics and mathematics, University of Nebraska
1961	Ph.D., physics, University of California at Berkeley

Professional Experience

	University of Pennsylvania
1962-1964	Assistant Professor
1964-1967	Associate Professor
1967-1982	Professor
1974-1981	Director, Laboratory for Research on the Structure of Matter
1981-1982	Acting Vice-Provost for Research
	University of Geneva
1968-1969	Visiting Professor of Physics
	University of California at Santa Barbara
1982-1999	Director, Institute for Polymers and Organic Solids
1982-present	Professor of Physics
1987-present	Professor of Materials (Engineering)
	University of Utah
1988-present	Adjunct Professor of Physics
	UNIAX Corporation
1990-1994	Founder and President
1994-present	Chief Scientist, Chairman of the Board

Honors

1963-1965	Alfred P. Sloan Foundation Fellow
1968-1969	John Simon Guggenheim Foundation Fellow
1968	American Physical Society Fellow

1983	Oliver E. Buckley Prize for Condensed Matter Physics
1989	John Scott Award
1992	Doctor of Science (h.c.), Université d'Etat a Mons, Belgium
1995	Balzan Prize, "Science of New Materials," Bern, Switzerland
1996	Doctor of Technology (h.c.), University of Linköping, Sweden
1996	Doctor of Technology (h.c.), Abo Akademi University, Finland
1999	Doctor of Humane Letters (h.c.), University of Massachusetts at Lowell
1999	Doctor of Science (h.c.), University of Nebraska
2000	Nobel Prize in Chemistry
2000	Institute of Physics Fellow, UK
2001	Doctor of Science (h.c.), Japan Advanced Institute for Science and Technology
2001	Doctor of Science (h.c), South China Institute of Science and Technology
2001	National Academy of Sciences (USA)
2001	President's Medal for Distinguished Achievement, University of Pennsylvania
2001	Chancellor's Medal, University of California at Santa Barbara
2001	Korean Academy of Science (Foreign Member)
2001	Doctor of Philosophy (h.c.), Bar-Ilan University, Israel
2001	Presidential Chair, University of California at Santa Barbara
2002	National Academy of Engineering (USA)
2005	Doctor of Science (h.c.), Trinity College, Dublin
2005	Albert Einstein Honorary Chair Professor, Chinese Academy of Sciences

ABSTRACT

Alan J. Heeger begins the interview by describing his early decision to attend college and reasons behind changing his major from electrical engineering to mathematics and physics at the University of Nebraska. After obtaining his undergraduate degree, Heeger enrolled in Cornell University to pursue his interest in theoretical physics. After one year Heeger moved and attended University of California at Berkeley and switched his focus to experimental physics. Upon receiving his Ph.D. under Alan Portis, Heeger took an assistant professorship at the University of Pennsylvania's physics department. At Penn Heeger's interests included spin-wave theory, metal physics, the Kondo problem, and nuclear magnetic resonance (NMR) in magnetic materials. After achieving tenure, Heeger took a sabbatical at the University of Geneva to work on metal physics. Before leaving for Geneva, Heeger was introduced to TCNQ and shifted the focus of his research on that upon returning to the United States. Then in 1973, Heeger began investigating polysulfur nitride along with Alan MacDiarmid and Hideki Shirakawa that led to seminal publications on conducting polymers. After twenty years at the University of Pennsylvania, Heeger moved to the University of California at Santa Barbara's physics department, where he continued to conduct his research and collaboration with other scientists. Heeger concludes the interview by discussing thoughts of his role as a device physicist, and how he can best move technology development forward.

INTERVIEWER

Cyrus Mody is an Associate Professor of History at Rice University. Prior to that position he was the manager of the Nanotechnology and Innovation Studies programs in the Center for Contemporary History and Policy at the Chemical Heritage Foundation. He has a bachelor's degree in mechanical and materials engineering from Harvard University and a Ph.D. in science and technology studies from Cornell. He was the 2004-2005 Gordon Cain Fellow at CHF before becoming a program manager. Mody has published widely on the history and sociology of materials science, instrumentation, and nanotechnology.

TABLE OF CONTENTS

NOTES

1. Theodore P. Jorgensen, *The Physics of Golf* (New York: The American Institute of Physics, 1999).

2. Alan J. Heeger, Alan G. MacDiarmid, and Hideki Shirakawa were awarded the 2000 Nobel Prize in Chemistry for the discovery and development of conductive polymers.

3. Walter Kohn was awarded the 1998 Nobel Prize in Chemistry for his development of the density-functional theory.

4. *Power of the Sun*, DVD, directed by David Kennard (University of California Santa Barbara, 2005).

5. Charles Kittel, *Introduction to Solid State Physics, 2nd Edition* (New York: Wiley, 1956).

6. Kenneth G. Wilson was awarded the Nobel Prize in Physics in 1982 for his theory for critical phenomena in connection with phase transitions.

7. I. Dzialoshinsky, "A thermodynamic theory of "weak" ferromagnetism of antiferromagnetics," *Soviet Physics JETP* 6 (1958): 1130.

8. A. A. Abrikosov, L. P. Gorkov, and I. E. Dzyaloshinskii, *Methods of Quantum Field Theory in Statistical Physics*, Translated and edited by Richard A. Silverman (New York: Dover Publications, 1975, c1963).

9. A. J. Heeger, A. M. Portis, O. Beckman, "Magnetic Properties of KMnF3. II. Weak Ferromagnetism," *Physical Review* 123, no. 5 (1961): 1652-1660.

10. Eric Lax, *The Mold in Dr. Florey's Coat: The Story of the Penicillin Miracle* (New York: Henry Holt and Company, 2004).

11. Sir Alexander Fleming, Ernst Boris Chain, and Sir Howard Walter Florey were awarded the Noble Prize in Medicine in 1945 for the discovery of penicillin and its curative effect in various infectious diseases.

12. T. Nagamiya, K. Yosida, M. Kubo, "Antiferromagnetism," *Advances In Physics* 4, no. 13 (1955): 1-112.

13. W. H. Parker, D. N. Langenberg, A. Denenstein, and B. N. Taylor, "Determination of e/h, Using Macroscopic Quantum Phase Coherence in Superconductors: Implications for Quantum Electrodynamics and the Fundamental Physical Constants," *Rev. Mod. Phys.* 41 (1969), 375–496.

14. Leo Esaki and Ivar Giaever were awarded the Noble Prize in Physics in 1973 for their experimental discoveries regarding tunneling phenomena in semiconductors and superconductors, respectively. Brian David Josephson was awarded the Noble Prize in Physics in 1973 for his theoretical predictions of the properties of a supercurrent through a tunnel barrier, in particular those phenomena which are generally known as the Josephson effects.

15. A. J. Heeger, "Kondo Effect: Does it Exist?" *Journal of Applied Physics* 41, Issue 3 (1970): 1129-&.

16. A. J. Heeger, P. Pincus, "Spin-Wave Instability and Premature Saturation in Antiferromagnetic Resonance," *Physical Review Letters* 10 (1963): 53-55.

17. Neil W. Ashcroft and N. David Mermin, *Solid State Physics* (New York: Holt, Rinehart and Winston, 1976).

18. A. J. Heeger, M. A. Jensen, "Ground State of Kondo Many-Body Scattering Problem," *Physical Review Letters* 18 (1967): 488-491.

19. P. W. Anderson, P. Morel, "Calculation of the Superconducting State Parameters with Retarded Electron-Phonon Interaction," *Physical Review* 125 Issue 4 (1962): 1263-1271.

20. B. Giovanni, A. J. Heeger, M. Peter, "Spin Fluctuation Effects With Strongly Magnetic Impurities," *Helvetica Physica Acta* 43, Issue 2 (1970): 101-&.

21. P. W Anderson, "Absence of Diffusion in Certain Random Lattices," *Physical Review* 109, Issue 5 (1958): 1492-1505.

22. L. B. Coleman, M. J. Cohen, D. J. Sandman, et al, "Superconducting Fluctuations and Peierls Instability in an Organic Solid," *Solid State Communications* 12, no. 11 (1973): 1125-1132.

23. G. A. Thomas, D. E. Schafer, F. Wudl, et al, "Electrical-Conductivity of Tetrathiafulvalenium-Tetracyanoquinodimethanide (TTF-TCNQ), *Physical Review B* 13, no. 11 (1976): 5105-5110.

24. V. V. Walatka, M. M. Labes, J. H. Perlstei, "Polysulfur Nitride—One-Dimensional Chain With a Metallic Ground-State," *Physical Review Letters* 31 (1973): 1139-1142.

25. P. M. Grant, R. L. Greene, G. B. Street, "Optical-Properties of Polymeric Sulfur Nitride, (SN)x," *Physical Review Letters* 35, Issue 25 (1975): 1743-1746.

26. A. A. Bright, M. J. Cohen, A. F. Garito, et al, “Optical Reflectance of Polymeric Sulfur Nitride Films from Ultraviolet to Infrared,” *Physical Review Letters* 34, Issue 4 (1975): 206-209.

27. C. K. Chiang, A. J. Heeger, A. G. MacDiarmid, “Effect of Uniaxial Stress on Electrical-Conductivity of Sulfur Nitride Polymer,” *Physics Letter A* 60 (1977): 375-377.

28. M. Akhtar, J. Kleppinger, A. G. MacDiarmid, J. Milliken, M. J. Moran, C. K. Chiang, M. J. Cohen, A. J. Heeger, D. L. Peebles, “A ‘metallic’ derivative of polymeric sulphur nitride: poly(thiazylbromide), (SNBr0.4)x,” *J. Chem. Soc., Chem. Commun.* (1977): 473—474.

29. C. K. Chiang, C. R. Fincher, Jr., Y. W. Park, A. J. Heeger, H. Shirakawa, E. J. Louis, S. C. Gau, and A. G. MacDiarmid, “Electrical Conductivity in Doped Polyacetylene,” *Physical Review Letters* 39 (1977): 1098—1101.

30. K. Lee, S. Cho, S. H. Park, A. J. Heeger, C. W. Lee, S. H. Lee, “Metallic Transport in Polyaniline,” *Nature* 441, No. 7089 (2006): 65-68.

31. M. J. Rice, E. J. Mele, “Phenomenological Theory of Soliton Formation in Lightly-Doped Polyacetylene,” *Solid State Communications* 35, Issue 6 (1980): 487-491.

32. W. P. Su, J. R. Schrieffer, A. J. Heeger, “Soliton Excitations in Polyacetylene,” *Physical Review B* 22 (1980): 2099-2111.

33. Kenichi Fukui and Roald Hoffmann were awarded the Nobel Prize in Chemistry in 1981 for their theories, developed independently, concerning the course of chemical reactions.

INDEX

D

E

F

G

V

W