

GERHARD ERTL, 2007 NOBEL CHEMISTRY LAUREATE

J.-P.Adloff, G.B.Kauffman*

(Université Louis Pasteur, Strasbourg, France. jp.adloff@noos.fr;

* California State University, Fresno, CA, USA. georgek@csufresno.edu)

On October 10, 2007 Svenska Kungliga Vetenskapsakademien (the Royal Swedish Academy of Sciences) awarded the Nobel Prize in Chemistry to the German physical chemist Gerhard Ertl, Professor Emeritus at the Abteilung Physikalische Chemie, Fritz-Haber-Institut der Max-Planck-Gesellschaft [1] in Berlin “for his studies of chemical processes on solid surfaces” [2–13]. Ertl received the unexpected but welcome news on his 71st birthday. He told Deutsche Presse-Agentur (DPA), “I got two presents today... I was almost in tears. Of course, one knows that one is a candidate. Yesterday [October 9, 2007] the Physics prize went to a German [13], so I thought the Prize for Chemistry should not go to me” [14]. Ertl will receive the Nobel gold medal, certificate, and the 10 million Swedish kronor (\$1,5 million) prize money in Stockholm from the hands of Swedish King Carl XVI Gustav on December 10, 2007, the 111th anniversary of Alfred Bernhard Nobel’s (1833-1896) death. The award was the first to be granted to a surface chemist since Irving Langmuir (1881-1957) received the prize in 1932 “for his outstanding discoveries and inventions in the field of surface chemistry”.



Gerhard Ludwig Ertl, the son of Ludwig and Johanna Ertl (née Schneider), was born on October 10, 1936 in Bad Cannstadt, a district of Stuttgart, Germany. He attended the Kepler Gymnasium (high school) in Bad Cannstadt and obtained his *Abitur* (the diploma required for higher studies) in 1955. He studied physics at the Technische Universität Stuttgart (1955-1957), followed by an academic year (1957-1958) at the Université de Paris and a second academic year (1958-1959) at the Ludwig-Maximilians-Universität in Munich. Returning to Stuttgart, Ertl worked from 1959 to 1961 on his diploma (Dipl. Physiker) thesis, “Temperature jump experiments to study fast dissociation reactions using microwave pulses” [16], under the guidance of Heinz Gerischer (1919-1994), who was then working at the Max-Planck-Institut für Metallforschung in Stuttgart. In 1962 Gerischer was appointed Professor of Physical Chemistry at the Technische Hochschule München (after 1970, Technische Universität München, TUM), where he remained until 1969.

On September 18, 1964, Ertl married Barbara Maschek; the couple has two children, Christine and Mathias, and three grandchildren. Ertl followed

Gerischer as an assistant, and in 1965 under his mentor's supervision he completed the thesis for his doctorate (Dr. rer. nat.), "On the kinetics of the catalytic hydrogen oxidation on germanium single crystals" [17]. In 1967, he submitted his *Habilitationsschrift* (original research paper required to teach at a college or university), "Surface structural and reactivity studies using low energy diffraction" [18], and he became a *Privatdozent* (an unsalaried lecturer whose income is derived from *Kollegiengelder* – fees paid by the students who enroll in his courses). He then accepted a chair at the Technische Universität Hannover, where he became Professor and Director at the Institute of Physical Chemistry (1968-1973). In 1973, together with his research group he returned to Munich where he held the same position at the Ludwig-Maximilians-Universität until 1985.

During these years, Ertl was Visiting Professor at the California Institute of Technology in Pasadena (1976-1977), the University of Wisconsin, Milwaukee (1979), and the University of California, Berkeley (1981-1982). He retained his position in Munich despite tempting offers from the prestigious University of California, Santa Barbara and Westfälische Wilhelms-Universität Münster. In 1985, he succeeded his mentor Gerischer as Director of the Department of Physics at the Fritz-Haber-Institut der Max-Planck-Gesellschaft in Berlin, taking along with him his entire research team from Munich. At the same time, he became Honorary Professor at the Technische Universität and the Freie Universität Berlin. After the reunification of Germany in 1989, he also assumed the same position at the Humboldt Universität zu Berlin. In 2004, Ertl retired as Professor Emeritus, an event that was commemorated in a *Festschrift* published in a special issue of the *Journal of Physical Chemistry* [15].

Chemical reactions on solid surfaces are the *Leitmotiv* of Ertl's scientific work. The press release for the Nobel Prize award explains: "Gerhardt Ertl has founded an experimental school of thought by showing how reliable results can be attained in this difficult area of research. His insights have provided the scientific basis of modern surface chemistry; his methodology is used in both academic research and the industrial development of chemical processes" [2].

Step by step Ertl created a methodology for surface chemistry by demonstrating how different procedures can be used to provide a complete picture of a surface reaction. Reactions on metallic surfaces are prominent for catalysis as emphasized by the Committee for the Wolf Foundation Prize in Chemistry, which was awarded to Ertl in 1998: "Gerhard Ertl has determined the detailed mechanisms at the molecular level, of the catalytic synthesis of ammonia over iron and the catalytic oxidation of carbon monoxide over palladium. During these very careful studies, he discovered the important phenomenon of oscillatory reactions on platinum surfaces and, using photoelectron microscopy, was able to image for the first time the oscillating changes in surface structure and coverage that occur during reaction. His work has been especially distinguished by his ability to design experiments, which

identify and isolate the key parameters, which control chemical reactions at catalytic surfaces” [19].

Ertl also elucidated the mechanism of the Haber–Bosch industrial process for the synthesis of ammonia from elemental hydrogen and nitrogen on an iron catalyst [20] and of the oxidation of carbon monoxide on platinum, a reaction that takes place in the exhaust pipes of cars. His work on surface chemistry also found applications in many processes that are vital today, such as those involving chlorofluorocarbons (CFCs, “freons”) used in air conditioning systems that cause deterioration of the ozone layer by reacting on the surfaces of small crystals of ice in the troposphere, rusting that occurs on exposure of iron surfaces to oxygen, the manufacture of semiconductor materials for the electronics industry, and renewable fuels produced on catalytic surfaces [21] (Figure). Ertl's scientific bibliography consists of almost 700 publications from 1961 to 2007 with contributions of more than a hundred Ph.D. students and many postdoctoral associates from all over the world.



Some Applications of Surface Reactions.

Surface reactions are vital in cleaning automobile exhausts, in reactions reducing the ozone layer, in preventing the rusting of iron surfaces, and in the production of renewable fuels, semiconductor materials, and artificial fertilizers. (Courtesy, Nobel Foundation)

Ertl is a member of the advisory editorial boards of many journals, for example, *Angewandte Chemie*, *Science*, *Faraday Transactions*, the European journal *Physical Chemistry Chemical Physics*, and the *Chinese Journal of Catalysis*. He is co-editor of the *Handbook of Heterogeneous Catalysis*, the second of the eight volumes of which will appear in 2008.

The list of Ertl's honors, awards, memberships, and lectureships is impressive. In 2007 alone, in addition to the Nobel Prize in Chemistry, he received the Gold Medal of the Slovak Chemical Society and the Otto Hahn Prize in Chemistry and Physics given jointly by the German Chemical and Physical Societies and the city of

Frankfurt-am-Rhein, he held the Faraday lectureship, the oldest award of the Faraday Division of the Royal Science Academy, and the Baker lectureship at Cornell University.

In 1998, together with Gabor A. Somorjai (b. 1935) of the University of California, Berkeley, Ertl won the Chemistry Prize of Israel's Wolf Foundation “for their outstanding contributions to the field of the surface science in general and for their elucidation of fundamental mechanisms of heterogeneous catalytic reactions at single crystals surfaces in particular” [19]. Ertl also received the Centenary Medal of the Royal Society (1985), the Japan Prize of the Science and Technology Foundation of Japan (1992), and the Medard

W. Welch Award of the American Vacuum Society (1995). Ertl had earned his first foreign awards when he was a Visiting Professor in the United States – the Sherman Fairchild Distinguished Scholar at the California Institute of Technology (1976), the E.W. Muller Award from the University of Wisconsin, Milwaukee (1979), and the Paul H. Emmett Award in Fundamental Catalysis from the North American Catalysis Society (1979). Altogether, he held more than 40 lectureships in Europe, the United States, and Japan.

Ertl received a large number of awards from German scientific institutions, including the Justus von Liebig Medal (1987) and the Karl Ziegler Prize (1998), both from the Gesellschaft Deutscher Chemiker, the Carl Friedrich Gauss Medal of the Braunschweigische Wissenschaftliche Gesellschaft (1985), the Leibniz Prize of the Deutsche Forschungsgemeinschaft (1991), and the Robert Wilhelm Bunsen Medal of the Deutsche Bunsengesellschaft für Physikalische Chemie (1992). He holds honorary doctorates from the universities of Bochum, Germany (1992), Münster, Germany (2000), Aarhus, Denmark (2003), Leuven, Belgium (2003), Göteborg, Sweden (2003), and, as seen above, of the three Berlin Universities. In 1992, he received the *Grosses Bundesverdienstkreuz* (high reward for merit) from the President of the Bundesrepublik Deutschland. Ertl is an honorary fellow of the Royal Society of Edinburgh (1985), foreign honorary member of the American Academy of Arts and Sciences (1993), corresponding member of the Österreichische Akademie der Wissenschaften (2001), foreign associate of the U.S. National Academy of Sciences (2002), honorary member of the Deutsche Bunsengesellschaft für Physikalische Chemie (2006), and member of several German scientific academies, including the prestigious Leopoldina (1986) [22, 23].

When he relaxes, Ertl plays the piano, mostly classical but also popular songs. He often plays for his colleagues when there is a celebration at the institute, where he still has an office. He has two cats and a holiday home in Bavaria [14]. In 2004 Ertl retired from his position as Director of the Abteilung Physikalische Chemie, Fritz-Haber-Institut der Max-Planck-Gesellschaft. The Editors of the *Festschrift* commemorating the event stated he would leave a gap that will be hard to fill. We are sure; however, this will not set an end to his scientific curiosity... Gerhard Ertl has, as no one else, influenced the fate and direction of surface science and we are grateful for it [15].

On this occasion his colleagues, students, and associates wished Ertl and his family – his wife Barbara, his two children, and three grandchildren – the tranquility of retirement, a hope hardly consistent with the award of the Nobel Chemistry Prize to this indefatigable researcher. His retirement will likely be an active one, for he told Adam Smith: “A scientist is never, never at the end, and when we solve a problem, five other problems develop anew. So that’s why a scientist will always think about his work and what he can do next... I think you never should give up, you should always try to solve the problem as

far as it is possible. And you must be patient. You must be patient. That's very important" [6].

References and Notes¹

1. Fritz-Haber-Institut der Max-Planck-Gesellschaft. Department of Physical Chemistry. <http://w3.rz-berlin.mpg.de/pc/pc.html> (accessed Nov 2007).

2. The Nobel Prize in Chemistry 2007. http://nobelprize.org/nobel_prizes/chemistry/laureates/2007 (accessed Nov 2007).

3. Scientific Background on the Nobel Prize in Chemistry 2007. Chemical Processes on Solid Surfaces. http://nobelprize.org/nobel_prizes/chemistry/laureates/2007/sci.html (accessed Nov 2007).

4. Adam Smith. The Nobel Prize in Chemistry 2007. Exploring Chemistry at the Frontier. http://nobelprize.org/nobel_prizes/chemistry/laureates/2007/speedread.html (accessed Nov 2007).

5. The Nobel Prize in Chemistry 2007. Press Release. Modern surface chemistry – fuel cells, artificial fertilizers and clean exhaust. http://nobelprize.org/nobel_prizes/chemistry/laureates/2007/press.html (accessed Nov 2007).

6. Gerhard Ertl. Interview with Adam Smith, Editor-in-Chief of Nobelprize.org. http://nobelprize.org/nobel_prizes/chemistry/laureates/2007 (accessed Nov 2007).

7. Service, R.F. Nobel Prizes: Chemistry Laureate Pioneered New School of Thought Service. *Science* **2007**, *318*, 373-374.

8. Cressey, D. Happy Birthday. Chemist's work on surface reactions secures an unusual present. *Nature* **2007**, *449*, 767. <http://www.nature.com/news/2007/071017/full/449767a.html> (accessed Nov 2007).

9. Maugh II, T.H. Another Nobel for a German. The chemistry prize goes to Gerhard Ertl for groundbreaking studies on surface reactions. His fellow citizen shared the physics award a day earlier. *The Los Angeles Times*, October 11, 2007, p.A3.

10. Ritter, M. German wins Nobel for chemistry research. *The Fresno Bee*, October 11, 2007, p A11.

11. Halford, B. Nobel Prize in Chemistry. Awards: German chemist nabs prize for surface science on his 71st birthday. *Chem. Eng. News* **October 15, 2007**, *85* (42), 9.

12. BBC News. Surface chemistry awarded Nobel. German scientist Gerhard Ertl has been awarded the 2007 Nobel Prize for chemistry for his studies of processes on solid surfaces. <http://newsvote.bbc.co.uk/mpapps/pagetools/print/news.bbc.co.uk/2/hi/science/nature/7037210.stm> (accessed Nov 2007).

13. The 2007 Nobel Prize in Physics was awarded to the German Peter Grünberg (b. 1939) of the Research Center Jülich and the Frenchman Albert Fert (b. 1938) of Centre National de la Recherche Scientifique (CNRS) and the Université de Paris-Sud at Orsay "for the discovery of Giant Magnetoresistance." http://nobelprize.org/nobel_prizes/physics/laureates/2007 (accessed Nov 2007); Associated Press. Europeans share Nobel for Physics. *The Fresno Bee*, October 10, 2007, p A13; Cho, A. Effect that Revolutionized Hard Drives Nets a Nobel. *Science* **2007**, *318*, 179; Petkewich, R. Nobel Prize in Physics. Awards: Pair shares prize for discovery that enabled high-density computer hard disks. *Chem. Eng. News* **October 15, 2007**, *85* (42), 13.

¹ Библиографическое описание оставлены в авторской редакции. – Прим.ред.

14. Profile: Nobel prize the perfect birthday present for Ertl. Deutsche Presse-Agentur. October 10, 2007. http://science.monstersandcritics.com/features/printer_1364188.php (accessed Nov 2007).

15. Freund, H.J.; Knözinger H., Eds. Foreword for the Gerhard Ertl Festschrift. *J. Phys. Chem. B* **2004**, *108*, 14183-14186.

16. Ertl, G., Gerischer, H. Eine Temperatursprungmethode zur Untersuchung schneller Dissoziationsreaktionen mit Hilfe eines Mikrowellen-Impulses. *Ber. Bunsenges. Phys. Chem.* **1961**, *65*, 629–633.

17. Ertl, G. Über die Kinetik der katalytischen Oxidation von Wasserstoff an Germanium Einkristallen. *Z. Phys. Chemie (Frankfurt)* **1965**, *46*, 49-62.

18. Ertl, G. Untersuchung von Oberflächenreaktionen an Kupfer mittels Beugung langsamer Elektronen (LEED). *Surf. Sci.* **1967**, *7*, 309-331.

19. The 1998 Wolf Foundation Prize in Chemistry. <http://www.wolffund.org.il/full.asp?id=58> (accessed Nov 2007).

20. Fritz Haber (1868-1934) received the 1918 Nobel Chemistry prize (awarded in 1919) for the synthesis of ammonia. Together with Carl Bosch (1874-1940) he established the Haber-Bosch procedure for a large-scale catalytic production of ammonia from hydrogen and nitrogen. A scientific “family relation” links Fritz Haber to Gerhard Ertl via Karl Friedrich Bonhoeffer (1899-1957) and Heinz Gerischer, who all acted successively as Directors at the Fritz-Haber-Institut.

21. Information for the Public. The Nobel Prize in Chemistry 2007. From artificial fertilizers to clean exhaust. http://nobelprize.org/nobel_prizes/chemistry/laureates/2007/info.html (accessed Nov 2007).

22. The Deutsche Akademie der Naturforscher Leopoldina, founded in 1652 in Schweinfurth, is the oldest academy in Germany; since 1878 its seat has been in Halle. Members selected from all over the world have distinguished themselves by demonstrating scientific excellence. The number of members is limited to one thousand.

23. For a more detailed list of Ertl’s education, positions, honors, memberships, and publications log onto <http://hcr3.isiknowledge.com/author.cgi?&id=312> (accessed Nov 2007).