BIOGRAPHICAL MEMOIRS

Robert Gomer

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A Biographical Memoir by Robert L. Opila

Figure 1 Robert Gomer with one of his field emission microscopes. *Photo courtesy of Hanna Holborn Gray Special Collections Research Center, University of Chicago Library.*

Robert Gomer was a chemical physicist most notable for his pioneering techniques in the study of surface physics and chemistry. He made notable contributions to the surface diffusion of atoms and molecules and adsorbates on metallic surfaces. He was also a distinguished academic who spent almost fifty years teaching at the University of Chicago. Devoted to lifelong learning, Gomer and his wife, Anne, established an interdisciplinary lecture series that brought a range of scholars to their Hyde Park home.

Robert Gomer grew up in Vienna as the only child of Richard Goldmann, a dermatologist, and Mitzi Goldmann. The Goldmanns lived in the same building as the chancellor of Austria. Gomer attended the Akademisches Gymnasium. While there, he was friends with Walter Kohn, who became a Canadian physicist and chemist and shared the Nobel Prize in Chemistry with John Pople in 1998. Gomer's family was Jewish, and in 1938 when the decrees banning Jewish doctors from practicing were issued, Gomer's parents fled the country and moved to London. When Gomer was fourteen, his parents moved to the United States without him, leaving him in London with another Jewish family. Gomer's father got a license to practice medicine and became a dermatologist in a small town in Ohio. During the Blitz, when children in London were sent to the countryside, Gomer was taken in by a farm family near Dundee, Scotland.

The Austrian borders closed a few months after Gomer and his parents left, trapping all the remaining members of Gomer's family. All of Gomer's family members were later killed in the concentration camps, other than Mitzi Goldmann's brother, Fritz Feigl. Feigl was an analytical chemist on the faculty at the University of Vienna and had developed spot tests. The Brazilian government wanted Feigl to develop spot tests for them, and they made an agreement with the Germans to have Feigl released from a concentration camp and sent to Brazil. Feigl went on to a successful career in Brazil. The trauma of being Jewish in Vienna in the 1930s had a major psychological influence on Gomer, including having to wear a yellow star outside the apartment, abuse from the Nazis, the experience of his life being suddenly uprooted in 1938, and all his relatives being killed. (Several committed suicide when the Nazis came to take them away.)

In 1940, Gomer came to the United States and became an undergraduate at Pomona College in California, majoring in chemistry. Around 1942, Richard Goldmann changed the family name to Gomer. There were no summer breaks because of the war, so everyone graduated in two and a half years. From 1943–45, Gomer served in the U.S. Army. Like many chemistry and physics graduates, the Army did not send Gomer off to fight; instead, he went to a series of technical schools to learn about radios, which were so important to the war effort, and other technical aspects related to national defense.

After his term of service, he began doctoral studies at the University of Rochester with W. Albert Noyes Jr. Noyes had studied at the University of Paris (Sorbonne), where he was a graduate assistant in the lab of Henry Le Chatelier and earned his Ph.D. in chemistry just after World War I. Gomer completed his Ph.D. studies with a thesis entitled "Photochemistry of ethylene oxide and mercury dimethyl." The photochemical degradation of ethylene oxide occurs through a mechanism still known as the Gomer-Noyes mechanism.[1,2] Gomer then became a postdoc at Harvard University with George Kistiakowsky, with whom he developed a method to determine the absolute rate of recombination of two methyl radicals, a fundamental result that has proved most useful for determining the rates of other free-radical reactions.[3] As part of the Manhattan Project, Kistiakowsky developed the lenses for the explosives used in the atomic bomb. He also served as the science advisor to Pres. Dwight D. Eisenhower. These contacts were to prove influential during Gomer's career.

In 1950, Gomer joined the faculty at The University of Chicago. Soon after hearing a seminar account of E. W. Muller's field emission microscope, he built one and became active in developing this instrument as a tool for surface studies. His first paper in this field was submitted in June 1952 and published in January 1953.[4] This work was possible because of Gomer's outstanding skills as an experimentalist. For his entire career, Gomer worked actively in the laboratory, whether it was glass blowing, assembling intricate electron optics, or building sophisticated electronic systems. Figure 1 shows a young Gomer looking at one of the field emission microscopes that he had built.

This work initiated a long career in surface science. Gomer was one of several pioneering surface scientists to achieve ultrahigh vacuum (e.g., 10^{-10} Torr and lower) in all-glass vessels using mercury diffusion pumps and cryo-pumping via liquid hydrogen. This allowed early adsorption experiments to be performed without the effects of contamination. A great deal of work was done around the different binding states (e.g., dissociative or not) of small molecules on metal surfaces. Even as early as 1959, Gomer began investigating the diffusion of small molecules and atoms on surfaces.[5]

With postdoc Dietrich Menzel, Gomer found that incident electrons could stimulate the desorption of adsorbed molecules from a surface. Molecules bound differently to the surface had different cross sections for the probability of electron stimulated desorption. Menzel and Gomer proposed a mechanism in 1964 to explain this phenomenon, simultaneously with P. A. Redhead of the National Research Council of Canada.[6] This mechanism is widely applicable to many different systems and is referred to as the Menzel-Gomer-Redhead (MGR) mechanism. Menzel went back to Germany in 1964 to continue research there. He held a chair of experimental physics and surface physics at the Technical University of Munich from 1973 to 2003; then he continued research at the Fritz-Haber Institute in Berlin. Menzel recently noted, "I learned from him that you can accomplish what you can clearly imagine and figure out in your mind, and if you are persistent. … Our common reason, I guess, was that for both of us the important point was to understand."

Some of Gomer's basic work on the adsorption on tungsten field emission tips was done with Lanny Schmidt. Together they studied the adsorption of potassium on different planes of tungsten. They were able to correlate changes in the dependence of field emission current on voltage with changes in the surface work function. These work function changes were associated with the potassium coverage on that surface.[7] Schmidt served as a professor in the chemical engineering department at the University of Minnesota from 1965 until his death in 2020.

In 1968, with student Thomas Engel (later professor of chemistry at the University of Washington), Gomer used field emission to study the adsorption of CO on the various crystalline faces of the field emission tip. They were able to distinguish different binding states on each of the (110), (100), (211), (111) and (210) planes of tungsten by selectively measuring the field emission current from each of these surfaces.[8] Changes in the emission current were determined by changes in the work function of the surface; these work function changes were changes in the chemical binding of the carbon monoxide. At elevated temperatures they could also see diffusion of CO from the smoothest surfaces with faster diffusion to the most highly corrugated surfaces with slower diffusion.

Diffusion of atoms or molecules on metal surfaces attracted Gomer's attention from his first assembly of field emission microscopes. By dosing one side of the field emission tip with, for example, oxygen, he was able to observe oxygen diffusing across the metal tip and populating the initially bare tip surface. Oxygen modifies the work function of the bare metal, and, as a result, the electron emission changes, so the diffusing oxygen boundary can be observed in real time. Diffusion, in this case, can be complicated, because the rate of diffusion (or the diffusion coefficient) depends upon the local concentration of the adsorbate. Since there is a sharp concentration gradient across the moving front, the diffusion coefficient is changing continuously (depending on its relationship to the concentration) as the diffusion front proceeds.

Gomer later realized that if he monitored the electron emission from a small area on the tip surface, at nominally constant adsorbate coverage, he could derive the diffusion behavior of the adsorbate as a function of coverage. Because of diffusion of adatoms into and out of the small area, there are fluctuations around the average coverage. By measuring the time constant of these fluctuations, he determined the chemical diffusion coefficient as a function of coverage in the small area. By changing the shape of the small area to a rectangle, Gomer and student Michael C. Tringides (later a professor of physics at Iowa State University and a senior scientist at Ames National Laboratory) were able to determine diffusion coefficients in different directions depending how the probe area was oriented. In addition, they were able to relate the temperature and coverage dependence of the measured diffusion coefficients to the statistical mechanics of 2-D systems of high theoretical interest, especially for understanding 2-D phase transitions.[9] Tringides later noted, "Gomer was a complete scientist skilled in both experiment and theory, consumed by endless passion to understand, fully transferable to his students.…" Years later, with Chrisitian Uebing, many of these results were confirmed using Monte Carlo modeling of surface diffusion.[10]

In the late 1970s, Gomer was attracted to a complementary problem. Students in basic chemistry classes are taught that the electrochemical potential for oxidation and reduction half-cell reactions are known only relatively, that is, with respect to each other. Students are taught that it is impossible to know absolutely how much energy it takes to remove an electron from a metal surface in contact with an aqueous solution and take that electron infinitely far from that surface. Gomer had been doing exactly this experiment (without the solution) for many years, however. He found that if this experiment is done in a vacuum, the energy required to move this electron to infinity is just the work function. Through a series of clever experiments and calculations, Gomer was able to determine the absolute half-cell potentials for a series of oxidation reactions.[11]

I joined the Gomer group in 1975, and instead of working with field emission in a glass system, we used a commercial stainless-steel system to investigate basic phenomena in physisorption and chemisorption. Electron spectroscopies and thermal desorption were used to elucidate basic properties of inert gas adsorption on metal surfaces.[12,13] After graduating, I worked at Bell Laboratories for twenty years and then moved into the materials science department at the University of Delaware. Gomer taught me, like Menzel, that research consisted of two things—a deep look into physical phenomena, driven by questions and hypotheses, and persistence.

In the 1980s and 1990s, Gomer and colleagues Yongbo Zhao and Jim Whitten (later in the chemistry department at the University of Massachusetts Lowell) performed experiments to study the properties of metal overlayers physically and electronically decoupled from an underlying substrate by chemisorbed or physisorbed adsorbates. Using electron spectroscopies and work function measurements, they were able to deduce the structure and metallicity, or lack thereof, of a monolayer or several layers of the metal overlayer.[14,15] Whitten has remarked that one of the things he learned from Gomer was how to extract a large amount of information from even a simple, well-designed experiment. He also fondly remembers Gomer riding his bicycle between his house and the university almost year-round.

Robert Gomer was elected to the National Academy of Sciences in 1981. His other honors include appointment as the Carl William Eisendrath Distinguished Service Professor at the University of Chicago, the Davisson-Germer Prize from the American Physical Society, the Arthur Adamson Award for Distinguished Service in the Advancement of Surface Science from the American Chemical Society, the Alexander von Humboldt Award for Senior American Scientists from Germany's Alexander von Humbolt Foundation, and the Medard W. Welch Award from the American Vacuum Society. He worked on the editorial boards of the *Journal of Chemical Physics, Annual Review of Physical Chemistry,* and *Journal of Applied Physics.*

The University of Chicago was a paradise of incredibly smart people. Gomer's friends and colleagues included Stuart Rice, whom he recruited to Chicago from Harvard, Subramanyan Chandrasekhar, Courtenay Wright, Steve Berry, Peter Meyer, Dietrich Muller, and Ole Kleppa. After a daily swim at the pool, he enjoyed lunch at the Quad Club with his colleagues and finished lunch daily with a quick game of billiards. After Gomer became a professor emeritus in 1996, he and his wife, Anne, organized regular interdisciplinary talks for faculty in their home.

Gomer was an outspoken opponent of the proliferation of nuclear weapons. He was a regular contributor to and chaired the editorial board of the *Bulletin of the Atomic Scientists*, a journal founded by Manhattan Project physicists that covers policy issues related to the dangers of nuclear weapons.

Part of this opposition was expressed in his membership in JASON, a group of scientists that directly advises the executive branch of the U.S. government on scientific issues. It was named for the Greek hero who led the Argonauts. Initially, the group formed after the launch of Sputnik and included some members of the Manhattan Project. In JASON, Gomer, Freeman Dyson, Courtenay Wright, and Steven Weinberg responded to a threat about the potential use of nuclear weapons in the Vietnam War, concluding that such strikes would be catastrophic for U.S. global interests. "It was our purpose to show that using nuclear weapons would be an immoral folly and set an awful precedent," Gomer said.[16]

Gomer's family was very important to him. He met Anne after giving a talk at Westinghouse in Pittsburgh. Robert and Anne were married in 1955 and had a son, Richard, in 1956 and a daughter, Maria, in 1959. As the children grew, Anne took a variety of classes in languages and mathematics, later getting a master's degree in mathematics. She taught math at the University of Illinois Chicago, and then at DePaul University.

In the early 1960s, Robert and Anne decided they wanted a getaway place outside of the city. In 1963, they settled on a 200-acre farm near Richland Center, Wisconsin, with a little house, a barn, a few outbuildings, horses, a two-acre pond, and hilltops of exposed sandstone rock formations. The property had been a failed vacation dude ranch. The family all loved it; there were trails in the woods, skiing (hike up the hill with skis, then ski down), and swimming in the pond in the summer.

The family would go there almost every weekend during the school year. It was a 4.5-hour drive from Chicago, so on Friday after work, they would drive, eating sandwiches and drinking tea from a Thermos bottle, and then drive back Sunday night. During the summer, Anne, Maria, and Richard would stay at the farm, and Gomer would come up to Richland Center on the Greyhound bus on Friday afternoon. They would drive into town to get him, and then he would go back to Chicago on Sunday afternoon or Monday morning. Sometimes the Gomers would have friends come up and stay for a few days. For example, Subramanyan Chandrasekhar and his wife came for a weekend, walked the trails up and down hills, and then all went to visit a local orchard.

Dietrich Menzel had arranged for a postdoc in the United States with Gomer after completing his Ph.D. on catalysis in Darmstadt, Germany, in 1962. When he arrived with his family in Chicago's Hyde Park neighborhood, he was acutely aware of the problems a German family would encounter. Gomer never showed any hostility, and later when they had become friends, Menzel realized what it must have meant for him to accept a German postdoc. Even for quite a few years after Menzel left, Gomer refused to visit Germany, and even longer Austria. He did visit in the 1970s, and they became real friends. Later on, he and Anne traveled to Germany and Austria almost every year in spring to go skiing in the Alps (the Kaunertal in Tyrol, especially); they often visited with the Menzels in Munich on their way.

Years later, Gomer took his family to visit his home in Austria. Gomer's son Richard recalls,

> "[My] Dad fondly remembered his father having a little weekend cabin on the Danube in a place called Greifenstein, a few miles Northeast of Vienna, and being able to play there and swim in the Danube. We all (my dad, my mom, me, my wife Deb, Maria, and the 3 grandchildren) went to Vienna around 2000 and for Dad this was a bit tough—he showed us all the places where the relatives lived in Vienna, telling the story of each one, 'That was uncle Earnst's music shop, he tried to get out in '39 and got as far as Belgium and disappeared....' Revisting Greifenstein was also tough, but he laughed seeing how small the Danube is compared to his childhood memories of a huge river."

Robert Gomer died of Parkinson's disease on December 12, 2016. Anne died on April 17, 2023. They are survived by son Richard (daughter, Katie, born August, 19, 1987) and Maria Luczkow (daughters, Anna, born April 19, 1990, and Julia, born October 21, 1992).

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