

# Charles Alexander Lee

*August 28, 1922 — June 11, 2001*

Charles Alexander Lee was born in Brooklyn, New York, on August 28, 1922. After graduating with the B.E.E. degree in Communications from Rensselaer Polytechnic Institute in June 1943 and spending three years in military service, Charles entered graduate study at Columbia University and obtained his Ph.D. degree in Physics under Nobel Laureate I.I. Rabi in 1953. He remained at Columbia for a year of postdoctoral work on molecular-beam analysis of the rotational and hyperfine structures of potassium chloride, and then joined the technical staff of Bell Laboratories where he collaborated and obtained patents with another Nobel Laureate, William Shockley, the inventor of the transistor. Charles came to Cornell as an Associate Professor of Electrical Engineering in 1967, attained full professorial rank in 1972, and retired as Emeritus Professor in July 1991.

During his 13 years with Bell Labs, Professor Lee made two extraordinary contributions that have shaped the technology we use and study today. At the time of this groundbreaking work, the fields of integrated circuits and optoelectronics were non-existent. His pioneering work helped to initiate both fields and continues to guide developments in these important areas 40 years later.

Specifically, Charles developed and demonstrated the first diffused-based transistor in 1955 by introducing the concept of planar semiconductor processing which was a critical step for the invention of the integrated circuit by Jack Kilby a few years later, for which Kilby was awarded the Nobel Prize in Physics in 2000. In his 1956 paper, "A High Frequency Diffused Base Germanium Transistor," *Bell System Technical Journal*, pp. 23-34, Charles emphasized that the diffusion process gave precise control over the transistor feature size in the vertical direction, and opened the way to development of transistors of unprecedented speed. The 500 MHz cut-off frequency of his germanium device would still be state-of-the-art for a transistor with the 1.5-micron minimum feature size used in his experiments. A particular feature of this diffused-base design was the graded doping of the base. Such a gradient produces an internal electric field in the base that accelerates carriers, thereby enhancing the speed. This design is used today by IBM in its fastest silicon-germanium bipolar transistors.

Charles and his collaborators also carried out pioneering work on avalanche breakdown in semiconductors. Avalanche breakdown is used to make microwave oscillators and photodiodes with built-in amplification via avalanche gain. The silicon avalanche diode remains the detector of choice for photon counting today where low-noise avalanche gain is critical. The results of their 1964 keystone publication, "Ionization Rates for Holes and

Electrons in Silicon,” *Physical Review*, Vol. 134, A761, remain the gold standard against which almost all newer results have been evaluated for 30 years.

The major portion of Charles’ 24-year academic career at Cornell was given principally to teaching junior, senior, and graduate courses in solid-state electronics and semiconductor devices and physics, and to directing the thesis research of his graduate students. His participation in the founding of the National Research and Resource Facility for Submicron Structures (now the Cornell Nanofabrication Facility), in particular in establishing the ion-implantation capability in the early facility, represents one of his prime contributions to the EE School.

In addition to teaching in his areas of specialty, Charles also taught broader undergraduate laboratory courses, served as a class advisor, and was a member of the EE Graduate Committee, the EE Policy Committee, the Engineering College Admissions Advisory Committee, and the Program Committee of the Submicron Facility. From 1976-79, he was a participant in a program to enhance graduate studies at Howard University in Washington, D.C. and at North Carolina A. & T. State University. His research at Cornell was supported extensively by federal and corporate agencies, and he was a frequent consultant to industrial laboratories. He was a Life Senior Member of the Institute of Electrical and Electronic Engineers (IEEE) and a member of the American Physical Society. Charles was elected to the engineering honorary societies Tau Beta Pi, and Eta Kappa Nu, and the scientific research society Sigma Xi, and was a member of the American Association for the Advancement of Science. Following his retirement, he continued to do research and contribute to the literature in his fields of interest.

Charles is remembered for his infinite patience, calm demeanor, and good humor. He was always willing and able to share his knowledge of the latest theories and techniques (as well as the latest chess moves) with his colleagues, both within the school and from other departments, and, of course, with his many graduate and undergraduate students. He mentored younger faculty and prodded graduate students gently. He encouraged his students to question authority, and showed them that scientific research is a game to be enjoyed rather than a life and death struggle to the top. His teaching has helped them to wind up on the right side of most questions, if not always the winning one. Many could say they truly loved him for his friendly presence, wise counsel, technical expertise, and especially for the twinkle in his eye.

Charles and Lillian Rezek were married on May 31, 1953, in New York City, New York. Following 14 years in New Providence, New Jersey, while Charles was with Bell Laboratories, the last 34 years of their 48 years of life together were spent in Ithaca, New York. Charles is survived by his wife, Lillian, of Ithaca, New York; his son,

Kevin, of Gaithersburg, Maryland; and his daughter, Susanne, of Albany, New York. He was predeceased by his elder brother, John Alfred Lee.

Charles will be long remembered as a dedicated and creative scholar, a devoted teacher and advisor, a highly respected colleague, an intellectual companion, and a good friend.

*Simpson Linke, Chung L. Tang, G. Conrad Dalman*