1941–1959

Introduction: Advances in Optical Science and Technology

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World War II and the Start of the Cold War

The decades of the 1940s and 1950s saw tremendous change. The United States entered the war as the leading industrial power. It became even more dominant as the war progressed and the European Allies and the Axis Powers suffered great damage. The Cold War, which started shortly after World War II, led to further changes in the industrial outlook of the United States and the world in general. The harnessing of science in the national interest had become a priority prior to the war, and the Cold War and the development of nuclear weapons made its application even more imperative. At the same time, increased industrial sophistication led to more reliance on science to facilitate change and to the application of the tools of science in everyday industrial activity. A diverse group of scientific entrepreneurs developed new technological applications in academia, small start-ups, and corporate research laboratories. Optics and applications of optics played an important role in this progress.

In war time, the United States could not rely on Germany for optical materials and sophisticated optical designs. This had occurred in the First World War, and the U.S. did not want to have this problem repeated. Through the National Defense Research Committee (NRDC) a robust capability was developed for designing and manufacturing innovative optics for aerial reconnaissance. Optical scientists and engineers also contributed to the development of gun sights, range finders, and submarine periscopes. Anti-reflection coatings, which had been introduced in the 1930s, were developed and applied to military optics. Camouflage was another important area of optics that rapidly progressed during the war.

In the 1950s Edwin Land and James Baker persuaded President Eisenhower to develop the U-2 for surveillance of the Soviet Union. Baker had been a leading designer of aircraft reconnaissance cameras. His skill at optical design together with Land's close collaboration with the aircraft designer, Kelly Johnson of Lockheed, led to a well-integrated, optimal system still in use today. The U-2 was designed to fly above the existing intercept altitude of Soviet antiaircraft missiles and the U.S. was quite surprised when the USSR deployed a more capable missile system.

In 1947 Land introduced instant photography. In the black-and-white process, two sheets of paper are employed, one to produce a negative image, the other a positive. The same basic method as in conventional photography is used to produce a negative image. The negative paper is coated with small crystals of silver halide. Exposure to light produces some free silver atoms on the crystallites. After exposure, liquid chemicals are released that begin the development. The free atoms act as a nucleus for further free silver production, turning the exposed crystallites dark. Some of the silver halide crystals that are not initially exposed to light are transported to the adjacent second sheet of paper and then developed to produce a positive image. The Polaroid camera soon became very popular because of the excitement of instantly seeing one's photographs. Polacolor that produced color prints was introduced in 1963.

Applied spectroscopy, which saw increased application during the war, blossomed after the war as manufacturing became increasingly complex and diverse [1]. Synthetic rubber was crucial to the military, and infrared spectroscopy played a vital role in the rubber manufacturing process. The entry of Perkin-Elmer and Beckman into the spectrometer business was motivated by the use of their equipment in rubber manufacturing and fuel refining. Chemists, biologists, and other scientists soon came to embrace the use of physical measurements, most particularly optical spectroscopy in the infrared region. In 1950, the first Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy (Pittcon) was held. Optical techniques continue to play a central role in this enormous conference, which in 2015 had 16,000 attendees, 925 exhibitors, and more than 2000 sessions.

In 1957 fiber endoscopes were used for medical imaging by Hirschowitz employing bundles of clad fibers developed by Peters and Curtiss at Michigan [2,3]. In 1930 Heinrich Lamm demonstrated the concept of imaging through fiber bundles, H. H. Hopkins developed the fiberscope using coherent fiber bundles in the early 1950s [4], and, also in the early 1950s, A. C. S. van Heel proposed the use of cladding to avoid crosstalk between fibers. Fiber endoscopes are now widely used in clinical medicine, and fiber optical communication relies on the use of clad fibers.

In 1961 Xerox announced the first Xerox copier, which was based on an invention by Chester Carlson in 1938. The basic idea was to use optical transfer to produce an electrostatic pattern or image on a drum. This pattern then attracted black material (toner), which could be transferred to paper. Other printing technology developments in the 1940s and 1950s included phototypesetting, inkjet printers, and dye sublimation printing. A somewhat related area, photolithography of semiconductor circuits, was initially developed by Andrus and Bond at Bell Labs [5,6]. This was based on techniques used to make printed circuits. In one of its first large-scale applications, the printed circuit had been used during World War II for proximity fuses. The work of Andrus and Bond was quickly followed by efforts at Texas Instruments and Fairchild to miniaturize silicon circuits, an effort that would lead to the microelectronics revolution.

The most revolutionary invention in the century of optics, the laser, was first realized just after this period ended. Its precursor, the maser, came in the 1950s. Gordon, Zeiger, and Townes reported [7] the operation of the ammonia maser in 1954; this was followed by the development of solid state masers used in radio astronomy [8]. In 1958 Schawlow and Townes published a paper [9] describing the physics of masers and lasers and a proposed method for making a laser. The next year a conference was held at Shawanga Lodge in New York State, where further discussions were held concerning the possible operation of the laser [10]. The race was on.

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