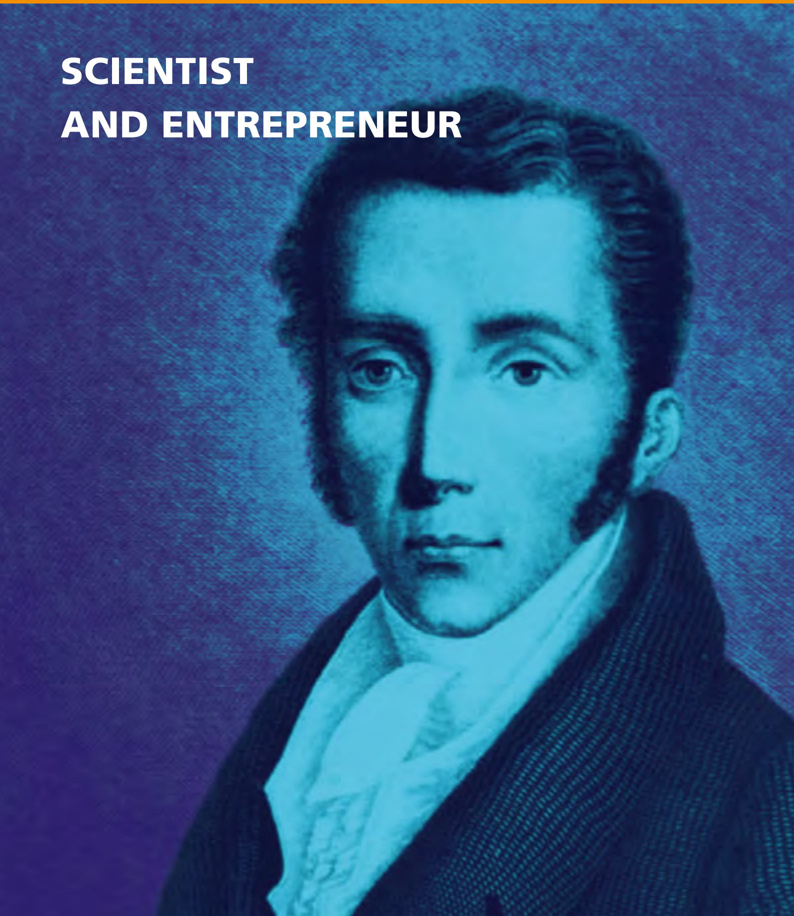
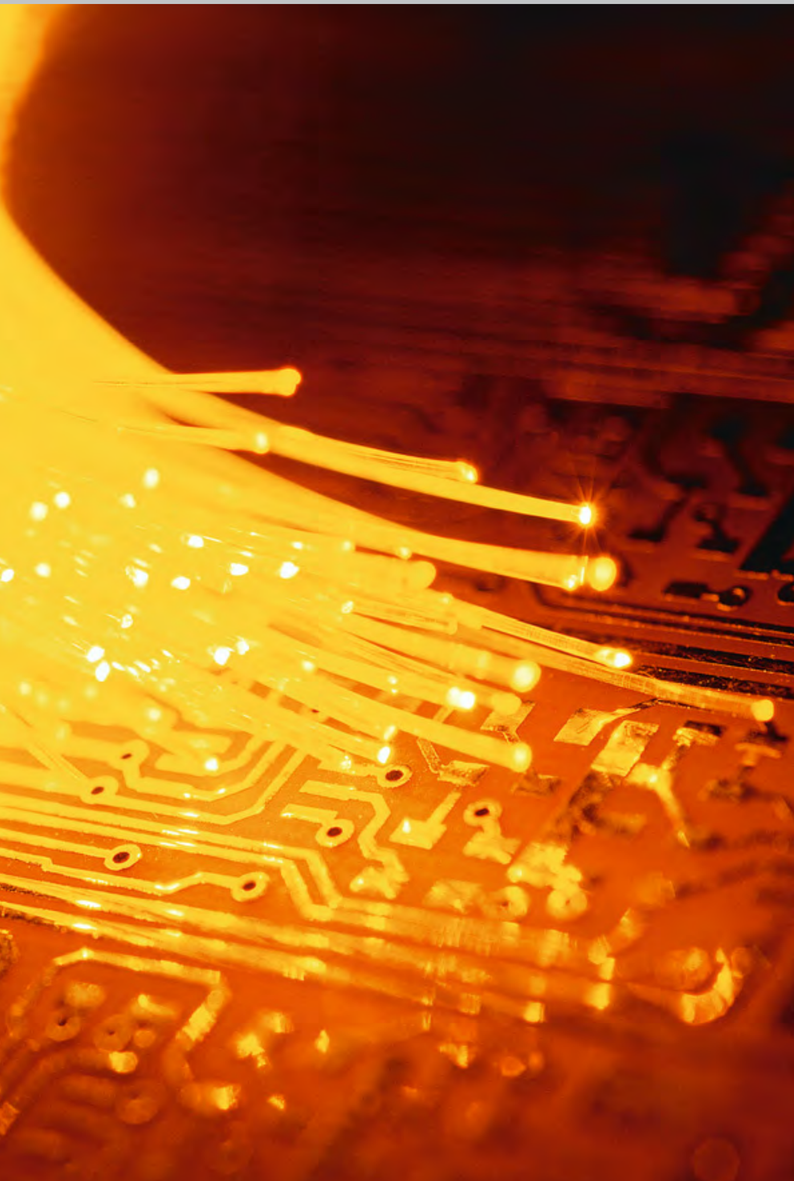
Fraunhofer

JOSEPH VON FRAUNHOFER

SCIENTIST AND ENTREPRENEUR





Only very few researchers are accorded the privilege of having their names immortalized in name by the scientific community. Joseph von Fraunhofer is one of them. The Fraunhofer absorption lines in the solar spectrum and Fraunhofer diffraction are phenomena that soon become familiar to students of optics. This is all the more impressive considering that Fraunhofer completed no more than an apprenticeship as a glassmaker, and died at the early age of 39.

Fraunhofer, however, was a pioneer in the field of optical research and his work has had a lasting influence on this field of technology, and laid the foundations for the light-based analysis and production techniques still in use today. At the same time, his success was not limited to pure science: He also set new standards as an entrepreneur and inventor. The advances he brought to glass production and the manufacture of optical instruments not only paved the way for his scientific discoveries, they also brought him commercial success. Under his direction, the Optical Institute became a thriving factory and a profitable enterprise.

Fraunhofer's working principle was research of practical utility. That is why the founders of the Fraunhofer-Gesellschaft chose to name their society after him. We firmly believe that his approach and contributions to science and business, applied for the good of humanity, serve us well as guiding principles in all of our activities.

Prof. Dr. Reimund Neugebauer
President of the Fraunhofer-Gesellschaft

JOSEPH VON FRAUNHOFER: FROM APPRENTICE TO DISTINGUISHED SCHOLAR

At the beginning of his career, there was little indication that Fraunhofer would achieve such extraordinary success. Born in 1787, he had lost both parents by the age of twelve. Too weak physically to take up the trade of wood turner as originally planned, Fraunhofer followed in his father's footsteps and became an apprentice glassmaker. But the master glassmaker who took him on, however, Philipp Anton Weichselberger, would not allow the young knowledge-thirsty Fraunhofer to read books or attend school on his free days.

This situation only changed with a favorable turn of fate: When Weichselberger's house collapsed in 1801, Fraunhofer was rescued from the ruins after many hours. This event brought him into contact with the Prince-Elector Maximilian IV Joseph, and thereafter with the entrepreneur Joseph von Utzschneider. This unexpected entry into the public limelight gave a tremendous boost to Fraunhofer's possibilities for personal development. From this point onwards, he was allowed to attend school and received instruction in the craft of lens-grinding. It was not long before he was recommended to the renowned inventor and designer Georg von Reichenbach, who employed Fraunhofer as an optician in his workshop, in which Utzschneider was also a partner.

Joseph von Fraunhofer (1787–1826).

Fraunhofer’s talent and determination were immediately evident. Reichenbach and Utzschneider thus appointed him at the very early age of 22 to head of the glass works in Benediktbeuern, which belonged to their company. His work on the development of new types of glass, his decisive improvements in glass production and in perfecting the manufacture of optical instruments, led to remarkable results. Fraunhofer succeeded in establishing standardized production methods, while substantially extending the workshop’s product range and thereby boosting the company’s commercial success. Its products included telescopes, binoculars, microscopes, magnifying glasses and astronomical telescopes – all produced to then unmatched standards of quality. Fraunhofer’s instruments were sold and put to use throughout Europe.

The instruments developed by Fraunhofer also proved indispensable for his own pioneering scientific research. His spectrometer allowed him to investigate sunlight and other sources of light with extraordinary precision; the optical gratings he constructed made it possible to analyze the phenomenon of light diffraction and to describe its effects on the design of optical instruments.

Top: Joseph von Fraunhofer presents his spectrometer. Right: Certificate for Fraunhofer’s Order of Civil Service.

№. · München den 15. August 1824

mit Anschluß der Ordens-Gesetze.

Civil-Verdienst-Orden

der Baierischen Krone.

Der Großkanzler

An Herrn Joseph Fraunhofer, Mitglied der kgl. Akademie der Wissenschaften.

Eurer Wohlgebohrnen

ertheile ich mit besonderm Vergnügen die Nachricht, daß Seine Majestät der König Dieselbe zum Ritter allerhöchst Ihres Civil-Verdienst-Ordens zu ernennen geruht haben. Mit diesem Merkmale der königlichen Gnade werden Eure Wohlgeborne die belohnende Überzeugung erhalten, daß des Königs Majestät Sie jenen Männern beyzählen, welche durch Auszeichnung in ihrem Wirkungskreise sich um den vorzüglichen Dank des Vaterlandes verdient gemacht haben.

Meinem aufrichtigen Glückwunsche füge ich die Versicherung meiner vorzüglichen Hochachtung bey.

Auf königlich besonderen allerhöchsten Befehl.

Rinzel.

Zu 5460

Fraunhofer achieved national and international fame and won many honors for his unmatched optical instruments and scientific accomplishments. Leading scientists and politicians of the time visited him at the works where his ideas took shape. These notables included the physicist Carl Friedrich Gauß, Max I Joseph, King of Bavaria, and – it is widely believed – the Czar of Russia, Alexander I.

As a result of his scientific renown, against the initial resistance of established scientists, Fraunhofer was elected a full member of the Bavarian Academy of Sciences. The King of Bavaria also made him a Knight of the Order of Civil Service, raising him into the ranks of the nobility. Joseph von Fraunhofer died in 1826 of pulmonary tuberculosis, at the age of 39.

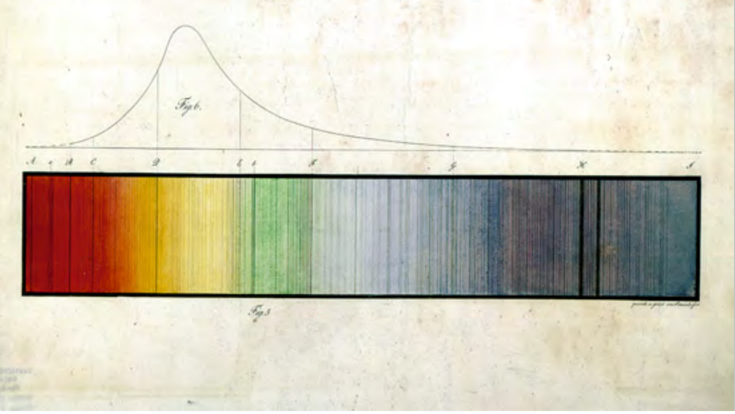
The spectroscope developed by Fraunhofer.

RESEARCHER AND ENTREPRENEUR: FRAUNHOFER'S OUTSTANDING ACHIEVEMENTS

Fraunhofer is regarded as the founder of scientific methodology in the field of optics and precision mechanics, as the first German exponent of precision optics, and as a successful entrepreneur.

After joining the Mathematical-Mechanical Institute run by Utzschneider and Reichenbach, and starting work at its glass manufacturing operations in Benediktbeuern, Fraunhofer first devoted himself to improving the quality of glass. He carried out precisely documented experiments with altered raw materials and modified melting processes and so succeeded in manufacturing glass free of streaks. He also standardized the processing of finished glass – a striking innovation at the time – which made the final result largely independent of the respective skill of the individual lens grinder.

His precise knowledge on the diffraction characteristics and color dispersion of different types of glass helped Fraunhofer to design exceptionally large achromatic telescopes. This led to a completely new generation of astronomic refraction instruments. These employed lens diameters and generated images of a quality that until then were considered impossible.



The quality of these telescopes remained unsurpassed for many decades and enabled dramatic new astronomical discoveries. The astronomer and mathematician Friedrich Wilhelm Bessel was able to use Fraunhofer's heliometer to determine a fixed-star parallax for the first time in 1883. Fraunhofer's most famous instrument is the parallactic refractor he constructed for the imperial Russian observatory in Dorpat. An identical 9-inch refractor, now on exhibit at the Deutsches Museum in Munich, led the astronomer Johann Gottfried Galle to discover the planet of Neptune in 1846.

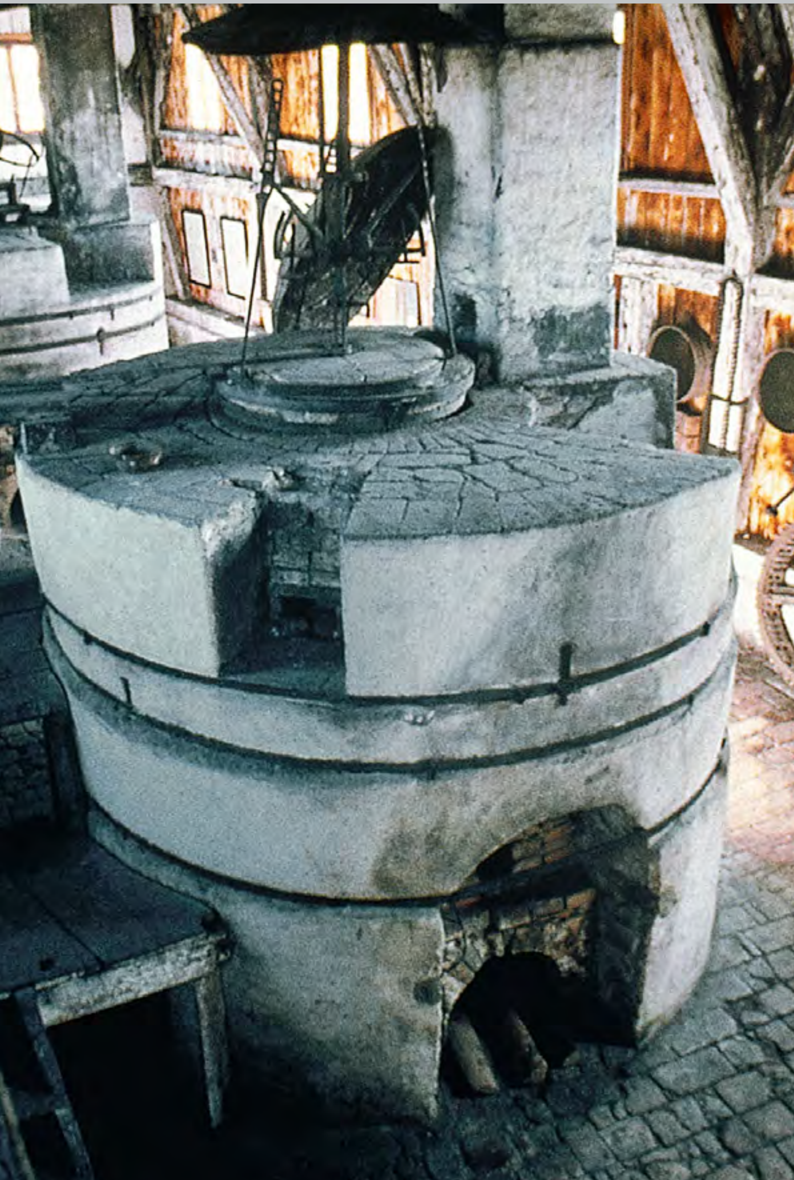
The new optical instruments developed by Fraunhofer were also of crucial significance in his own research work. Prisms which he made allowed him to investigate the spectrum of visible light. Other scientists before him had already noted dark strips in the spectrum of sunlight, but it was Fraunhofer who first ascertained that these strips – known today as Fraunhofer lines – were an inherent property of sunlight. His fundamental research work on the spectral composition of light made Fraunhofer one of the founding fathers of modern spectral analysis.

Top: The spectrum of sunlight drawn by Fraunhofer. Right: A 9-inch refractor built by Fraunhofer.

Fraunhofer’s studies of the diffraction of light represented a further milestone in his scientific career. Using a diamond, he constructed a diffraction grating with grooves spaced only 0.003 millimeters apart. This enabled him to measure the wavelength of light in various colors with extraordinary precision.

Scientific research and practical applications were mutual stimuli in all of Fraunhofer’s work. The discovery and descriptive analysis of the absorption lines in the spectrum of sunlight, for example, allowed the diffraction characteristics of individual varieties of glass to be ascertained with high precision. Analysis of diffraction was of immediate practical value in the construction of improved telescopes. Fraunhofer knew how the insights gained through experiment could subsequently be utilized in products and processes. The advances he achieved in manufacturing optical instruments at the same time laid the basis for renewed success in his scientific research. This made Joseph von Fraunhofer one of the true founders of modern application-oriented research.

Top: Glass prisms from Fraunhofer’s workshop. Right: Melting furnace in the Benediktbeuern glassworks.



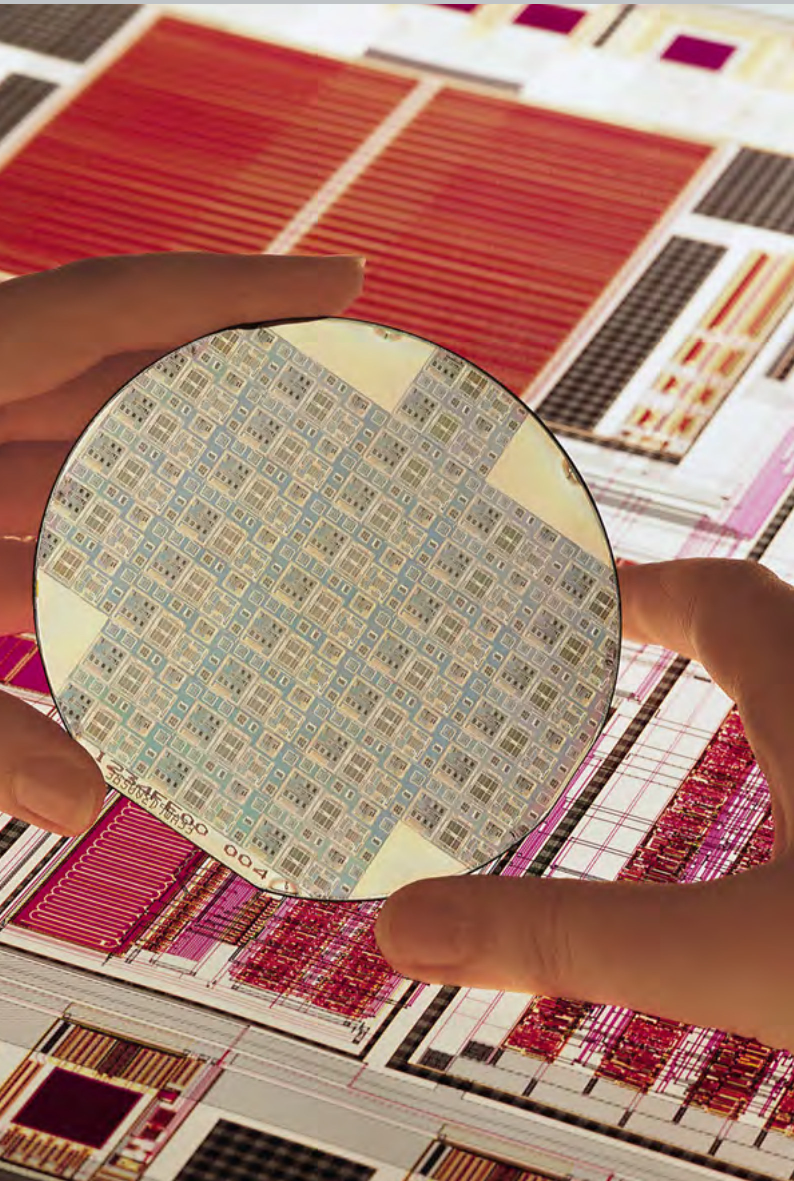
FRAUNHOFER'S LEGACY: OPTICS IN SCIENCE AND TECHNOLOGY TODAY

Joseph von Fraunhofer's fundamental and systematic research significantly influenced the field of optics. The impact of his accomplishments is still felt to this day, since optical systems have become an intrinsic part of our modern world.

This is most evident in the sphere of information and communications technology. Glass fibers transmit data much more effectively than conventional copper cables and optical CDs allow impressive amounts of information to be stored and accessed using lasers. The development of the Internet shows that the volume of data transfer taking place is increasing every day, and in future will only be manageable with the help of optically based transmission and storage systems. The ability to control laser beams precisely is then an essential requirement of data storage and of many further applications.

Laser light has become a universal tool in science and industry. We use it to cut and join materials, as well as to change their structure in specific ways. Rapid prototyping methods enable us to use laser beams to make complex components from powdered substances directly from the design data.

Glass fiber data transmission cables.



Optical processes play a decisive role in measuring technologies, too. Using laser-based processes, even traces of impurities in the atmosphere several kilometers above the Earth can be detected and diagnosed. Spectral analysis, built on the technical foundations laid by Joseph von Fraunhofer, is now a standard procedure in modern laboratory analysis.

Microelectronics is yet another key technology in which optics plays an essential part. Integrated circuits are made by exposing photosensitive materials to light and then treating them with chemicals. The transmission of electrical and optical signals is an important aspect of modern microsystem development.

Optical systems have also long been intrinsic to the practice of medicine. Laser surgery is gaining popularity as a preferred surgical technique, and advanced optical endoscopes are essential instruments in minimally invasive surgery. Microscopic analytical devices the size of a wrist watch now enable medical professionals to record and monitor patients' physiological data on an ongoing basis.

Left: Microchips produced through the exposure of photosensitive materials. Top: High precision laser in production engineering.

Innovative light sources offer us a variety of technological possibilities that also affect the way we live our lives. High-performance LEDs, for example, are destined to replace conventional energy-saving lamps. Inorganic and organic LEDs can also be used in applications such as monitor screens, light signals, and lighting for rooms and vehicle interiors. Their long life, low price, environmentally friendly manufacture and disposal, their lower energy consumption and their enormous flexibility will see these new sources of light breaking new ground in a great many fields of application.

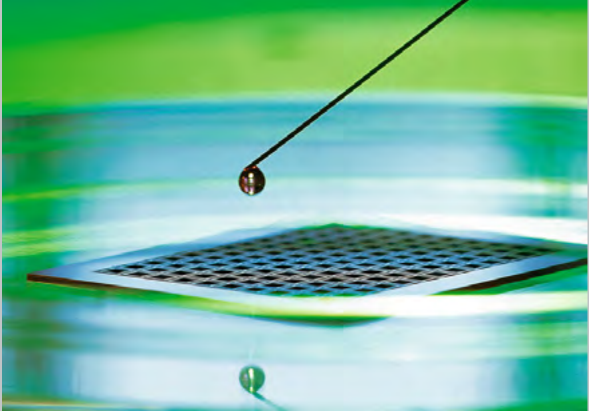
Joseph von Fraunhofer's legacy lives on. His short life gave the decisive impetus that encouraged the rapid developments in optics from which we still profit today.

Organic light-emitting diodes (OLED) are extremely efficient and suitable for a diverse range of applications.

THE CONCEPT OF APPLIED SCIENCE: THE FRAUNHOFER-GESELLSCHAFT

However eager he may have been to further the cause of science, Fraunhofer never lost sight of his true objective: to apply his inventions and concepts in the real world. This principle continues to guide the activities of the Fraunhofer-Gesellschaft, one of the largest organizations of applied research in the world.

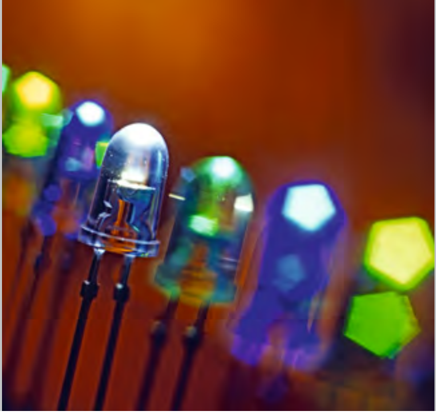
Geared to applied science and focused on tomorrow's key technologies, the Fraunhofer-Gesellschaft plays a central role in innovation processes in Germany and Europe. The scope of applied research extends beyond the direct benefits gained by the association's customers: Through its research and development work, the Fraunhofer Institutes contribute to the competitiveness of Germany and Europe. They promote innovations, strengthen technological capabilities, increase the acceptance of modern technology and provide education and training to foster the young talent urgently needed to meet tomorrow's scientific and technical challenges.

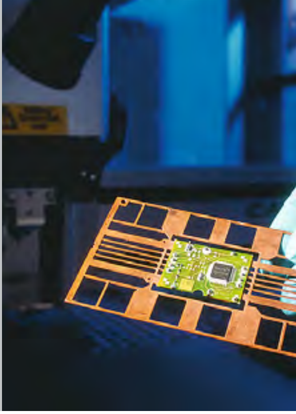


The Fraunhofer-Gesellschaft provides its staff with opportunities for professional and personal development to qualify them for challenging positions at the institutes, in the academic world, in business and society at large. The focus at Fraunhofer Institutes on practical training and experience provides students with excellent career opportunities in companies, both at the entry level and for long-term development.

At present, the Fraunhofer-Gesellschaft maintains 67 institutes and research units. The majority of the more than 23,000 staff are qualified scientists and engineers, who work with an annual research budget of 2 billion euros. International collaborations with excellent research partners and innovative companies around the world ensure direct access to regions of the greatest importance to present and future scientific progress and economic development.

Rapid prototyping processes speed up the manufacture of complex components.





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