

Industrial Research: Past, Present, and Future

Physics underpins much of the growth that has occurred in the U.S. economy during the past century. "To reach a second century, industrial R&D has had to change; to survive a second century as a vital force for industry, physicists must continue to adapt," says Lewis Edelheit, senior vice president for corporate research and development at General Electric Co. This demand for change can produce cultural shock, he points out.

Edelheit offered this assessment at the 100th anniversary meeting of the American Physical Society in Atlanta. He and other speakers explored the importance of physics to industry in a special centennial session sponsored by the Forum on Industrial and Applied Physics (FIAP).

"In the past, physicists used fundamentals to understand fully and thoroughly the technology, then handed it off to engineers," Edelheit said. "Today, physicists must use fundamentals to help industry innovate faster. Speed is of the essence."

The 20th century has seen extraordinary physics-based advances emerge from industrial laboratories, Edelheit noted. Among those at GE: the invention of the modern X-ray tube; synthetic diamonds; the semiconductor laser; and development of the fan-beam CAT scanner and the high-field magnetic resonance imager.

Today's industrial physicists must not only be bright and possess boundless energy, Edelheit suggested, they must work well in teams, relish change, find and use good ideas from every source possible, be flexible amid shifting priorities, and be willing to interact with customers, marketers, and manufacturing people. "Different companies, different realities, different solutions, but in today's world, everybody must be vital," he said.

The century's surge in information technology is but a prelude. At IBM, a triad approach to research has served the company well, said Paul Horn, senior vice president for research. IBM balances its research among efforts to refine and expand established technologies, such as magnetic storage; explore future alternative technolo-

gies to replace those reaching their natural limits; and pursue basic research (Figure 1). "We are an information technology company, and we study information in the deepest physical sense," Horn said.

This approach has sustained IBM in the competitive world marketplace and led to

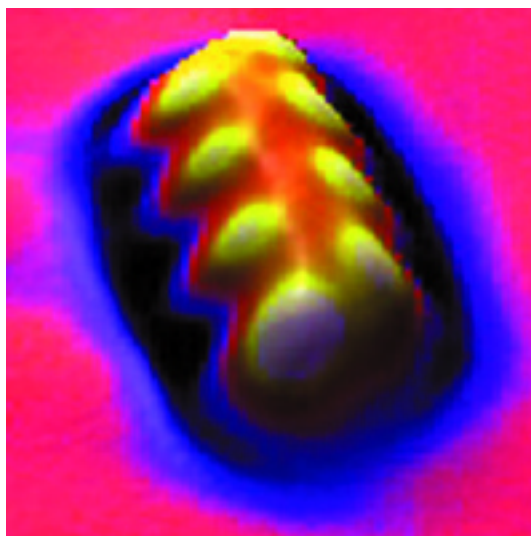


Figure 1. IBM's research into scanning probe techniques led it into imaging and manipulating atoms, and molecule assembly, as with this cesium iodide grouping (CsI)₈.

such recent innovations as silicon chips that use copper rather than aluminum wiring; disk drives for computers and consumer electronics based on giant magnetoresistance; and the ultrahigh-resolution flat-panel display technology known as "Roentgen," whose resolution approaches the limits of human visual perception.

The decades ahead will see today's supertechnologies, such as magnetic storage, begin to reach their physical limits. Yet, said

Horn, "we believe the fundamental limits are way beyond the natural limits of these particular technologies." Looking ahead, IBM scientists are investigating many potential replacement technologies, including micromechanical approaches to storage in which thousands of probes would write and read information simultaneously on a scale of hundreds of gigabits per square inch; molecular electronics, including carbon nanotubes to act as switches; and quantum computation.

The communications revolution—past and future—is no less dependent on physics, said William F. Brinkman, vice president for physical sciences at Lucent Technologies' Bell Laboratories. "A close relationship between fundamental physics and telecommunications was established early on, and it continues to this day."

Important advances in telecommunications technology have emerged from four fundamental discoveries of physics—electromagnetism, the electron, quantum mechanics, and quantum optics, Brinkman noted. "Today's work toward an optical network involves some of the most basic concepts of physics, nonlinear interactions, solitons, amplifiers, and many fundamental materials problems."

The demand for innovation in telecommunication is fueled by an unparalleled customer demand, Brinkman said. Installing the world's first 700 million phone lines took about a century; an additional 700 million lines are expected within the next two decades. Today, there are more than 200 million wireless subscribers worldwide; another 700 million are expected to be added over the next 15 to 20 years. And by 2001, another 100 million Internet users will go on-line.

The extraordinary demand anticipated for speed and capacity drives the optical innovations that are transforming the lines of telecommunications from metal to glass. Over the last 10 years, the capacity of optical fibers has increased 100 times, compared with a 60-fold increase in the capacity of integrated circuits during the same period. Wavelength-division multiplexing has opened a single fiber to multiple data-carrying channels, each utilizing a different wave-

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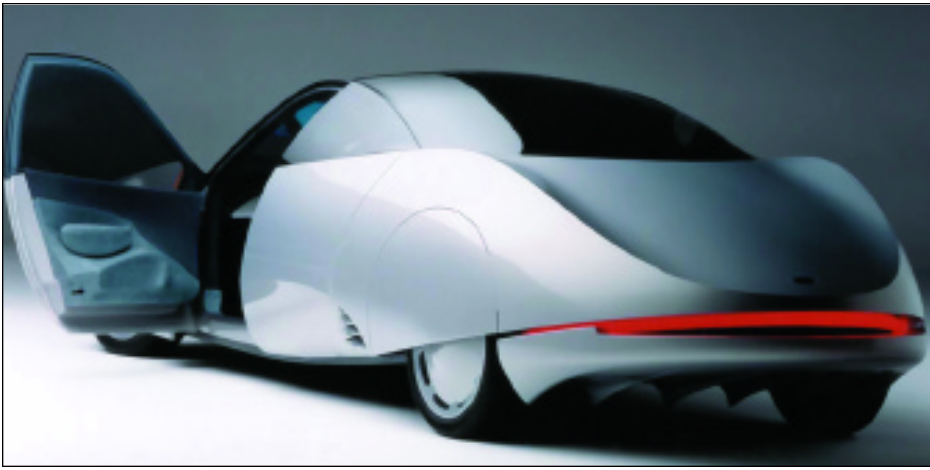


Figure 2. Ford’s scientists and engineers created this concept car, Synergy 2010, displayed at the APS Centennial, to test some technologies of the future.

length of light. “The revolution is fueled by the pace of technology,” Brinkman said.


Physics research helped make the U.S. transportation sector, which accounts for 11% of the nation’s gross domestic product, one of the world’s largest industries, noted Neil W. Ressler, vice president and chief technical officer for research and vehicle development at Ford Motor Co. The reliance on physics will only increase in coming years.

“The automobile industry around the world is undergoing a major transformation—some might even call it a revolution,” Ressler said. Companies must deal with increasingly demanding customers; some-

times conflicting demands for increased fuel economy and reduced emissions; concerns about global climate change; and an increasing awareness of safety issues.

Meeting those demands will require innovations in areas such as lightweight materials, essential for improving fuel economy; computer software to speed the design process; and propulsion systems that use less fuel and produce fewer noxious emissions, he said. “These challenges will take the combined talents of physicists, chemists, materials scientists, and engineers.”

Although physics research is alive and well in the automotive industry, it has

changed considerably in recent decades, as it has in other industries, Ressler said. Academic-like research has decreased, applied research has increased, time scales of projects have been shortened, and the bottom line determines the form and pace of research more than ever. “Those laboratories that have survived have seen new approaches to research, new expectations, and new ways of operating that make them more responsive to company needs,” Ressler added. 

The Forum department is initiated by the American Physical Society’s Forum on Industrial and Applied Physics (FIAP). For further information on FIAP, please contact the chair, Galen B. Fisher (galen.b.fisher@delphiauto.com).