FIAP September 1997 Newsletter

INSIDE

FIAP -- Year Number Three

L. Craig Davis, FIAP Chair

Since the formation in 1995 of the Forum on Industrial and Applied Physics, the organization has experienced phenomenal growth. At present FIAP has over 5000 members, making it one of the largest units in the American Physical Society. In two short years, under the able leadership of Abbas Ourmazd and Len Brillson, FIAP has instituted a number of standard activities. These include organizing invited sessions at the March meeting, publishing a newsletter, compiling a colloquium speakers list and electing Fellows. We have addressed the jobs issue by creating a Jobs Engine, finding speakers for the "Meet the Industrial Physicist" series at the March Meeting (organized by the American Institute of Physics) and sponsoring a tutorial entitled "Industrial and Applied Physics."

Our invited sessions at the March Meeting have attracted considerable attention. Last year's session "Physics and Finance" and this year's session "Entrepreneurial Physics" were very popular. Many of our technical sessions have been noticed by the media-physics applications seem to be easier to explain to the public than more fundamental research. We have enjoyed support from and close relations with The Industrial Physicist, a publication of the AIP devoted to the same interests and constituency as FIAP.

This year, for the first time, FIAP is a full co-sponsor of a major conference. With the Division of Compu- tational Physics, FIAP has organized PC 97 to be held at the University of California, Santa Cruz, in August. The conference brings together industry leaders, national lab scientists and academics to discuss the forefront in computation and the demands of applications. The intention is to form a bridge between the users and the innovators of computational advances.

Although the jobs situation has improved somewhat, it remains a vital goal of FIAP to acquaint students and post-docs with the requirements of industry, the nature of applied work, and the possibilities for employment. Likewise, we wish to expand the opportunities for FIAP members to present technical work of an applied nature at the March meeting, e. g., more focused and contributed sessions. We will continue to work with other APS units, such as the Topical Groups on Instrumentation & Measurement Science and on Magnetism, to organize sessions where research topics are strongly connected to applications. We will remain active in soliciting deserving candidates for APS Fellows and for APS prizes.

However, I think we must do more. We have attempted to make industrial and applied physics an equal partner in the American Physical Society, yet we have not completely reached that large group of physicists who have little connection at present with APS. In fact, we have not even begun to use the many people who volunteered to help FIAP.

In the future, FIAP should be concerned with the professional aspects of physicists' careers. The APS Task Force on Careers and Professional Development has identified a number of opportunities to serve its membership better. I believe FIAP should play a leading role in this endeavor. Some possibilities are workshops on management skills, communication and time management.

Thus, as FIAP starts its third year, the Forum is off to a good start. We enjoy the enthusiastic support of the APS leadership and the FIAP membership. Ahead lie many challenges as we strive to fulfill the expectations of our members.

FIAP Jobs Engine About To Launch

Leonard J. Brillson

One of FIAP's top priorities is jobs and career develop-ment for physicists. Careers in industry are of particular relevance for our profession, given the many diverse technical opportunities in the industrial sector and the profound changes taking place in industries which have historically provided jobs for physicists. In order to provide APS members access to rapidly changing job postings of high technology companies, the Forum on Industrial & Applied Physics is planning to launch a jobs engine. We have already contracted with a commercial service on the Web to manage this engine. This past month we requested suggestions for electronic search fields from FIAP employers to better identify good matches to jobs, and we received dozens of useful suggestions. Many of these suggestions were from employers with jobs to post right now! Our Webmaster is now creating the pages for entering applicant information and job postings, and we expect to launch the web site within the next few weeks. Stay tuned!

Leonard J. Brillson is a professor and CMR Scholar at Ohio State University and a former FIAP Chair.

Synchronizing Research and Development

Robert C. Morris,

Gregory R. Smith,

How much of a company's profits should it spend on Research and Development? Too little R&D investment imperils the company's future while too much is an undue burden on financial performance. The problem has gained urgency as global competition has driven streamlining of all business processes.

Several years ago, Wallin and Gilman[1] provided an empirical analysis correlating R&D spending with stock market returns. The results indicated an optimum level of R&D spending which varied significantly depending upon the industry. This was a valuable contribution which clearly demonstrated the existence of an optimum. However, it provided little specific and compelling

guidance for the unique circumstances of any individual company. Recent activities of business consultants have focused mostly on streamlining manufacturing operations and reducing product development cycle time, leaving research virtually unanalyzed.[2] We believe that this narrow focus may lead to incomplete and invalid conclusions regarding how to best manage the continuous revitalization of industrial companies over time.

A more complete analysis is needed which considers research and development as separate, but linked, sub-processes integrated with and driven by the strategic needs of the business. The concept of "synchronized manufacturing," introduced by Goldratt and Fox,[3] and other ideas from the total quality movement[4] provide a framework for the analysis.

We must first draw an analogy between a unit of "product," which gains value as it proceeds through the pipeline of manufacturing processes, and an "idea," which evolves and gains value as it proceeds from research through development and into commercialization. While this analogy is an oversimplification, it does allow us to begin measuring the yields and cycle times of the various process steps; a necessary foundation to optimize any process.[5]

Consider a simple new business development process model with several sequential sub-processes, including research, development and commercialization. The sub-processes may be further subdivided but this level of detail is sufficient for our purposes here. Inventive ideas for new business arise at a rate Fi and are investigated for feasibility in the research stage. Count an idea when it becomes a funded project start. At any given time there are some number, NR, of ideas under active research consideration. The average cycle time for a Research project is tR. Most of the ideas from research are ultimately discarded, but some fraction, YR, survive and evolve into development projects. Again, there is a time-averaged steady state population of development projects, ND, with average cycle time, tD, and an overall yield for the Development process, YD. Similarly, the commercialization process is characterized by NC, tC, and YC. Commercialization delivers successful product introductions at a rate, FC.

Suppose that the CEO, with guidance from the Board, has set a target of introducing one significant internally developed new product every two years, i.e. FC = 0.5/yr. Presumably, this target is based on careful consideration of the company's capacity to invest (cash flow) and prior knowledge of the cash outlay required for commercialization efforts. Suppose also that we have measured the sub-process yields and found YR = 0.04, YD = 0.75 and YC = 0.9; values which may be typical for a composite of industrial companies. Working backwards, FC = FiYRYDYC, so that the new business development process "rolled throughput yield", RTY = YRYDYC = 0.027. It follows that the inventive input to the system Fi =FC/RTY = 18.5 new starts/ yr. If the average cycle time for Research projects, tR, is say 1.5 years, then the steady state population of research projects will be NR = Fi tR = 27.7

The research sub-process will deliver risk reduced product concepts to development at a rate FR = FiYR = 0.74/yr. Assuming an average development cycle time tD of 2 yrs, the development pipeline will contain an average of 1.5 projects and deliver fully developed products to commercialization at a rate of 0.55/yr; the rate needed to support the CEO's target. This is a synchronized new business development pipeline in which the capacities to generate and develop new ideas are balanced with each other and with the capacity of the business to invest and to commercialize. Clearly, excess or under capacity in any sub-process will lead to waste and/or diminished throughput.

Such an analysis begins to provide a basis for rationally sizing a company's research and development capabilities based on top down strategic goals. It can also be extended to model the dynamics of increasing innovative output and to develop rational targets for continuous improvement of the new business development process. Finally, this analysis suggests a set of useful metrics which can be used to track improvements.

Based on our assessment of recent trends in light of the foregoing discussion, we speculate that some of the recent frustration with internal R&D is due to the fact that companies lump together and confuse the Research and Development functions. There is then a tendency to accumulate excess capacity for development while neglecting to foster the inventive input which feeds the pipeline. This overemphasis on development appears to result from the fears experienced by financial managers when they contemplate the intrinsically high risks of the research phase. The resulting shortage of inventive input leads to a low level of innovation and poor productivity in the development and commercialization stages. This drives many companies to turn to mergers and acquisitions as their primary source of growth and revitalization. Unfortunately, the market values risk-reduced innovations and it is highly difficult to gain commanding business advantage and foster strong and sustained growth by acquisitions alone.

In conclusion, we believe that the future belongs to companies which learn to synchronize and rationally manage internal growth from research and development.

They will benefit from strategically focused internal developments and can profit from a better ability to extract synergistic technological value from mergers and acquisitions.

References:

1. C. C. Wallin and J. J. Gilman, "Determining the optimum level for R&D spending," Research Management, 29, No. 5, p. 19, 1986.

2. M. E. McGrath, M. T. Anthony, and A. R. Shapiro, Product Development - Success Through Product and Cycle Time Excellence, Butterworth - Heinemann, Boston, Massachusetts, 1992.

3. E. M. Goldratt and R. E. Fox, The Race, North River Press, Croton-on-Hudson, New York, 1986.

4. M. J. Harry, The Vision of Six Sigma-Case Studies and Applications, 2nd ed., Sigma Publishing Company, Phoenix, Arizona, 1994.

5. R. C. Morris, G. R. Smith & R. Schroeder, Implementing Process-Focused, Front End Innovation, Product Development Management Association conference proceedings "Right Products Right," Orlando, Florida, October 1996.

Give Us Your Ideas

The following members of the FIAP executive committee would very much appreciate your ideas on how to further increase the usefulness of FIAP for the physics community.

Craig Davis (Chair)

John Rowell (Chair-Elect)

Galen Fisher (Vice Chair)

Harry Atwater (Secretary-Treas.)

Matthew Richter (APS Councillor)

Ray Baughman (Member-At-Large)

Margaret Weiler (Member-At-Large)

Andrew Sessler (Member-At-Large)

James Tsang (Member-At-Large)

Paul Murphy (3/2000)

Cherry Ann Murray (Member-At-Large)

Members of the FIAP Executive Committee Graduate

Our special thanks are given to Don Sandstrom and Neville Connell for serving on the FIAP executive committee, during the critical time when FIAP graduated from its beginnings to one of the largest units of the APS. Neville was responsible for founding the FIAP Newsletter and serving as its editor until the present issue.

Thirteen APS Fellows Elected in Area of Industrial and Applied Physics

Douglas Kirvin, Research Development Group Inc.

Each year fewer than half of 1 percent of the members of the American Physical Society are selected to become fellows of the society. Although all nominations receive final approval from the APS Council, they are screened by the appropriate APS division, forum or topical group. This year the Forum of Industrial Physics (FIAP) recommended 13 physicists for fellowship, as part of a new effort to recognize work in applied physics. In addition to doing outstanding work in physics, each of the new fellows played a key role in the development of an industrially important technology. The new fellows, together with the fellowship citations, and a brief description of accomplishments are as follows:

Leonard Cutler

Hewlett-Packard

For fundamental applications of physics in the development of precision, commercial atomic frequency standards and clocks, and the two-frequency laser interferometer, an essential tool in modern integrated-circuit manufacturing.

Dr. Cutler received his Ph.D. in physics from Stanford University in 1966, where he worked on coulomb corrections to inelastic scattering and Maser oscillator thermal noise analysis. One of the founders of Hewlett-Packard Labs, Dr. Cutler has made significant contributions involving both the theory and design of atomic frequency standards and metrological laser interferometer devices. His theoretical contributions have ranged from analog and digital design to special and general relativity. The performance of the latest cesium clocks has been increased by an order of magnitude using Cutler's contributions. The two frequency laser, co-invented by Cutler, has become an essential part in VLSI circuit manufacturing.

Harvey E. Cline

General Electric

For sustained and significant applications of physics to semiconductor processing and medical imaging, most notably thermomigration production of vertical pn junctions and 3D medical display algorithms for X-ray CT and MRI.

Dr. Cline developed high temperature directionally solidified composite materials and the Thermomigration Process to produce vertical PN junctions in electronic materials. A project on inspecting 3D surfaces with moir� contours was followed by the invention of algorithms for 3D imaging "Marching Cubes" of computed tomography and magnetic resonance (MR) data. This led to a workstation for the display for 3D MR data. He is presently working on the development of improved tools for image guided therapy, such as the use of magnetic-resonance-guided focused ultrasound energy for tumor destruction.

Lee A. Feldkamp

Ford Motor Company

For contributions in the applications of physics to practical automotive control systems and computed tomography and to fundamental understanding of electron spectroscopies.

Dr. Feldkamp received his Ph.D. in 1969 from the University of Michigan. While a member of the Physics Department in Ford Research from 1969 to 1989, his fields of interests included neutron scattering, electron energy-loss spectroscopy, the theory of electronic spectroscopies, machine vision for robotics, image processing, x-ray tomography, and the biomechanics of bone. In 1989, he formed a group at the Ford Research Laboratory to study neural networks and pursue promising applications - which led to the practical demonstration that neural networks can efficiently control dynamic systems having severely nonlinear responses. He has published one book (on vibrations in crystal lattices) and has authored more than 90 papers and reports.

Massimo Vincenzo Fischetti

IBM

For the development of first-principle modeling that predicts accurately the performance of sub-micron semiconductor devices.

Massimo Fischetti graduated with his Ph.D. in Physics at the University of California at Santa Barbara in 1978. Dr. Fischetti's work on Monte Carlo simulation of electron transport in silicon dioxide has advanced the understanding of the basic physics of electron transport in wide-gap materials. Together with Steven Laux, he has applied these Monte Carlo techniques for simulating the performance of semiconductor devices. Predictions from the resulting program, called DAMOCLES, enabled IBM to successfully predict the broad future of device technology, including the limits of device scaling.

Zafar Iqbal

AlliedSignal Inc.

For outstanding contributions to the design, synthesis, understanding and application of nonconventional electronic, optical, and energetic materials - from porous silicon to polydiacetylenes, high-temperature superconductors, and explosives.

Dr. Iqbal's current and recent work in the area of applied materials physics has centered around the development of advanced components for proton- exchange-membrane fuel cell systems for vehicular and space applications. His work also involves new composite piezoelectric sensors for sonar applications and the correlation between microstructure and performance of carbon-carbon composites in aircraft brakes. In addition, he is collaborating with various academic groups on the synthesis and structural characterization of novel carbon phrases and the study of ladder-like quasi-one-dimensional copper-oxide magnetic and superconducting systems.

Jack Dean Kingsley

General Electric Corporate, retired

For sustained excellence in the science and technology of lasers, lighting, television, displays and medical diagnostic imaging equipment.

Dr. Kingsley received his Ph.D. in Physics at the University of Illinois in 1960 under Dr. Robert Maurer, where his doctoral thesis was on "Color Center Reactions in the Alkali Halides." Essentially all his professional career has been spent at General Electric's Corporate Research and Development Center, where he was the first employee to work on solid state lasers. He also contributed to the demonstration of the semiconducting junction GaAs laser and the development of improved medical diagnostic X-ray imaging. His work on the excitation of luminescence by charged particles led to the development of phosphors for high resolution cathode ray display tubes. Display tubes using these inventions remained on the market for many years. Additional inventions were made in lighting and solid state detectors for CT scanners, which are currently used commercially. Perhaps of even greater importance, he is an inventor of a revolutionary x-ray imaging technology, which has not yet reached the market place and which is considered confidential by the General Electric Company.

Robert D. Maurer

Corning Glass Works, retired

For fundamental studies of the optical properties of glass that led to the fabrication of the first low-loss optical fibers, now used worldwide for long distance telecommunication.

Dr. Maurer is a native of Arkansas who received his Ph.D. in Physics from MIT in 1951, having done his graduate work in low temperature physics. An openness to a change in specialty and a desire to make an economic impact, led to an industrial research position at Corning Glass Works. His early work there involved the development of improved glasses for applications involving infra-red transmission, as well as other problems related to light scattering, glass lasers and photosensitive glasses. This led to a basic article patent that is the basis for all fibers used today in optical communications. The patent's importance led to challenges in five trials, but its validity was always upheld. Later, his research helped improve the performance of fibers, including their strength.

Thomas Perine Pearsall

University of Washington

For seminal contributions to the InGaAsP alloy system, a material used in the emitter and detector components of optical fiber communication links.

Dr. Pearsall received his Ph.D. in Applied and Engineering Physics at Cornell University in 1973. Starting his career just as the optical communications field began to unfold, he is one of the pioneers of groups III-V optoelectronics. Among his earliest contributions was the invention of the InGaAsP/InP double-heterostructure, light-emitting diode and heterojunction-assisted impact ionization. This stimulated much of what we have called band structure engineering during the past 10 years. Indeed, much of Pearsall's career parallels the evolution of quaternary InGaAsP semiconductor materials to their present pre-eminent role in optical fiber communications. While at Thomson/CSF in Orsay, France, he invented and demonstrated the form of InGaAsP/InP photodiode now in most common use for long distance optical fiber communication links around the world. Also, at the same time, he measured most of the fundamental alloy properties of the InGaAsP alloy series: mobility, band gap and effective masses. This body of work forms an important part of material's basis on which today's optoelectronics is built.

Frederick E. Pinkerton

General Motors Research and Development Center

For his research on the physics of rare-earth/transition-metal materials and his contributions to the establishment of a commercial permanent magnet technology.

Dr. Pinkerton's scientific accomplishments began with his graduate studies at Cornell University, where he discovered the low frequency optical resonance signature of valence fluctuations in $CePd_3$, one of the early examples of heavy fermion systems. He was a key member of the General Motors Research team who discovered rapidly solidified neodymium-iron-boron Magnequenchtm magnet materials and developed them for industrial applications. They were the first to determine the crystal structure of the novel ternary compound $Nd_2Fe_{14}B$ and thereby understand the origin of the spectacular magnetic properties of such materials. He has since made numerous contributions to the technology of magnet production by rapid quenching, as well as to the continuing quest for new permanent magnets. He has contemporaneously published extensively on the fundamental physics of R2Fe14B compounds and rapidly quenched magnets, especially on the origins of magnetism in rapidly quenched materials.

Calvin F. Quate

Stanford University

For his co-creation of atomic force microscopy, his inventive developments of applications of scanning probe microscopies and his critical role in bringing the technologies to industrial and academic use.

Dr. Quate received his Ph.D. at Stanford University. His contributions to acoustic and scanning probe microscopies have enabled outstanding physics, as well as providing essential tools for industrial and applied developments. The originality of the inventions of the two microscopies are arguably Nobel prize class. The further elaboration of the uses, both scientific and applied, both within his group and in the world community, make Dr. Quate's contributions truly outstanding. He is co-inventor of the Atomic Force Microscope. He has made profound impacts on the technology of the Scanning Tunneling Microscope and its applications. Dr. Quate has also expanded the applications of the Scanning Probe Microscope beyond the area of microscopy to data storage and nano-lithography.

Marion B. Reine

Loral Infrared & Imaging Systems

For technical leadership in the design and development of innovative photoconductive and photovoltaic HgCdTe devices for advanced infrared detectors.

Dr. Reine received his Ph.D. in Physics at MIT in 1970, completing his thesis on "Stress-Modulated Interband Magnetoreflectivity of Gallium Antimonide and Gallium Arsenide." He has spent his professional career advancing the device physics and technology of HgCdTe infrared detectors for a wide variety of commercial applications. He led a team that demonstrated experimentally for the first time that useful HgCdTe photodiodes could be made with cutoff wavelengths beyond 12 mm, a process which is required for thermal imaging applications.

Lewis Josiah Rothberg

University of Rochester

For pioneering work furthering applications and manufacturing approaches of organic electronics through fundamental understanding of organic photophysics and transport.

Dr. Rothberg received his Ph.D. at Harvard University in Physics in 1983, where his thesis was on "Collision- Induced Four Wave Mixing." He pioneered work at AT&T on various devices utilizing the unique properties of polymer-based semiconductors. This includes the application of organic electro- luminscence to display products, as well as organic transistors to semiconductor electronics. Also, in collaboration with others at Bell Laboratories, he demonstrated a microcavity fabrication technique that provides red, blue, and green pixel elements for emitting a full color display from a single organic emitting film.

Robert Max Schmidt

Boeing Defense & Space Group

For seminal research that demonstrated the dominant influence of gravity on cratering phenomena and applications to impact cratering of planets and to missile basing, as well as for spacecraft protection simulation techniques.

Dr. Schmidt's early experiments using an innovative centrifuge experimental technique led to the formulation of scaling laws that gave new insights into the formation and final size of nuclear and planetary impact craters. Subsequent collaboration with Prof. Holsapple of the University of Washington led to a unified scaling theory which governed all aspects of the kinematics of the cratering phenomena. The results resolved a "surface-burst cratering dilemma" caused by the discrepancy between previous calculations and results of nuclear explosion cratering in the Pacific. This ability to correctly predicted cratering phenomenon was important for guiding America's nuclear weapons strategy.

Submit Fellowship Applications for Next Year

As we join in congratulating these new fellows, we should also begin thinking about others to nominate for this honor. It has been said that an important measure of a society is its ability to recognize and reward its most distinguished members. But unless many people help in the search for new fellows, many highly qualified physicists will go unrecognized. Nominations of candidates who have been influential in applied physics, whether they are academics, government or corporate employees, should be submitted to the FIAP. Successful applications will show, through patents, publications and letters of recommendation, a record of outstanding scientific accomplishment.

The FIAP Fellowship Nomination Committee assesses scientific accomplishment as rigorously as other APS groups but makes a special effort to include in the evaluation technical achievements that have had major industrial impacts. In this way, the committee strives to balance the sometimes differing measures of success for applied and fundamental research.

Fellowship applications can be made at any time, but the evaluation process is annual. To be considered for the next fellowship awards, applications must be submitted by January 15, 1998.

Further information regarding submissions can be obtained by writing to the APS Fellowship Office (One Physics Ellipse, College Park, MD 20740-3844), calling 301-209-3268 or visiting the APS Web site