Bill Schwartz: Friend, force behind CREOL

As another outstanding group of students graduate from CREOL and move on to make their mark in the optics world, I am reminded anew of a good friend’s passing nearly six months ago. It is largely because of Bill Schwartz’s efforts that our students are able to receive the quality education required to keep the optics industry thriving. Bill’s farsighted efforts in the formation of CREOL and his enduring commitment to scholarship continue to influence students and have an impact on industry.

Bill’s involvement in laser research, development, and production began in 1961, shortly after the laser was invented in 1960. He was a founding Director and President of the Laser Institute of America (LIA), the country’s oldest laser trade association. He was awarded the Arthur L. Schalow Award by the LIA in 1999.

Bill is perhaps best known as president and chief executive officer of Schwartz Electro-Optics, Inc. (SEO), a company he founded in 1983. SEO designs and manufactures laser and electro-optical products for government and commercial applications.

Bill was the true pioneer of Florida’s laser industry. His influence can be readily seen in the numbers: Laser research groups or companies he has headed have been the source of 15 of Orlando’s 40 laser companies and organizations. For 15 years, prior to forming SEO, Bill was president and CEO of International Laser Systems (ILS), a company he founded in 1968. A nationally known supplier of military laser systems, ILS was purchased by Litton in 1983 and is now named Litton Laser Systems (LLS). Before forming ILS, Bill was employed by Lockheed Martin’s Orlando division, where he headed up laser research, development, and production programs.

Bill’s interest in education took a philanthropic bent following his days as a student. He received his BS degree in 1950 from the University of Chicago and his MS degree in 1951 from the University of Missouri, both in Mathematics, and completed additional graduate work at UCLA. In 1985 he was awarded a Ph.D. (Honorary) in Engineering Science from the University of Central Florida. He was a member of Pi Nu Epsilon, Tau Beta Pi and Phi Theta Kappa, honorary mathematics, engineering and scholastic fraternities.

When I was contemplating taking the position of director of CREOL, Bill, who was chair of CREOL’s Industrial Advisory Board, influenced me with the clarity of his vision. The first company spin-off from UCF in which the university maintained an equity share was in partnership with Bill. From the day I took the job he began to teach me the importance of partnership between the university, industry and the entire community.

It was a practice he took to heart. Aside from serving on far-reaching state and community boards dedicated to enhancing the availability and quality of higher education in our state, he took a spe...
I am happy to announce that Dr. Shin-Tson Wu to the faculty of the School of Optics under the PREP - Provost Research Enhancement Program designed for senior research faculty. He will join us next year from HRL Laboratories - formerly Hughes Research Labs in Malibu. His expertise is in liquid crystal devices for Internet appliances, mobile communications and optical communications. Dr. Wu is coauthor of two books: Optics and Nonlinear Optics of Liquid Crystals (with I.C. Khoo), and Reflective Liquid Crystal Displays (with D. K. Yang). He holds 18 patents on liquid crystal technologies.

Based on his outstanding contributions, Shin-Tson received the 2000 SID Special Recognition Award. Shin-Tson is also an OSA Fellow. We look forward to his arrival.

UCF has grown to about 34,000 students (destined to grow to 47,000 within 7 years), and the School of Optics/CREOL is growing with it. This gives us the opportunity to respond to the needs of industry in the burgeoning field of Photonics. Therefore, we have decided to make a major expansion into this field and are seeking leaders and team players to help form a faculty research and education force for this photonics revolution of the 21st century. A search committee has been established to recruit multiple scientist/engineer/educators to help lead the School of Optics/CREOL’s activities in photonics education and research. This major new incentive will significantly expand our five member faculty team in photonics and optical communications and we are seeking faculty at Asst./Assoc./Full professor levels including PREP positions.

We are also beginning planning our Industrial Affiliates Day, which is scheduled for April 6, 2001. I am happy to announce that Dr. Milton Chang, who has several success stories including his latest with New Focus, has agreed to speak. This day will also be an opportunity to meet our students, so please mark your calendars.

Schwartz (cont.)

He was a tireless advocate of economic development, serving, at various times, as Chairman of the Governors Florida Defense Industry Task Force, as a member of the Mid-Florida Industrial Development Commission (IDC), the Florida Delegation to the National Small Business High Technology Conference and as a Director and Chairman of the Board of Directors of the Enterprise Florida Technology Partnership. During his tenure as Chairman of IDC, Central Florida led the state in industrial growth, accounting for 23 percent of the state’s new industrial projects in 1983, as compiled by the Department of Commerce and 29 percent in 1984.

And he devoted equal passion to the United Way, Arts United of Central Florida, the Boy Scouts and his church. Perhaps unknown to some Bill spent the last 27 years as a singer with the Bach Festival Choir at Rollins College, recently touring with the group in Italy, and he frequently played the flute at the First United Methodist Church in Orlando.

Awards and recognitions Bill has received run the gamut from being honored as Florida’s Industrialist of the Year Award by the Tampa Museum of Science and Industry, 1987 to being named a Fellow, Laser Institute of America in 1993. He was especially delighted by the establishment of the UCF School of Optics, William C. Schwartz Endowed Graduate Fellowship Fund in 1999. While attending a UCF graduation ceremony just last spring to celebrate his establishment of the first company in which UCF holds an equity partnership role, he reveled in the activities, seemingly as thrilled as the students lined up to begin their new ventures. So it was especially jarring to hear of his death of a heart attack just three months later. Many in our industry have been influenced in some way by Bill’s efforts. And because of his vision, future generations will be as well.
The CREOL fall picnic was held in November at Jetty Park in Cocoa Beach. As is evidenced by the photos, students and staff made the most of the opportunity to unwind and enjoy good company and a fine day.

Patrick L. Thompson completed his PhD Degree in Optics by successfully defending his dissertation entitled *Optical Performance of Grazing Incidence X-ray/EUV Telescopes for Space Science Applications* on May 26, 2000. He is now employed by the Applied Physics Laboratory at John Hopkins University in Baltimore, MD.

One of our Ph. D. students, Jihua Du, won second prize for his paper entitled *Laser Marginal Lap Micro-Welding for Ultra Thin Sheet Metal* in the Student Paper Competition at the International Congress on Applications of Lasers and Electro-Optics, 2000 (ICALEO’00), Detroit, Michigan, October 2-5. He has accepted a position with Lucent Technology, Inc., Allentown, Pennsylvania.

The OSA Student Chapter at the School of Optics/CREOL has won the first annual Outstanding Student Chapter Award established by the Optical Society of America in recognition of remarkable achievements as programs and activities. OSA considered that the hard work and dedication of the student chapter volunteers is unique and deserves to be rewarded. Realization of display projects, CREOL laboratory tour guiding, meetings with the new students to introduce them in the academic community, organization of Faculty and Student Seminars, active participation at the Industrial Affiliates Day, organization of picnics and parties (CREOL Fall Picnic, Holiday Party, The Spring Thing) are just a few of the student activities that were greatly appreciated by OSA through this award. Our chapter received $1,000 and a certificate. The certificate has been displayed in CREOL’s lobby, and the money was used for purchasing of a laptop computer. Any time CREOL students go to conferences, they will be able to use this laptop for much nicer and more professional looking presentations than on transparencies.

Gabriel Popescu traveled to the Topical Meeting on Photon Correlation and Scattering, held in Whistler, Canada. This trip was partially funded from his Charles Gramm Travel Award received earlier this year.
Insights into CREOL Research

Laser Eye and Sensor Protection

by the Nonlinear Optics group

In recent years, considerable effort has been put into developing new materials and devices for high performance optical limiting devices to protect sensitive optical elements, detectors and eyes against exposure to high intensity laser pulses. Optical limiters (OL) are devices that exhibit high transmittance for low inputs and low transmittance for high inputs. This often requires using nonlinear transmissive properties of materials such as two-photon absorption, excited-state absorption or refraction, and/or nonlinear scattering. These optical devices are designed to keep the energy, fluence, power, or irradiance transmitted below some specified maximum value, independent of the magnitude of the input.

Photochromic sunglasses are an example of such a nonlinear device, however, the speed of the response is about 10 orders of magnitude too slow to protect against Q-switched laser pulses. In addition the maximum optical density when darkened is not large enough to be effective for protection. The performance of an optical limiter can be measured by its dynamic range, DR. The DR is defined as the ratio of linear transmittance to the minimum transmittance at high energy \( (T_L / T_{min}) \). This minimum transmittance occurs just below the energy at which the limiting device itself is damaged by the laser. Many different nonlinear processes in different materials have been studied for optical limiting and researchers at CREOL have pioneered many of these studies as well as developing unique designs and building optical limiters that best utilize the material’s nonlinear response.

In one of the best limiters to date, Reverse Saturable Absorber dyes, RSA, (organic dyes that show a strong excited-state absorption) in a multiple cell, tandem geometry a DR >400 was obtained. This geometry and device was invented by the CREOL NLO group.

However, recently, a new geometry has been used by the NLO group to obtain over an order of magnitude increase in DR while increasing the linear transmittance. Based on an f/5, cascaded-focus, (dual focus) optical geometry, a DR > 35000 has been demonstrated.

A 2-cm-thick carbon disulfide cell at the first focus provided a protective buffer for a 0.1-mm thick RSA solution made of lead phthalocyanine (PbPc(CP)_4) in chloroform placed at the second focus. The device was tested using a frequency-doubled, Q-switched, 5-ns, full-width at half-maximum (FWHM), single-longitudinal mode, Nd:YAG laser at a 10-Hz repetition rate. It has been shown that the encircled energy (defined as the transmittance through a 1.5 mrad aperture) is a good measure of the damage threshold energy of the human eye, so this was the quantity measured. The high performance of this new optical limiter is due to the strong self-focusing in CS_2 due to both the reorientational
GOES/SXI Team Adopts CREOL X-ray Telescope Design

The Geostationary Operational Environmental Satellite (GOES) system is a geosynchronous dual weather satellite system that continuously senses climatic changes in the western hemisphere of the earth’s atmosphere as well as measuring other environmentally crucial factors. The GOES system is operated by the National Oceanic and Atmospheric Administration (NOAA) with headquarters in Boulder, Colorado. NOAA’s mission is to create and disseminate reliable assessments and predictions of weather, climate, space environment, ocean and living marine resources, and nautical and geodetic phenomena. Future GOES systems will therefore continuously gather data on space weather occurring both locally and at the Sun.

The Solar X-ray Imager (SXI) is a complimentary, add-on instrument designed primarily for use on the GOES next generation satellites; however, its modular design is suitable for installation on many other spacecraft platforms. Its primary mission is to continuously observe the full solar disc at X-ray wavelengths; including coronal holes, active regions, flares, and coronal mass ejections. A solar flare erupts when stored magnetic energy in the sun’s convection zone is suddenly released into the corona. The corona is almost entirely composed of plasma. This plasma is dominated by the physics of magneto-hydrodynamics and by bremsstrahlung effects. Electrons are the main carrier of the plasma energy and are easily guided by the prevailing magnetic fields. When oppositely directed magnetic fields reconnect into a cusp, non-thermal electrons release hard X-rays that can be distinguished from the spectrum of soft X-rays produced by thermal electrons. Sunspots are the visible manifestations of flare footprints and represent the redistribution of ambient energy from the Sun’s blackbody spectrum into the X-ray spectrum.

For reasons not fully understood, solar flare and sunspot activity varies dramatically on an eleven-year cycle as shown in Figure 1. Solar flare induced space weather and its detrimental effects include: geomagnetic storms (malfuon of compass and GPS systems); electromagnetic interference (communication systems failure); ionospheric expansion (satellite deorbit); power grid overloads (blackouts); radiation overdose (astronaut health hazard); and single event upsets (satellite electronics malfunction).

UCF/COREL Professor James E. Harvey and graduate student Patrick Thompson are providing technical support to the Lockheed Martin Solar and Astrophysics Laboratory (LMSAL), prime contractor for the design and fabrication of the SXI telescope for the GOES N and O Satellites. Raytheon Optical Systems, Inc. of Danbury, CT is the X-ray mirror manufacturer.

Figure 1 Recent sunspot activity versus time.

Figure 2 SXI modular design illustrating specific optical features and support systems.

NASA’s Goddard Space Flight Center in Greenbelt, MD is serving as the contract monitor for the Lockheed Martin contract. The NASA baseline design for the SXI telescope is a classical grazing incidence Wolter Type I design consisting of a paraboloidal primary mirror and a hyperboloidal secondary mirror. Designs of this type have been successfully used on NASA’s recently launched Chandra (AXAF) Observatory, the European Space Agency’s ROSAT X-ray telescope launched in 1990, and the U.S. Einstein Observatory launched in 1978 which marked the beginning of the burgeoning field of X-ray astronomy. The Lockheed Martin SXI modular design and some of its specific optical features and associated support systems are illustrated in Figure 2. The entire telescope is only about
100 centimeters long and 20 centimeters in diameter.

CREOL's role in the SXI program was originally to perform detailed image quality predictions, including the detrimental effects of surface scatter at the very short X-ray wavelengths of 6-60 angstroms. Harvey and Thompson have developed a systems engineering approach to image analysis where they calculate the aperture diffraction point spread function (PSF), the geometrical PSF, the surface scatter PSF, and the miscellaneous residual error PSF independently. These four functions are then convolved numerically to yield the system PSF, or aerial image, produced by the X-ray telescope (see Figure 3). Once the system PSF is known, most of the commonly used image quality criteria are readily calculated.

The primary top level image quality requirement placed upon the SXI prime contractor was expressed in terms of on-axis fractional encircled energy, with the off-axis performance being dictated by the imaging characteristics of the telescope optical design. A similar requirement had been (appropriately) imposed by NASA upon both the Einstein and the Chandra Observatories. However, they were both small-field stellar X-ray telescopes that are precisely pointed at the object of interest. SXI is intended to operate as a staring telescope, pointed at the center of the sun, providing wide-field images of the full solar disc. Since the features of interest (solar flares or sunspots) can appear virtually anywhere on the solar disc, there is no merit in optimizing the on-axis image quality at the expense of the off-axis performance. A field-weighted-average measure of resolution is therefore more appropriate for the SXI application. Harvey suggested that minimizing the area-weighted-average half power radius ($HPR_{a_{wa}}$) over a particular field-of-view (FOV) would maximize the number of average spatial resolution elements in that FOV

$$N = \frac{A_{T}}{\frac{\pi}{(HPR_{a_{wa}})^2}}$$

and thus maximize the total information content of the image. This new image quality requirement led Harvey and Thompson to develop a whole new family of optimal grazing incidence X-ray telescope designs, where each member of the family is optimized for a different FOV. This new family of X-ray telescope designs differs from the classical Wolter Type I design in that they consist of a hyperboloidal primary mirror and a hyperboloidal secondary mirror. This is reminiscent of the well-known aplanatic Cassegrain ( Ritchey-Chretien) normal incidence telescope design that is corrected for spherical aberration and coma. However, since scattering effects dominate geometrical aberrations at small field angles, and field curvature and astigmatism dominate coma at large field angles, there is little merit in using precise design variables for eliminating either coma or spherical aberration. Instead the five free parameters of the hyperboloid-hyperboloid design can be sued to balance all aberrations (defocus against field curvature, spherical aberration and astigmatism against oblique spherical aberration) to obtain an optimum design for a given FOV. One member of this new family of generalized Wolter Type I X-ray telescope designs, designated at H-T#17, yields a predicted 80% increase (over the baseline design) in the number of spatial resolution elements in an 18 arc min radius FOV. The HPR versus field angle is illustrated in Figure 4 for the H-T#17 X-ray telescope design.

After an intensive effort during which NASA and ROSI corroborated the predictions of Harvey and Thompson, and after the necessary cost and schedule impact on the mirror fabrication program, the GOES/SXI team formally adopted the H-T#17 optical design for the SXI telescopes for the GOES N and O satellites at the Lockheed Martin SXI Critical Design Review (CDR) briefing on July 15-16, 1999.

Dr. Peter Delfyett gave the Keynote Presentation at this year’s National Science Foundation Presidential Early Career Awards for Scientist and Engineers Award Ceremony on October 24. The NSF PECASE is awarded each year to the nation’s top 20 young scientists and engineers. This year’s recipients were selected from more than 1800 applicants. The 20 awardees were identified as the most outstanding of the roughly 350 NSF Career Award recipients. Dr. Delfyett was asked to discuss his thoughts on the changing directions in academia and the importance of integrating research and education activities. He also provided numerous examples on how he has been able to leverage his PECASE award to his advantage in achieving his goals.

A. Kar was recently elected a Fellow of the Laser Institute of America. The LAMMMP (Laser-Aided Manufacturing, Materials and Micro-processing) group, headed by Kar, has successfully completed a STTR Phase II project entitled „Innovative Applications of Advanced Photonics - Precision Laser Welding of Thin-Sheet Metals for Gasket Fabrication“, in collaboration with Joe Longobardi, President, Metal Tech Industries, Inc.

This project was awarded the Fifth Annual Tibbetts Award in October by the U.S. Small Business Administration, Washington, D.C., in recognition of its unique contribution as a Model of Excellence for the Small Business Innovation Research Program.

James E. Harvey has been elected to the Board of Directors of SPIE-The International Society for Optical Engineering.

Harvey has also been appointed to the Editorial Advisory Board of the new SPIE publication called OEmagazine.

Two faculty members at CREOL/School of Optics, Drs. Guifang Li and Patrick LiKamWa are taking partial leaves of absence for a period of two years in order to devote their attention to the creation of a local start-up company.

Optium Inc. is developing optical networking technology. The University owns an equity stake in this venture and is excited about its potential outcome.

One of CREOL’s goals is to transfer technology into industry in the local area and it has been quite successful in doing so by a variety of mechanisms such as writing joint proposals with industry partners, doing industry sponsored work and graduating M.S. and Ph.D. students who take up employment in local industry as well as individual faculty consulting for local industry.

Another effective way of transferring technology into the local industry is for faculty to participate in the formation of new companies. This is especially effective when the technology is new and very different from technologies in existing local industry. Several such new “start-ups” have already been formed in the last couple of years. Drs. Nabeel Riza and Bruce Chi have also taken leaves to work on developing startup companies.

Optium adds yet another piece to the variety of optical technologies being commercialized in the Central Florida area. Optium would provide more high-tech jobs to the area and it is hoped that an avalanche of such enterprises would ensue.

On the down side, the School of Optics is finding itself having to deal with a temporary shortage of faculty as this exciting trend continues.

AC Kerr effect and electrostriction, which causes optical breakdown in the liquid CS₂ (this rapidly self heals). This effect limits the transmitted energy incident on the RSA cell, keeping it below its damage threshold. The overall encircled energy output was limited below 0.400 J (see Fig. 1), which is below the human eye damage threshold, even for inputs greater than 57 mJ (maximum available energy from the laser) – and the device never showed evidence of damage. The output should remain clamped for much higher input energies. The low irradiance transmittance for the dye solution was 56 % and the total linear transmission for the entire system was measured as 25% including parasitic reflection losses from uncoated optics.

By optimizing the setup the total linear transmittance should increase to nearly 56 %.
In support of research aimed at nondestructive, three-dimensional imaging of polymer composites and biological systems, funding was received from the National Science Foundation and UCF Presidential Initiative to enable us to build a two-photon confocal laser scanning microscopy system with a tunable femtosecond laser. This system is also the platform for our research in three-dimensional microfabrication via two-photon induced polymerization. Synthetic efforts are directed towards preparing multiphoton absorbing organic dyes for use in site-specific labeling of polymeric composites and biological cells. We have recently acquired a time-resolved and steady state luminescence spectroscopy system for the characterization of these dyes through funding from the UCF Presidential Initiative and the Research Corporation. We have taken great strides in elucidating conditions for microfabrication via two-photon induced polymerization using both commercially available photoinitiators and specially designed initiators.

This research promises to help us develop a thorough understanding of multiphoton-induced polymerization while facilitating transition of this technology from the research laboratory to prototype manufacturing.

Efforts now focus on broadening the scope of two-photon polymerization and the microfabrication of functional polymeric microstructures. Results of our research have recently been published in the *Journal of the American Chemical Society*.

We have successfully synthesized a number of organic molecules that undergo efficient two-photon absorption and upconverted fluorescence emission. These materials are particularly important in the fast emerging field of nondestructive multiphoton fluorescence imaging. To date, our investigations include investigating the micromorphology of interfaces in polymer composites with an aim towards developing a technique for nondestructive failure analysis and prediction in multicomponent devices. We are also probing cancer cell structure and function through two-photon fluorescence imaging studies using our two-photon absorbing dyes. Recent publications in *Organic Letters*, *Chemistry of Materials*, and the *Journal of Organic Chemistry* highlight our accomplishments. Our work in microfabrication, two-photon fluorescence imaging, and two-photon induced photochromism will be featured in an upcoming issue of the *Journal of Physical Organic Chemistry*.

Our research involves a number of international collaborations, including scientists from the Ukraine and China.
Papers Published:


Seminar Presentations:


Papers Presented at Conferences:


P. LiKamWa, "Semiconductor Optoelectronic Switches for High Speed Data Communications," Photonics North, ICAPT-2000, Quebec, Canada.


CREOL Affiliates

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