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**Publisher's version / la version de l'éditeur:**

*APPLIED OPTICS*, 47, 13, pp. C98-C106, 2008-05-01

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# Charles Keith Carniglia (1944–2006): in memoriam

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Received 7 September 2007; accepted 13 September 2007;  
posted 26 September 2007 (Doc. ID 87079); published 28 November 2007

Chuck Carniglia was an industrial scientist, an educator, and a friend to all he met. He had an important impact on the optical thin-film community. This article highlights his career and accomplishments. © 2008 Optical Society of America

OCIS codes: 000.1410, 000.5360, 310.0310.

I have known Chuck Carniglia for a long time (Fig. 1). We met frequently at the Optical Society of America (OSA) and Society of Vacuum Coaters (SVC) annual meetings and at the Optical Interference Coatings (OIC) conferences. But we really became much closer when, during the past 20 years or so, we met each other at the University of Rochester for the Summer Course on Optical Thin Film Coating Technology, where Chuck was the main instructor. We spent many evenings together talking on all manner of subjects. I can't imagine anyone who knew Chuck a little bit more closely not liking him.

Chuck was born on 14 September 1944 in San Francisco, California, to Stefan John Carniglia and Dee (Vogel) Carniglia. He was a happy child. He finished Lincoln High School in San Francisco in 1962. Chuck then graduated *cum laude* from the University of California, Berkeley, in engineering math in 1966. He next went to the Institute of Optics of the University of Rochester to study under the world-famous optical scientist Leonard Mandel. His Ph.D. thesis was entitled "Emission, absorption and phase shifts of evanescent waves." He did work on the Goos-Haenchen shift—this work is still being cited.

After graduation and a six-year-long stay as an Assistant Professor of Physics at the University of Maine at Orno, where he received awards for outstanding teaching, Chuck became an industrial scientist. In 1977 he became a Senior Research

Physicist at the Optical Coating Laboratory, Inc. (OCLI) in Santa Rosa, California. In the years 1985–1989 he was employed by the Martin Marietta Aerospace Group as a Manager of the Optical Coating Laboratory at the Kirtland Air Force Base in Albuquerque, New Mexico. In the years 1989–1994 he became the Program Manager and Chief Scientist of the Developmental Optics Facility then operated by S Systems for the Kirtland Air Force Base. Between 1994 and 1998 he was the Manager of Advanced Technology Development at Aircro Coating Technology, later called BOC Coating Technology. Finally, in 1998 he returned to OCLI, now called JDSUniphase, as a Chief Scientist, where he stayed until his retirement in 2005.

During his career, Chuck had worked on a wide range of theoretical aspects of optical thin films, deposition processes, and coating products. He looked at the theory of the determination of optical constants of thin films, developed dispersion equations for indium-tin-oxide (ITO) and oxide materials, and studied the theory of scatter from rough surfaces. He investigated total internal reflection and the theory for thin-film coatings when the incidence media had absorption or gain. Chuck worked on the design of rugate filters and even looked at the theory of one-dimensional photonic crystals from the point of view of optical thin films. In his spare time, he found the energy to write, develop, and market an optical thin-film design program called Thin Film Designer Software.

With regard to deposition processes and equipment, Chuck Carniglia was involved in the development of a sputtering process for the deposition of



Fig. 1. Photograph of Charles Carniglia taken in 1980 at the Second OIC Topical Meeting at Mill's College in Oakland, California.

better ITO coatings. He participated in the design of improved optical monitors and even the development of in-line coating chambers for CRTs.

In a long-time collaboration with the Lawrence Livermore National Laboratory, he and his team developed processes for the deposition of high-power-laser damage-resistant coatings for the 1315, 1064, 532, 351, and 248 nm wavelengths.

Thin-film devices that he helped develop included antireflection (AR) coatings on plastic and glass for display applications, dichroic beam splitters, polarizers, narrow-bandpass filters, and phase-shifting coatings. With Joe Apfel he was the first to develop designs for highest-reflectivity mirrors in the presence of absorption within the coating materials.

While at the Kirtland base, he was also very involved with five major multimillion dollar Air Force programs. He had a yearly budget of the order of \$3 million and a staff of 25 people. His good friend, Brad Pond, recalls that *"Chuck was trying to build a world-renowned facility for conducting research on thin-film optical coatings used in laser systems. An important part of building this reputation and facility was to build capability in those who worked for him and to inspire those who worked at his side and above him to publish. Chuck's extensive knowledge of both thin-film coatings and optical system design allowed him to develop component designs that were smaller and lower in cost than the original concepts, which was critical for satellite-based optical systems."*

Now a few words about Chuck Carniglia's scientific legacy. An industrial scientist is not, as a rule, ex-



Fig. 2. Chuck and Olivia Carniglia with daughters Mary and Annika in Santa Rosa, California, in 1995.



pected to have many publications. When his wife, Olivia, e-mailed me to ask whether I would consider him to have an international stature, I made a quick search of my thin-film database and found that it contained about 45 references to papers, lectures, and patents listed under his name. I told Olivia that, in my experience, a more thorough search would probably show that the total number of publications is 1½ to 2 times as large. In my estimation this would certainly qualify him to be called an authority in our field. After I accepted the invitation to prepare this paper, for a while I thought that I might not be able to reach such a number of publications. In the end, I found 37 references to papers in refereed journals [1–37]. (Chuck was proud of the fact that two of these papers were selected for the cover of *Applied Optics*.) I had expected more refereed papers from the search of the scientific databases. However, it so happens that a very large number of Chuck's publications were in the form of talks presented at the Boulder Laser Damage Symposium, with which Chuck has been associated for many years. These publications were not normally abstracted. The number of papers that I found in various conference proceedings was 52 [38–89]. I also found eight articles in society and technical journals [90–97]. These are of a tutorial nature and are very useful for introducing newcomers to our field. Some of these address the claim of

photonic crystal researchers to have invented perfect mirrors. I also found four U.S. patents [98–101]. (Another patent application, with R. Wilbur, for a handheld bearing compass, does not seem to have been granted, and so it is not listed here.) My total count of Chuck's publications is thus 101. However, it would not be surprising if there were some publications that I have missed. The lists do not include short abstracts or the dozens of oral presentations that Chuck gave in Austria, Canada, England, France, Germany, Japan, Korea, Scotland, Switzerland, and the USA. To list all of these would be an impossible task.

Chuck Carniglia's contribution to our field is much larger than the work described in the publications listed at the end of this article. He was a teacher at heart, and wherever he worked, he was training and mentoring young engineers in the field of optical coatings. He will certainly also be remembered as an excellent educator who, with his humor and his enthusiasm, was able to infect his audiences with a like enthusiasm for our field. As already mentioned above, for about 20 years he was the main instructor at the Rochester Summer Course on Optical Thin Films. With an average attendance of 30 people per year, this translates to about 600 people who were taught by him at this one venue alone. But he also taught courses for the American Vacuum Society and at other conferences. Clearly, in a narrow field such



Fig. 3. (Color online) Chuck Carniglia and Jennifer Kruschwitz on the quintic bridge.

as ours, he has influenced and shaped a very significant fraction of the “practitioners of the art” of optical coatings in North America.

Chuck Carniglia was also active in the scientific societies pertinent to the field of optical coatings. He held various functions within the Optical Society of America. He was the Chairman of the Thin Films and Optical Materials Technical Group of the OSA, the Program Chairman for the Fifth Topical Meeting on Optical Interference Coatings in 1992, and the General Chairman for the Seventh OIC Topical Meeting in 1998. Chuck was also the Guest Editor of special issues of *Optics and Photonics News* and *Applied Optics* on optical thin films. Very deservedly he was elected as a Fellow of the Optical Society of America.

After all that has been said about Charles Carniglia the scientist and engineer, it is now necessary to tell those who did not know him personally a little more about Chuck the person. Chuck met his future wife, Olivia Anslinger, at the International Folk Dance Group at the University of Rochester. They were married on 22 August 1970. They have two daughters, Annika and Mary (Fig. 2). For his parents, Chuck and Olivia added an apartment onto their Santa Rosa house and took care of them there from 1998 to 2004. Both had Alzheimer’s disease, and in 2004 they transferred to a nursing home where they could receive more care. Chuck’s father died earlier this year. Chuck also has an artist brother, Jerry. The Carniglia family was very close and they supported and cared for each other very much. Each summer, at the Rochester University Summer

Course on Optical Thin Films, one evening when we were having supper, Chuck would pull out a pile of photographs to update me on the present state of his family. He was very proud of them. And for good reason. His wife, Olivia, single-handedly organized, first in Albuquerque and then in Santa Rosa, very active support groups for children in Belarus who suffered from the radiation of the Chernobyl disaster. They sent aid to them, as well as brought many over to spend their holidays in the USA.

Chuck Carniglia extended the same caring attitude and help to all people that he met. He was a member of the First Church of Christ, Scientist, and he just lived and practiced his faith. I know this because he extended his friendship to one of my colleagues, Glen Clark, when he joined OCLI. He disarmed and won over people through his straightforward approach and through not treating himself very seriously. He was always ready to put people at ease, for example, by wearing funny T-shirts or ties or ties that glowed in the dark or lit up. Chuck was always full of good humor and fun. I think that he would like to be remembered for that.

Chuck had very many outside interests and I have already mentioned one of them, folk dancing. He was also an ardent railway buff. He was a member of the California State Railroad Museum. Olivia and Chuck took train rides on historic or famous railroads. He took his hobby home: In his office, suspended from the ceiling, Chuck had a radio-controlled model railroad track. The trains ran from his office through holes in the wall to Olivia’s office and out into the hall.



Fig. 4. (Color online) Karen Hendrix, Terri Lichtenstein, Bill Klapp, Trudy Tuttle Hart, and Chuck at his retirement party.



Here is another anecdote. Bill Southwell, working with rugate filter design, showed how a quintic transition of the refractive index between two different media provided an excellent AR coating. Chuck also happened to be a handyman. One day he decided to build a double quintic bridge in his yard (Fig. 3)!

In 2004 Chuck celebrated his 60th birthday and Olivia invited very many of his friends. More than 90 people attended, many of them from out of town. For his retirement in 2005 from JDSUniphase, his colleagues gave Chuck a model train car painted with optically variable paint—a very appreciated gift! At the same party he had a chance to take a photograph with three ladies with whom he had published many papers in the past—Trudy Tuttle Hart, Karen Hendrix, and Terri Lichtenstein (Fig. 4). How many people know that archery was another hobby of Chuck's? I only found this out from a photograph sent to me by Karen Hendrix!

Chuck told me about his illness about 3 years ago, when we met in Rochester. Like others, I had hoped that he would be cured. Despite losing all his hair due to the chemo treatments, Chuck continued to smile and to live his life to the fullest. In May 2006 Olivia and Chuck came to Ottawa to an International Workshop on Optical Thin Film Coatings (Fig. 5). He was in great shape and my friends and I were very

heartened by this. There he attended a talk by Bill Southwell and had discussions with him on quintic AR coatings. This inspired him to start an investigation to see if lower power refractive index profiles might perhaps offer a better solution. Later, in June of the same year, Chuck had the strength and desire to attend the 40th reunion of the University of Rochester International Folk Dancers where he first met Olivia.

Then his health deteriorated. He was admitted to the hospital and then released back home. Friends started to visit him (Fig. 6). Perhaps the last out-of-town thin-film visitor was Doug Smith. Among other things, they talked about the paper on the alternative to the quintic AR coatings that Chuck was trying to write. His daughters Annika and Mary were both there to help. Karen Hendrix was a frequent visitor at the Carniglia home during this time, but Chuck was unable to transfer much information to her about the future paper.

Chuck died on 21 December. Immediately, messages started arriving from his friends and colleagues. Here are excerpts from a few of them.

**Doug Smith, Plymouth Grating Laboratory:**  
*"It was a little scary to see an icon slip away. Many of*



Fig. 5. (Color online) Chuck and Olivia Carniglia with Doug Smith at the 2006 International Workshop on Optical Thin Film Coatings in Ottawa.



Fig. 6. (Color online) Chuck Carniglia visited by Brad Pond in October 2006.

*us owe so much to Chuck for bringing clarity to the work we do. I am very glad I got to stop by."*

**Frank Jansen, BOC Edwards:** *"I will always remember Chuck from our days in Concord. His enthusiasm, his deep understanding of all aspects of optical technology and his ability to teach others were a hallmark of the way he plied his trade as an industrial technologist and manager of people. So many accomplishments, new optical designs, new materials and the development of thin film coating machines, which were state-of-the-art. Chuck was an industrial scientist par excellence, a model to be aspired to. Better than most, he understood the role of research and development in the corporate environment, never compromising scientific insights and technological reality for wishful corporate thinking. He is remembered and deeply missed."*

**John Corless, JDSUniphase:** *"I know you will receive many, many outpourings of affection for Chuck, but as someone who at least knew him for a little while, I'd like you to know how much I enjoyed his positive attitude, his great sense of humor, his incredible knowledge of optical physics, and his kind-hearted friendship."*

**Roger Philips, Flex Products:** *"Chuck will be remembered not only for putting OCLI in the forefront of thin-film design but for his eloquent style of teaching of thin-film optics and solid ray optics to the rest of us. He was able to bring very difficult concepts into a simple way of understanding so that less-versed people like me could understand what was going on. His enthusiasm for the technology rubbed off on ev-*



Fig. 7. (Color online) Chuck sitting on a stairway next to a tile bearing his name (see text).

*eryone he met. I can think of no one else who made the teaching of the technology such a joy."*

**George Dobrowolski, NRC:** *"Only yesterday I got an e-mail from Jennifer Kruschwitz in which she was enthusiastic about a telephone conversation with Chuck a day or two ago when Chuck offered her some very good advice. So typical of Chuck—helpful to the very end!"*

There are stairways in Chuck's neighborhood in San Francisco where it is too steep to have a street. On the 16th Avenue Steps the tiled risers on the steps form a mural of the sea up to the land up to the sky. Olivia sponsored tiles with the names of Chuck, his brother, parents, and grandparents. In the picture, the star-shaped tile to Chuck's right bears his name (Fig. 7). Olivia's caption to this photograph said, *"Olivia's bright and shining shooting star: Chuck Carniglia."* I would add to this, *"the bright and shining shooting star of all of us who knew and loved Chuck."* We will miss him very much!

Olivia Carniglia provided most of the 35 or so photographs that were shown during the oral presentation at the OIC 2007 meeting and which can still be viewed on the following web site: <http://www.osa.org/meetings/topicalmeetings/OIC/program/invitedspeaker/MA1%20-%20Carniglia%20Final.pdf>. I would like to thank her sincerely for all the help that she has given me. I am also very indebted to the following people for their assistance during the writing of this article: Karen Hendrix, Frank Jansen, Kamil Mróz, Brad Pond, Ric



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