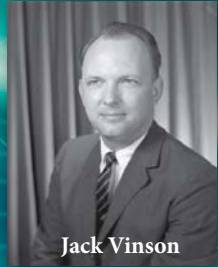




Top Story

# The Future is COMPOSITES:

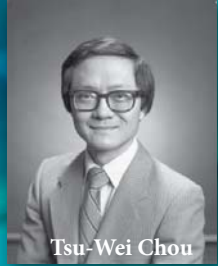
Thirty-Five Years of Composite Materials Research and Education at the University of Delaware



Jack Vinson



Roy McCullough



Tsu-Wei Chou



Byron Pipes

*Shown above are the four "Founding Fathers of CCM": Prof. Jack Vinson, Prof. Tsu-Wei Chou, the late Prof. Roy McCullough, and Prof. Byron Pipes*

University of Delaware  
Center for Composite Materials

## COMPOSITES UPDATE

July 2009

Four people—Jack R. Vinson, Tsu-Wei Chou, the late Roy L. McCullough, and R. Byron Pipes—are credited with founding and leading the early growth and development of UD's Center for Composite Materials. In conjunction with CCM's 35th anniversary celebration this year, the three living founders agreed to share their thoughts on CCM's early days, including the challenges they faced and the factors that led to the Center's ultimate success. Their presentations were videotaped and can be accessed in their entirety on our web site. This article provides highlights of the Center's history as seen through their eyes.



John W. Gillespie Jr.

John W. Gillespie Jr., Director and Donald C. Phillips Professor



# TOP STORY (Continued)

In 1974, Prof. Jack Vinson envisioned the formation of a center at the University of Delaware that would be an internationally recognized focal point for composite materials research.



*Prof. Jack Vinson  
1978*

Thirty-five years later, the Center for Composite Materials looks very much like Vinson's vision—a Mecca for composites research where the whole is greater than the sum of the parts through increased cooperation and the ability to obtain additional resources.

“If you look at the proposal we wrote in 1973 to establish CCM,” says Vinson, who served as CCM's first director, “you realize that it could have been written yesterday because it's just as accurate now as it was then.”

The 1973 proposal refers to the three-part mission that continues to serve as the Center's foundation today: analytical and experimental research and development, multidisciplinary education through courses and seminars, and efficient information transfer among

the users, manufacturers, and developers of systems utilizing composite materials.

Today, Vinson points to a number of factors that led to CCM's long-term success, including, most importantly, the three other pioneers instrumental in the establishment and early growth of the Center: Tsu-Wei Chou, Roy McCullough, and Byron Pipes.

While the Center was officially launched in 1974, the history of composites at UD actually dates back to the fall of 1969, when Vinson taught the first composites course at Delaware. That same semester, Chou, who had just completed his Ph.D. at Stanford, joined the UD faculty.

“Even though Delaware and California are far apart geographically, I immediately felt quite at home at Delaware because of the enthusiasm and kindness of the two senior professors, [then-Dean] Irv Greenfield and Jack Vinson,” Chou recalls.



*Prof. Tsu-Wei Chou  
1978*

## TOP STORY (Continued)

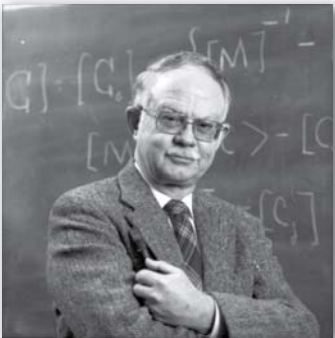
“My biggest challenge was identifying what I could contribute in teaching and research as a junior faculty member,” he continues. “But I remembered that when I had asked my advisor at Stanford, Professor Alan Tetelman, about future research directions, he had told me to ‘try composite materials.’ Although I had no knowledge of this mysterious subject, just the thought of getting into a new research area excited me immensely.”

Chou’s willingness to try something new quickly translated into his teaching UD’s second composites course in the spring of 1970. “The enthusiastic response we received from students about composites and the lack of a suitable textbook motivated Dr. Vinson and me to write our own,” Chou says. *Composite Materials and Their Use in Structures* was published by Elsevier-Applied Science Company in 1975.

McCullough joined the UD chemical engineering faculty in 1971 after spending several years in industry. With Vinson’s focus on structural mechanics, Chou’s on materials science, and McCullough’s on polymer science, the three complemented one another perfectly, but they realized that a four-legged stool would be stronger. Pipes, with his work focusing on experimental composite mechanics, was recruited from Drexel University to round out the expertise of the fledgling composites group at CCM.

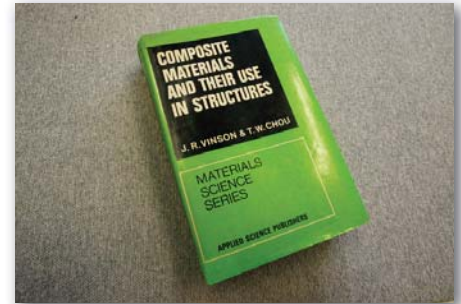
It soon became apparent that Pipes had come to UD not only to fill a needed teaching and research slot but also to initiate a new era in funding and partnerships.

*Prof. Roy L.  
McCullough  
1986*



Vinson wryly notes that the UD administration’s speedy authorization to start the new center was due to the fact that the group had asked for no money. As the approval memo stated, “The financial aspects of the Center appear to be straightforward: that no additional resources will be required, and that the funding is to come from outside contracts and grants.”

As it turned out, the funding would come from external sources, but Pipes and McCullough had new ideas about what those sources would be.



*Composite Materials and  
Their Use in Structures*  
© 1975



*Prof. R. Byron  
Pipes, 1978*

“Composite materials was a hot topic in industry at the time,” Pipes says, “and most of the available government money was going to institutions that had already become established in this area. Roy and I both viewed industry as an untapped reservoir of resources for this type of program because we saw that companies were unhappy with academic research and its lack of relevance to what they were doing.”

UD’s location provided a lucky break. “We were a stop along the way for people visiting DuPont and Boeing,” Pipes explains. Soon, the group was presented with not only a real industrial problem, but also the money to help solve it. The Rogers Corporation needed to eliminate the use of asbestos fibers in their automotive composite products, and, as Pipes puts it, “They were the first industry to put the money on the line and say ‘Lets do it.’”

The discontinuous short-fiber systems used by the automotive industry were very different from the material systems employed in aerospace applications, but the CCM team worked closely with the company to address the technical issues involved.

“The most important lesson we learned from this experience was how to do basic research to solve industrial problems,” Pipes says. “There’s a very delicate balance between the discovery of new knowledge and doing work that’s relevant.”

CCM’s early leaders took the lessons they had learned from working with Rogers and in 1978, with Pipes as Director, established the University/Industry Consortium: Applications of Composite Materials to Industrial Products. By the end of the first year, the consortium had eight sponsors, and within the next several years membership expanded to 40 companies world-wide, representing not only the automotive sector but also the aerospace industry.

To ensure that industry would be motivated to renew their memberships over the long term, Pipes led the Center in the development of a package of deliverables



*2009 University Industry  
Consortium  
Members*

*Relationships of the  
Elements of a  
Structural Hierarchy  
by R. L. McCullough  
circa 1984*

available only to sponsors, including the Delaware Composites Design Encyclopedia, an annual symposium to share the Center's research results, an annual workshop to provide continuing education to professionals in the composites community, and microcomputer software to facilitate composites design and analysis.

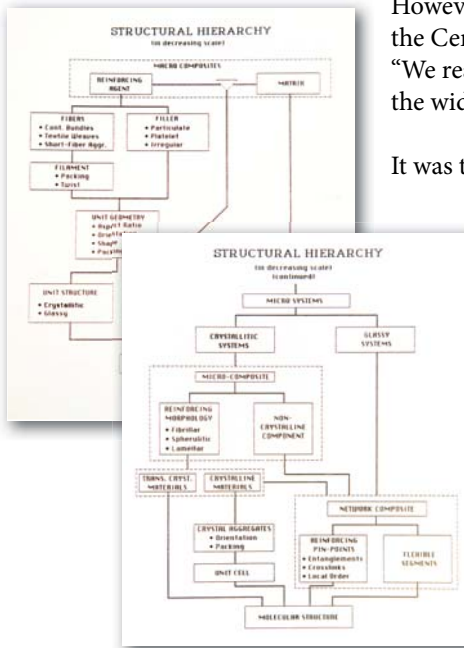
However, by the early 1980s, as industrial projects continued to grow, the Center's leaders began to question what other issues were important. "We realized that the cost of manufacturing was the primary barrier to the widespread use of composites," Pipes says.

It was time to shift gears, and the National Science Foundation (NSF) presented the perfect opportunity to address this issue through its Engineering Research Centers (ERC). Established in 1985, the ERC program supports cross-disciplinary research and education focused on technological advancement from an engineering systems perspective.

UD, with its proposal to establish the Center for Composites Manufacturing Science and Engineering, was one of just six universities to be selected for funding in the first round of ERCs. Chou recalls working with Pipes during the proposal-writing process to prepare a diagram showing the interdisciplinary character of the proposed research.

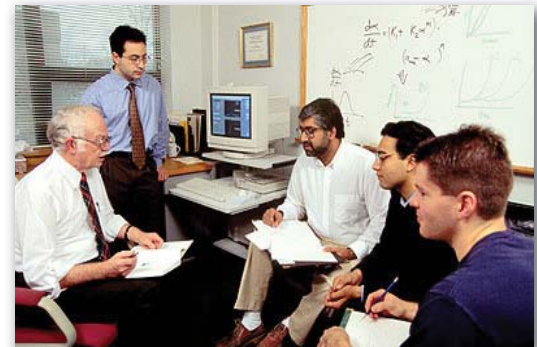
"We had four blocks—one each for processing and manufacturing, materials characterization, analysis and modeling of material behavior, and performance optimization—connected with arrows to show the iterative nature of our approach to manufacturing science studies," Chou says. "Even though such an approach is commonplace today, the implication of the concept was particularly significant some 25 years ago."

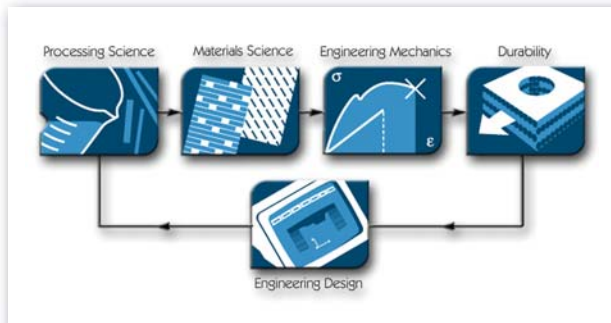
"Furthermore," he adds, "to make such an approach feasible in an academic environment meant that we needed to minimize the barriers between traditional academic disciplines.



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*Prof. McCullough  
with students*





*Multidisciplinary  
Approach to  
Manufacturing Science  
circa 1984*

CCM really played a pioneering role in advocating and practicing the multidisciplinary approach in academic research.”

Pipes points out that Delaware was in good company in winning the ERC award, with the others having gone to Purdue, MIT, Harvard/Maryland, Columbia, and UCSB. “This demonstrated that not only was UD the best in composites, but that it achieved a place among the best research centers in the country,” he says. “It also showed that NSF recognized what the automotive and

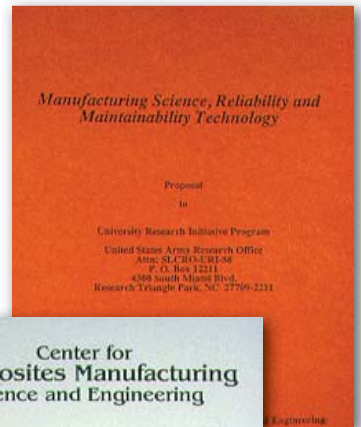
aerospace industries already understood—that CCM had indeed become the Mecca for composites in the U.S.”

Pipes’s pioneering approach to collaborate with industry and his role in developing the Delaware ERC was rewarded in 1987, when he was elected to the National Academy of Engineering for “interdisciplinary leadership in composite materials research and for development of an exemplary model of university, industrial, and governmental interactions in research and education.”

The ERC paved the way for CCM to win major funding from the Department of Defense. In 1986, the Center was awarded a University Research Initiative (URI) grant from the Army Research Office (ARO). Chou and McCullough partnered on the leadership of this new program, which focused on composites manufacturing science, reliability, and maintainability technology.

“With both the ERC and URI programs in place,” Chou says, “CCM gained its indisputable status as a leader in composites manufacturing science research. The ARO program lasted for 12 years, and it laid the foundation for our sustained interaction with Army laboratories, which continues today.”

The NSF-ERC and the ARO-URI programs established a strong foundation that led to CCM being awarded several additional DoD center of excellence grants over the next two decades under the direction of CCM’s current leaders, Director Jack Gillespie and Associate Director

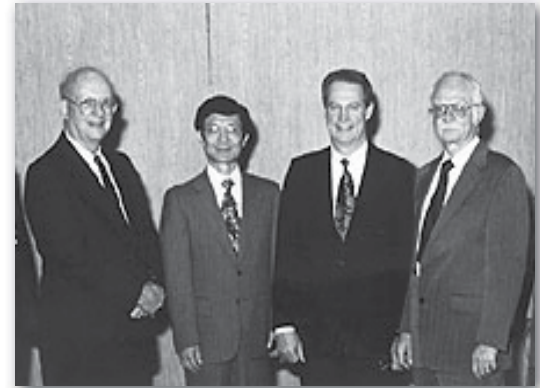


Suresh Advani. With those programs extending to 2014, CCM is now approaching 30 years as a center of excellence in composites.

At the same time, the 30-year-old industrial consortium has evolved and thrived under Gillespie's leadership. More than 65 companies, from small local firms to international corporations, are actively participating.

The Center's presence throughout the world has grown significantly in the decades since its founding, beginning with Chou's collaboration with Professor Anthony Kelly from the United Kingdom in the mid-1970s. After exchanging extended research stays with Kelly, Chou went on to visit key composites laboratories in Great Britain and continental Europe as part of a team appointed to assess European composites technology. He then became involved with the Asian composites community.

*The founding fathers of CCM*



*The Medal of Excellence in Composite Materials*

“Japanese visiting scholars first arrived in the late 1970s, and CCM soon became a major attraction for visitors from academic and industrial organizations throughout the world,” Chou recalls. “During the 1980s and 90s, I had the pleasure of working with some of the finest researchers and students from Japan, China, Taiwan, Korea and India. It was indeed a golden time for international exchange and cooperation.”

“Besides the research work they performed at Delaware,” he continues, “many visitors would vividly recall their great experience at CCM when I reconnected with them years later. Looking back at this wonderful period of international exchange, I feel that CCM established itself not only as a focal point for pioneering composites research but also as a model for international exchange.”

Now, in its fourth decade of operation, CCM continues to serve as a valuable resource to the composites industry and the DoD. SBIR and STTR programs provide fruitful opportunities for the Center to collaborate with small companies, stimulating economic development in the state and the region. The interdisciplinary research environment and open-lab philosophy at CCM promote innovation and discovery, team-oriented research, and unique educational experiences for students at all levels.

Vinson credits Gillespie with the continued growth of the Center, in terms of not only size but also quality. A graduate student advised by Pipes in the Center's early days, Gillespie is now Donald C. Phillips Professor and has held leadership roles at CCM since 1995. "He has matured into a great leader," Vinson says.

"Thirty-five years ago, the University gave us the opportunity to start the Center for Composite Materials, and the rest is history," he adds. "Back in those days, the concept was embryonic, but composites are still growing, with applications in wind turbines, ship hulls, and bridge decks. We haven't yet seen the full fruition of composite materials."

"One need only consider the importance of the coming 2010 flight of the all-composite Boeing 787 to the economy of the United States," Pipes adds, "to realize the significance of the contributions of CCM in the last 35 years in developing this important new technology."

Editor's Note: Jack R. Vinson retired as H. Fletcher Brown Professor of Mechanical Engineering in 2005 and is now Professor Emeritus. Tsu-Wei Chou is Pierre S. du Pont Chair of Engineering. Roy L. McCullough was Professor of Chemical Engineering until his death in 2001. R. Byron Pipes is the John L. Bray Distinguished Professor of Engineering at Purdue University.

*Article by Diane Kukich*



*The Late  
Prof. Roy L.  
McCullough*



Please click the links below to watch the historical accounts of the beginning of CCM as seen through the eyes of the founding fathers:



**Jack R. Vinson interview**



**R. Byron Pipes interview**



**Tsu-Wei Chou interview**



**NEW PUBLICATIONS*****Journals***

Gao, L. M., E. T. Thostenson, Z. G. Zhang, and T-W. Chou, "Coupled Carbon Nanotube Network and Acoustic Emission Monitoring for Sensing of Damage Development in Composites," *Carbon*, 47 (5) pp. 1381-1388, 2009.

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Leal, A. A., J. M. Deitzel, S. H. McKnight, and J. W. Gillespie, Jr., "Effect of Hydrogen Bonding and Moisture Cycling on the Compressive Performance of Poly-Pyridobisimidazole (M5) Fiber," *Polymer*, 50 (13), pp. 2900-2905, 2009. on-line: <http://dx.doi.org/10.1016/j.polymer.2009.04.019>.

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Lamontia, J. A., J. J. Tierney, M. B. Gruber, J. W. Gillespie, Jr., B. J. Jenson, and R. J. Cano, "Modeling the Accudyne Thermoplastic In Situ ATP Process," JEC-SAMPE Europe Conference, 2009.

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*Celebrating 35 years of significant contributions to composites science and technology, the education of students, and the creation and transfer of technology to industry.*

