SMU Graduate School Specializes in Green and Joining Technologies

The PhD program at Southern Methodist University works to develop advanced manufacturing technologies

Fig. 1 — Caruth Hall (left), opened April 2010, is the third new building in the last eight years in the Southern Methodist University Lyle School of Engineering. The Jenkins Building (right) houses the Research Center for Advanced Manufacturing (RCAM) and the Center for Laser-Aided Manufacturing (CLAM).

BY HOWARD M. WOODWARD

Founded in 1911, Southern Methodist University (SMU), Dallas, Tex., has a full-time faculty of 660, a student-faculty ratio of 11 to 1, and nearly 11,000 students from the United States and 90 countries in its seven degree-granting schools. The universities ten libraries house the largest private collection of research materials in the southwest.

Founded in 1925, the Lyle School of Engineering is one of the oldest engineering schools in the southwest that boasts a well-established graduate program in research and development in joining technologies. It offers eight undergraduate and 29 graduate programs, including master's and doctoral degrees through five departments. Last year, the school granted 486 engineering degrees.

In addition to being home to the Research Center for Advanced Manufacturing (RCAM) and the Center for Laser-Aided Manufacturing (CLAM), the school is home to cutting-edge research in areas such as network and system security, advanced optics, bio-informatics, signal processing, photonics, air-quality, thermal science, and fluid mechanics. For the last eight years, the participants in the AWS Certified Welding Inspector 9-Year Recertification Seminar, conducted by AWS Past President Ed Bohnart, visit SMU to tour the research center's facilities.

Current Research Projects Underway

During 2008–2009, the university received $16.54 million in external funding for research aimed at solving local, national, and global problems. Current research projects include creating a national geothermal database; studying the mechanical and energetic basis of movement and human performance; monitoring seismic wave propagation related to verifying international nuclear arms-control treaties; particle physics at CERN's Large Hadron Collider near Geneva, Switzerland; monitoring volcanoes to provide early warning of eruptions; searching for a glimpse of elusive "dark matter" deep within a Minnesota mine; developing tiny, high-performance camera systems for homeland security and the battlefield; determining ancient environments through sedimentary rocks to help understand Earth's greatest mass extinction 251-million years ago; and developing improved antennas for wireless communications, satellite communication, and military applications.

The Engineering School

The Lyle School is among the fastest-growing engineering schools in the country. In the last four years, the enrollment has doubled, and in the last eight years the school has added three new buildings, the

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latest was opened April 16, 2010 — Fig. 1. Two of the buildings are designed to meet Leadership in Energy and Environmental Design (LEED) green building standards.

In 1997, Radovan Kovacevic joined the SMU faculty as the Herman Brown Chair Professor in Mechanical Engineering. A Fellow of AWS, ASME, and SME, Dr. Kovacevic's main objective was to develop an internationally recognized program in advanced manufacturing. For the last 12 years he has worked with more than 100 graduate students, visiting scholars, and undergraduate interns; published and presented with his research team more than 250 technical papers; and was awarded four U.S. patents. The R&D programs in advanced manufacturing, funded by state and government agencies, The Brown Foundation, and industry, with more than $15 million, were developed to revolve around the joining technologies.

Currently, Dr. Kovacevic's major research areas include laser cladding, microplasma powder cladding, metal deposition using electron beam melting, laser welding, hybrid laser-arc welding, friction stir welding, paint stripping by direct diode laser, development of lead-free solders reinforced with nanoparticles, mitigation of tin whiskers growth, laser beam welding of galvanized high-strength steels in a gap-free lap joint configuration, and laser microwelding and machining.

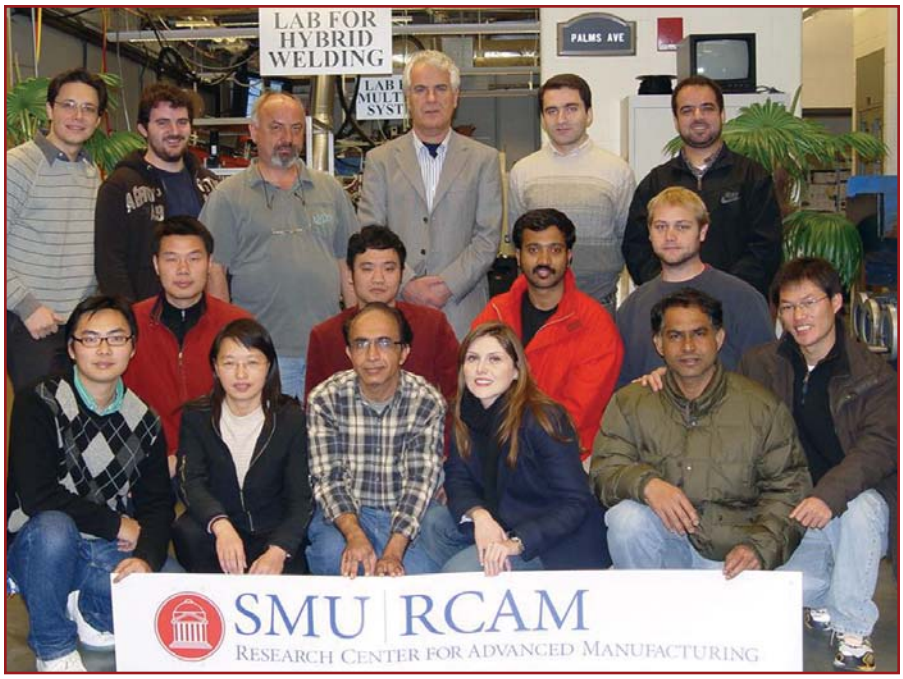

Fig. 2 — Shown Dec. 2009, the research team members are from left (front row) PhD candidate Wei Huang, Visiting Professor Xianfen Li, Dr. Shiva Gadag, Dr. Alekshandra Dimitrovska, PhD candidate Soundharaphandian Santhanakrishnan, and Dr. Shanglu Yang; (second row) Dr. Fanrong Kong, PhD candidates Junjie Ma, Prabu Balu, and Perry Leggett; (back row) Dr. Rouzbeh Sarrafi, PhD candidate Gilbert Chahine, research engineer Andrew Socha, Director Radovan Kovacevic, Dr. Eshan Foroozmehr, and PhD candidate Moussa Mirehei.

Industry's Involvement with the SMU Research Center

In order to respond to industry's needs and better educate its undergraduate and graduate students in the area of manufacturing engineering, the Research Center for Advanced Manufacturing (RCAM) was established September 1999 — Fig. 1.

In 2005, SMU was awarded a National Science Foundation grant to join the multi-university Industry/University Cooperative Research Center (I/UCRC) for Lasers and Plasmas for Advanced Manufacturing (CLAM). The other I/UCRC members are the University of Virginia, University of Michigan, and University of Illinois at Urbana-Champaign.

CLAM's industrial partners include Lockheed Martin Missiles and Fire Control, General Motors, the Army Research Laboratory, Halliburton Energy Services, Trinity Industries, Lee Laser, and Fruth Innovative Technologies (Germany).

Commenting on the centers, Blair Carlson, research program manager at GM LLC, Warren, Mich., said, "General Motors is a founding member of RCAM and CLAM (Industry/University Cooperative Research Center for Lasers and Plasmas) and has supported work on a number of R & D projects of interest to our industry. Most recently, we have collaborated with Dr. Kovacevic on ground-breaking work to achieve zero-gap laser welding of galvanized steels in lap joint configuration." Carlson explained, "The initial concept was a hybrid process which is technically feasible but not attractive from a manufacturing perspective. Continued work has now shown that this can be achieved using a single standard laser process which is in line with our current manufacturing bill of process thereby facilitating the transfer of technology from a lab bench to production. Recently, GM hired one of Dr. Kovacevic's graduate students for a senior research engineer position in the GM China Science Lab."

Ernest D. Levert, AWS president (2002–2003) and senior staff manufacturing engineer, Lockheed Martin Missiles and Fire Control, stated, "Lockheed Martin Missiles and Fire Control is a founding industrial member of RCAM and CLAM. For the past ten years, RCAM's research teams have been working on a number of R & D projects of interest to our company, such as friction stir welding of dissimilar aluminum alloys, a feasibility study of using variable-polarity plasma arc welding for repair of high-value aluminum parts, development of a rapid manufacturing/repair system based on laser cladding, real-time visualization of the molten pool, rapid manufacturing by electron beam, study the mechanism of cathodic cleaning of aluminum oxides, and hybrid laser arc welding of difficult-to-weld materials." Levert explained, "While every project is a success story in itself, the success of the project aimed at improving hybrid laser arc welding holds great promise. This project has been an excellent example of successful collaboration between industry and academia where research finds direct application. The SMU RCAM and CLAM provide an outstanding environment for educating and training the next-generation of research engineers. We are especially pleased that we have been able to engage graduate students and allow them to work directly with engineers and researchers from industry.

Steve Smith, vice president of engineering, Trinity Industries, Inc., stated, "Trinity Industries recruits engineering students with a strong interest in manufacturing who have a good balance of theoretical engineering and hands-on experience. SMU's Research Center for

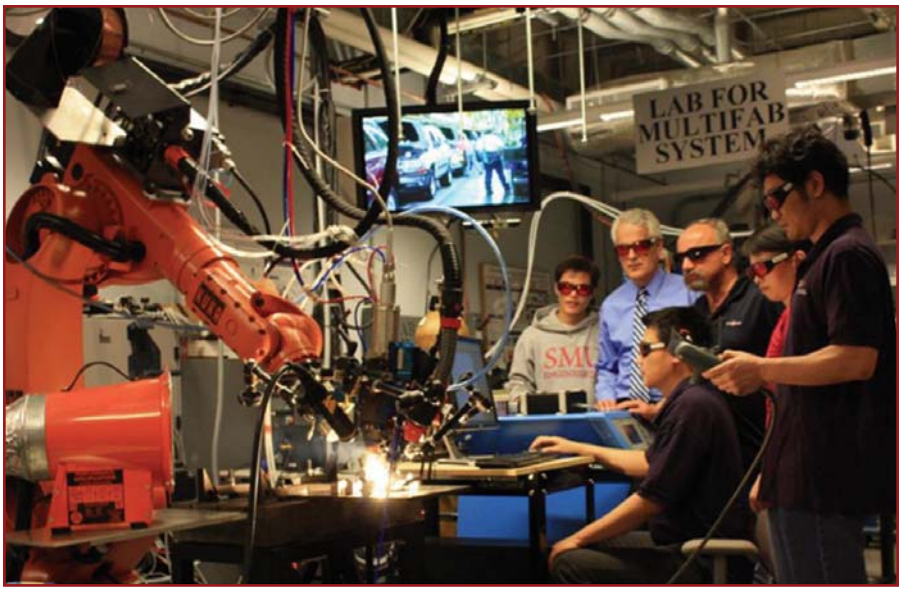

Fig. 3 — Research engineer Fanrong Kong (seated) demonstrates hybrid fiber laser arc welding of thick plates for (from left) Shanglu Yang, Radovan Kovacevic, Andrew Socha, Xianfen Li, and Junjie Ma in the SMU MultiFab System Laboratory.

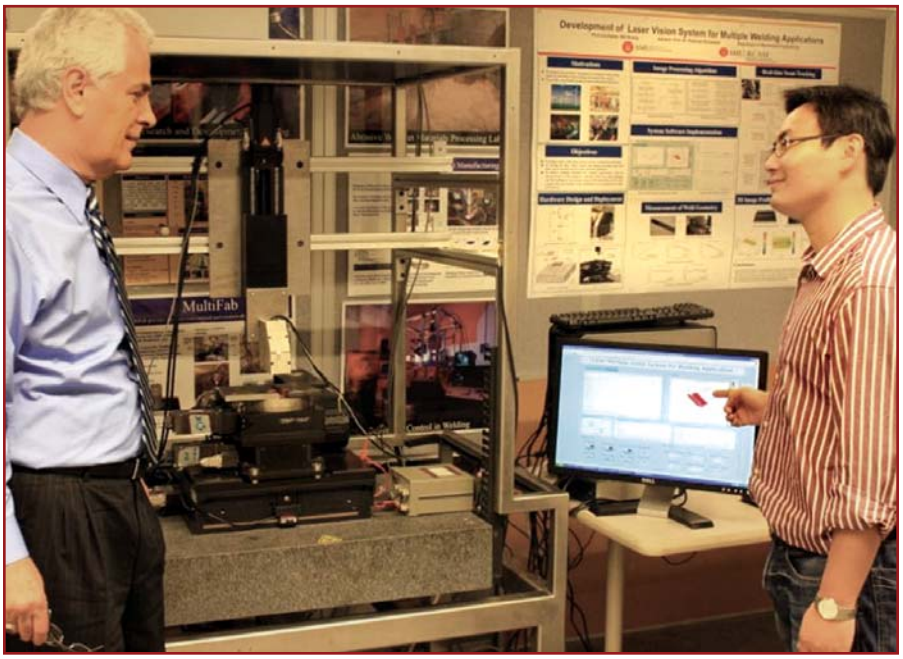

Fig. 4 — PhD candidate Wei Huang (right) explains to Dr. Kovacevic a newly developed laser-based machine vision system for joint tracking, adaptive fill control, and postweld inspection.

Advanced Manufacturing has consistently attracted top graduate students with a strong interest in welding and manufacturing. Our experience with SMU's engineering students has been outstanding."

Dr. Geoffrey Orsak, dean, SMU Lyle School of Engineering, stated, "The RCAM and CLAM have brought a great deal of international visibility to the SMU Lyle School of Engineering. The quality and impact of the work conducted in these two aligned centers is simply spectacular."

The Research Teams

The current RCAM's and CLAM's research teams include nine PhD candidates, four research engineers, a Visiting Professor, an undergraduate intern, and the director of the centers — Fig. 2. Just in the last year, five PhD students have graduated from these programs.

The RCAM and CLAM are internationally recognized for the work done on the development of a number of cutting-edge technologies such as rapid manufacturing processes based on a combination of additive processes (the deposition of material by different arc welding processes and laser cladding) with subtractive processes (milling, drilling, and turning), friction stir welding, electron beam materials processing, abrasive waterjet materials processing, micromachining by short pulse laser, hybrid welding of difficult-to-weld materials, surface modification in order to improve the resistance to heat, corrosion, abrasion, and, erosion, paint striping by high-power laser and other innovative projects — Figs. 3, 4. The RCAM and CLAM laboratories are well-equipped with the latest lasers, welding, cutting, and diagnostic equipment to facilitate the students' work in these areas.

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The Laboratories

The SMU RCAM encompasses numerous laboratories, including Electron Beam Materials Processing, Abrasive Waterjet Materials Processing, R&D in Welding, Friction Stir Welding, Sensing and Control, Materials Characterization, Electroplating, and CAD/CAM. The CLAM has the following laboratories: Laser Materials Processing, Rapid Manufacturing, Reverse Engineering, Hybrid Welding, and the Micromachining. The research activities are supported with the most advanced research and manufacturing equipment and software valued at more than $12 million in addition to a well-equipped machine shop and computing facility.

The SMU RCAM has developed an integrated platform for demonstrating and expanding the concept of multifabrication (MultiFab) where robotized additive operations based on laser cladding, microplasma powder cladding, and controllable metal deposition by gas metal and gas tungsten arc welding are combined with high-speed multiaxis machining via integrated software to control the CNC-based system. The MultiFab platform can be additionally configured with dimensional scan capability for reverse engineering, as well as for in-process and post-process inspection. Different engineering materials in the form of powders can be used to manufacture components such as Ni-alloys, tool steel, metal-ceramic composites, etc. The result of this work is the developed prototype of the MultiFab system for rapid manufacturing and repair for which Kovacevic was awarded a U.S. patent in 2006.

Students' Life on Campus

The school has implemented a gender-parity initiative with the goal to be the first school in the nation to enroll 50% female undergraduates. Currently, the Lyle School of Engineering has more than 35% female enrollment, which is much better than the national average of 19%.

Nearly 2000 undergraduate and graduate students live in 14 residence halls and two houses. About 2300 students are members of sororities and fraternities. The university employs 1779 students, including 33 postdoctoral, 674 graduate, and 1072 undergraduate students.

Students can gain valuable leadership experience through participation in the nearly 180 campus organizations. More than 2500 student volunteers serve annually through approximately 70 nonprofit agencies. Students also have the opportunity to participate in service-learning courses and alternative spring break national service projects.

The SMU Service House (SMUSH) is home to 28 student volunteers that offers a one-of-a-kind experience for serving others. It is a unique community of on-campus residents who care deeply for the community. Throughout the semester, "SMUSHies" perform a wide variety of service-oriented projects, ranging from providing after-school activities for kids in the Dallas area to assisting needy people, to cleaning up White Rock Lake.◆