Materials Science and Engineering 1906-2006

Centennial Issue

MAKING MATERIALS MATTER FOR 100 YEARS

Ceramic Engineering by Grant Wood, 1934, ISU

IOWA STATE UNIVERSITY

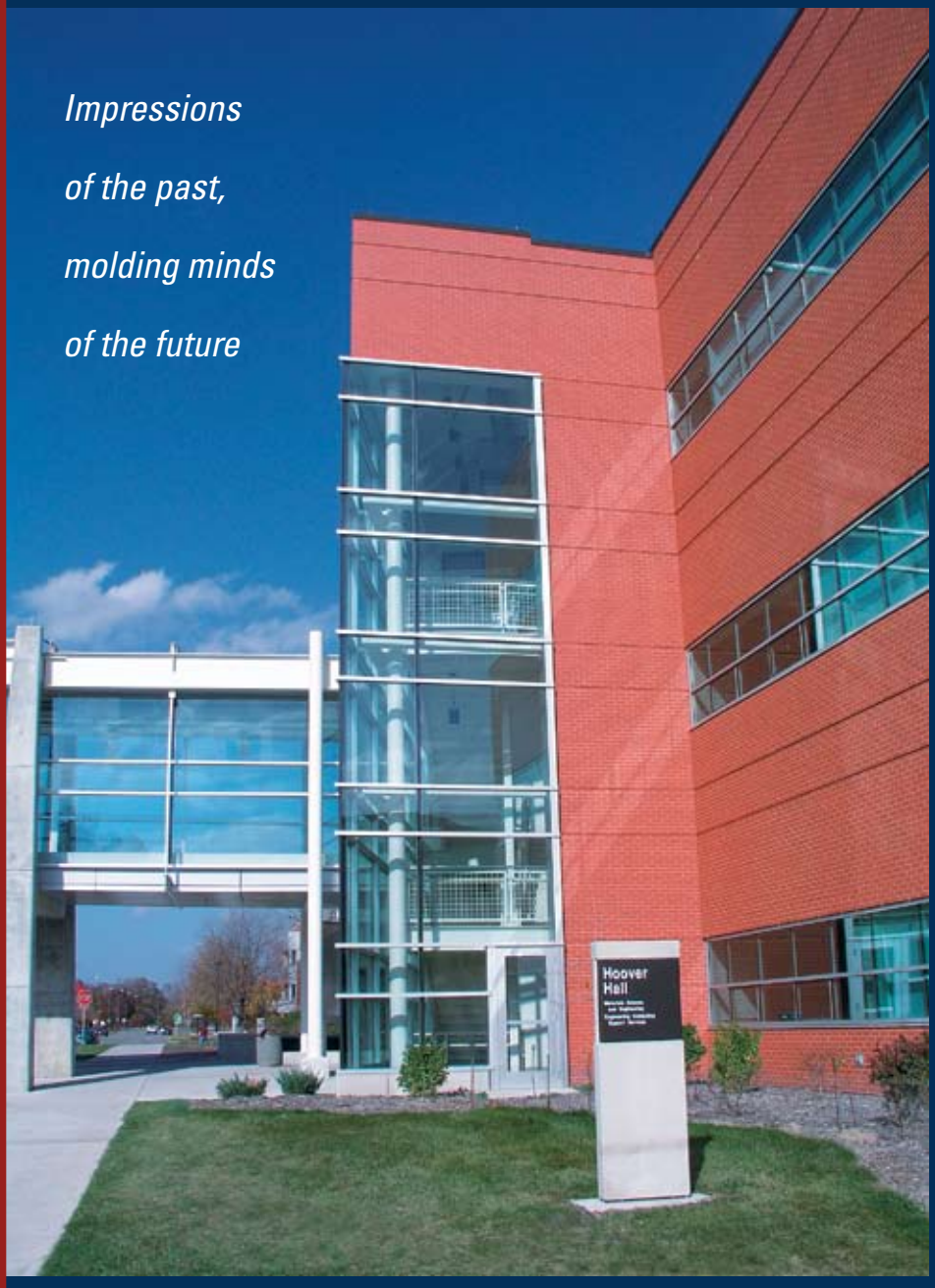
100 Years of Materials Engineering…

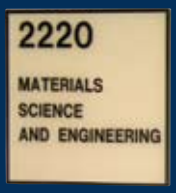
Impressions

of the past,

molding minds

of the future





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IOWA STATE UNIVERSITY

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University Archives, Iowa State University Library
U.S. Department of Energy's Ames Laboratory
University Museums, Iowa State University

Making Materials Matter for 100 Years

1906–2006

Greetings from the President

To the faculty and staff of the Department of Materials Science and Engineering:

It is a very great pleasure to congratulate the Department of Materials Science and Engineering on the milestone of its 100th anniversary.

Materials science and engineering has long been one of Iowa State University's outstanding academic departments and programs and one of the cornerstones of our College of Engineering. From its beginnings as a program focusing largely on ceramics and the large brick and tile industry in Iowa to its modern day role developing groundbreaking new materials, this department has excelled in every way—in the quality of its teaching programs, in its research accomplishments, and in the development and application of modern technology.

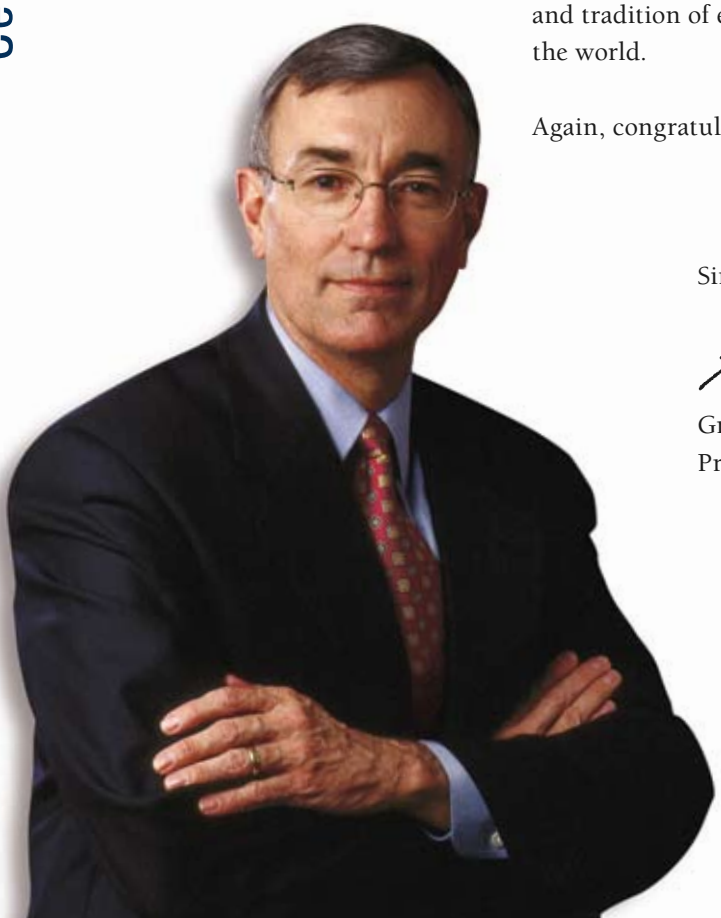
Today, the Department of Materials Science and Engineering is a key contributor to the academic excellence of Iowa State University. Its faculty are consistently among the most productive in the university in their research and their national recognition for excellence, and its students are consistently among the highest achievers in the university.

Iowa State University is very proud of the Department of Materials Science and Engineering's rich history of achievement and tradition of excellence in serving Iowa, the nation, and the world.

Again, congratulations on your centennial year!

Sincerely,

Gregory L. Geoffroy
President



1906-2006

Materials Science and Engineering
Centennial Year

From the Chair

As the brief history that accompanies this impressive centennial issue of *MSE Elements* suggests, the first century of materials at Iowa State was in many ways focused inward: first in our original mandate to serve Iowa's brick and tile industry, and, secondly, in our own evolution toward a concept of "materials science" that would take its place as fully equal in intellectual rigor and social utility to any other engineering discipline.

I hope that, despite the struggles of our early colleagues to justify their work, the state's brick and tile industry got their money's worth. As for the discipline itself, in my opinion we have succeeded beyond the wildest dreams of our early materials forebears—and the next century holds wonders we have scarcely begun to imagine.

But I'll leave you to conjecture on those scientific wonders and limit my comments to my role as MSE chair.

What are my goals for the department? Well, since I might not be here 100 years from now, I'd like to leave a platform from which our students and colleagues as yet unborn can realize these amazing discoveries. That means an outward focus that increases the national profile of MSE at Iowa State.

This work has already begun. In the past several years we've attracted to our program some of the most accomplished and promising materials scientists anywhere. But, as any coach knows, it's not enough to hire a bunch of all-stars; you also have to get them functioning as a team. And I'm convinced that what puts our people a cut above the typical all-star is their collegiality, the kind of intellectual generosity that delights in the achievements of others as much as their own—and in the accomplishments of the team more than either.

Which brings me to another goal: reconnecting with alumni and retired faculty in order to strengthen the bonds of our larger MSE family. For in a very significant way, you are all integral members of the MSE team. When I became chair in 1995, I saw industry looking for broadly educated rather than narrowly educated engineers—that's one reason we went to a unified materials engineering degree. But part of that base includes a broad base of people invested in our work, and that's where you come in. Whether you taught here half a century ago or graduated only last year, you are the foundation upon which our future success will be built.

So join me in celebrating our past and in anticipating our future: it's going to be a great 100 years!

Sincerely,

Mufit Akinc
Chair

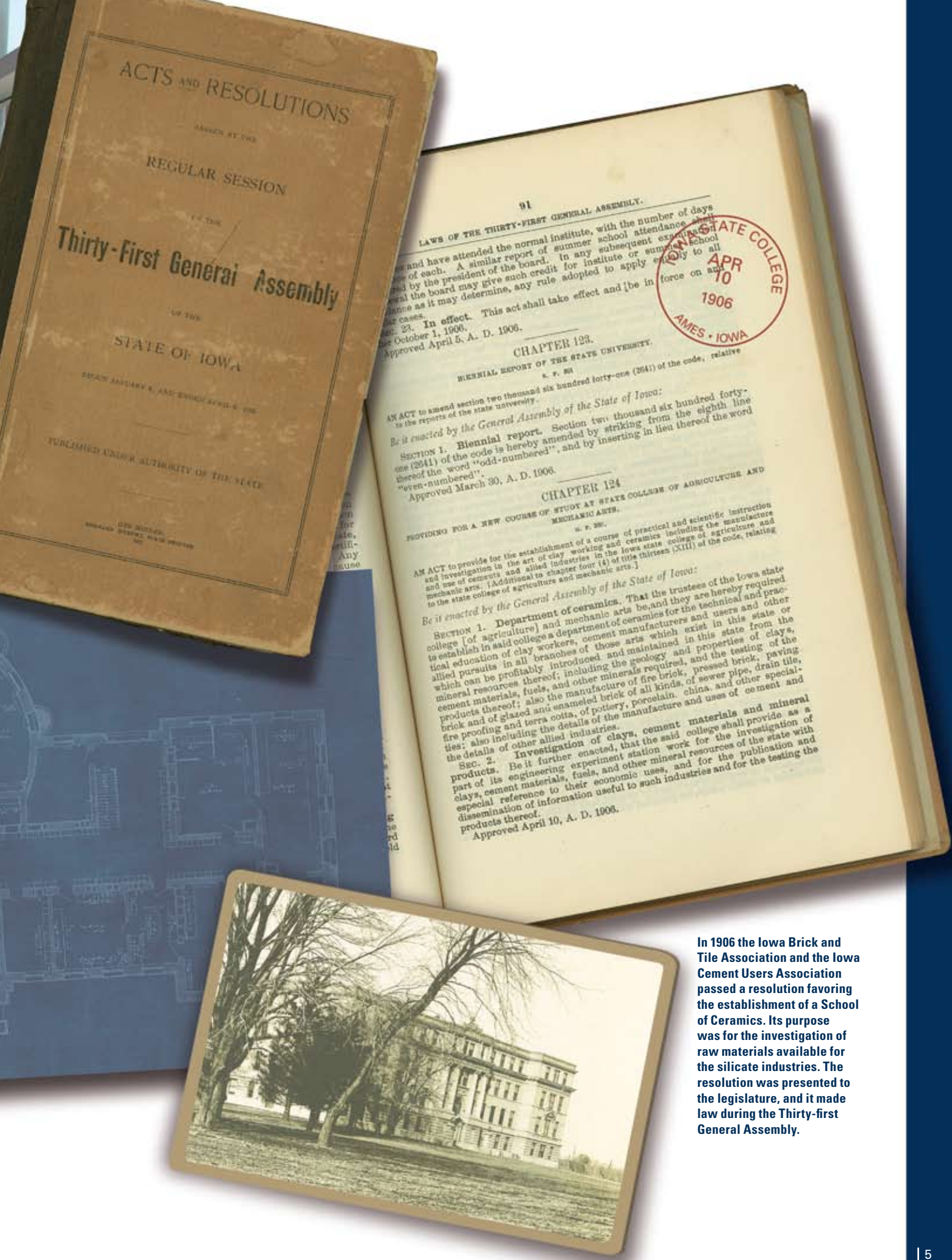
1906-2006

Making Materials Matter for 100 Years

Of all the engineering disciplines at Iowa State, none is more cutting edge than materials science, with research and teaching that ranges from the merely exotic to the breathtakingly bold. But here's something maybe you didn't know: we weren't always this different.

Take a walk with me down the hallway of our history to see how we began, how we've changed through the decades, where we are today—and where the future may take us. For as much as materials mattered a century ago, in the century to come they will matter more than ever before.

In 1906 ceramic engineering moved into Engineering Hall. Later, the building was renamed Marston Hall.



In 1906 the Iowa Brick and Tile Association and the Iowa Cement Users Association passed a resolution favoring the establishment of a School of Ceramics. Its purpose was for the investigation of raw materials available for the silicate industries. The resolution was presented to the legislature, and it made law during the Thirty-first General Assembly.

1906–1916

Ceramic Engineering

In 1906, few disciplines were less exotic than the new course in ceramic engineering mandated by the Iowa legislature. The assembly had earlier passed a law allowing farmers to form drainage districts for common outlets. Seeking to capitalize on the demand for ceramic drainage tile, manufacturers lobbied for technical support for their industry from the state's technical college.

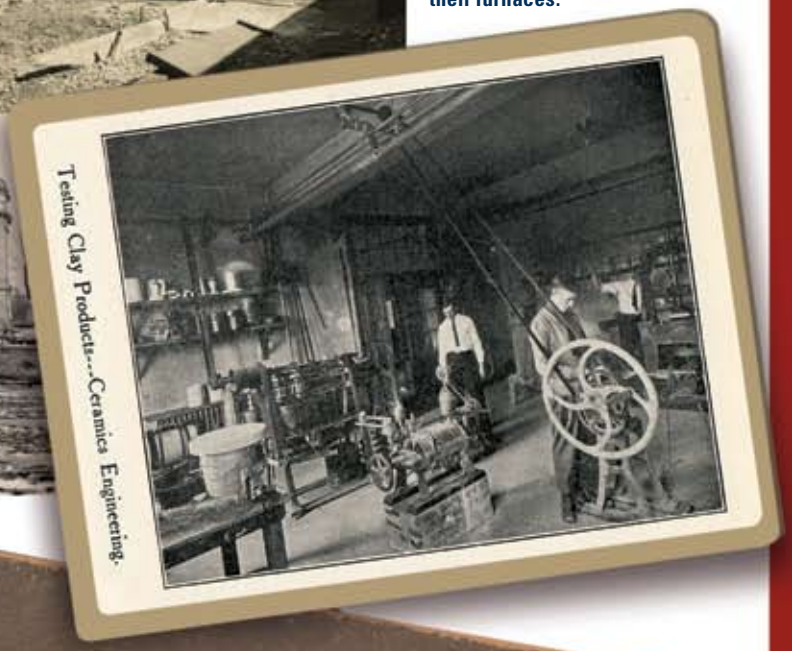
"They wanted someone who could evaluate clays to advance their business interests," says former ceramics department head and MSE chair David R. Wilder. "None of them had facilities to do this on their own."

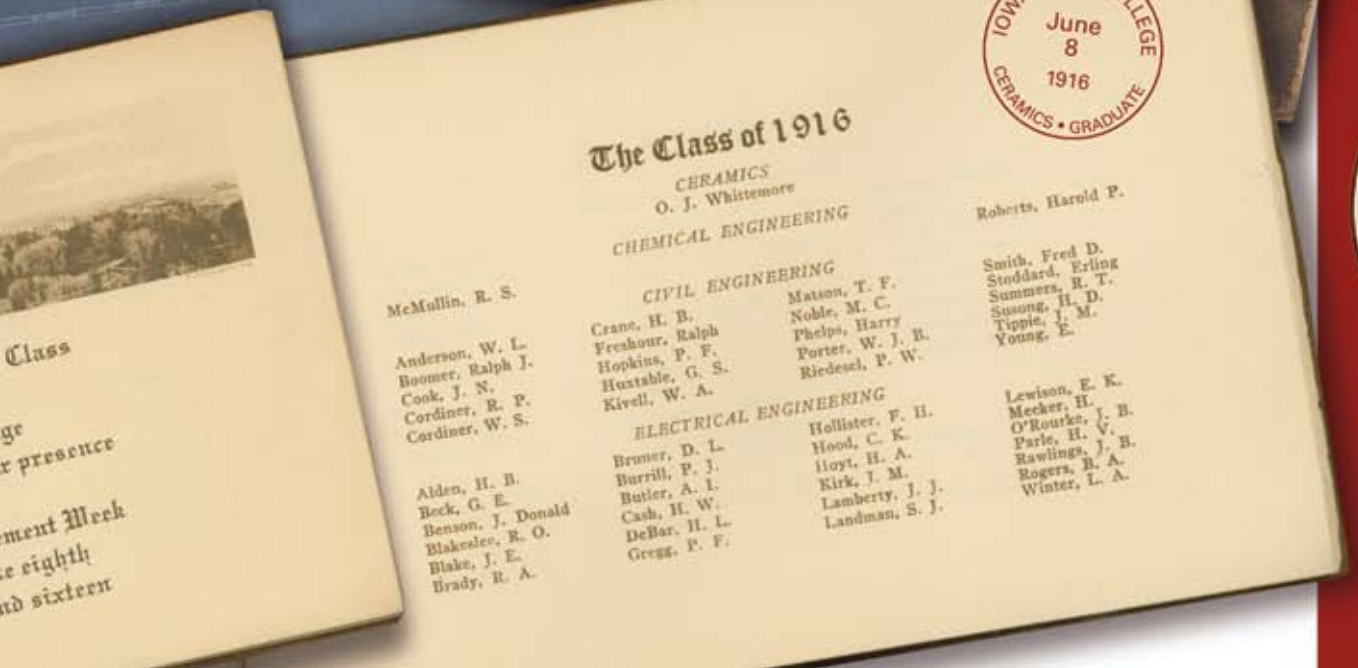
America's only other ceramics program was at Ohio State, so there wasn't much scholarship on which to base either a curriculum or a research program. But that was OK, because there weren't many students either. "The course of study was similar to that laid down by (Ohio State's) Professor Orton," recalled acting department head Paul E. Cox in 1923. "No students appeared."

In 1907, however, one Milton F. Beecher appeared, becoming Iowa State's first graduate in ceramics in 1910. He promptly joined Professor Samuel W. Beyer as the only other faculty member of the fledgling program.

1906-1916

After the Engineering Annex building was built in 1909–1910, the ceramic engineering department moved into the southwest wing. The interior courtyard housed some of their furnaces.





Department Heads—

Anson Marston
1906–1913

Samuel W. Beyer
1914–1919

Milton F. Beecher
1910, first graduate

1916–1935

Ceramic Engineering

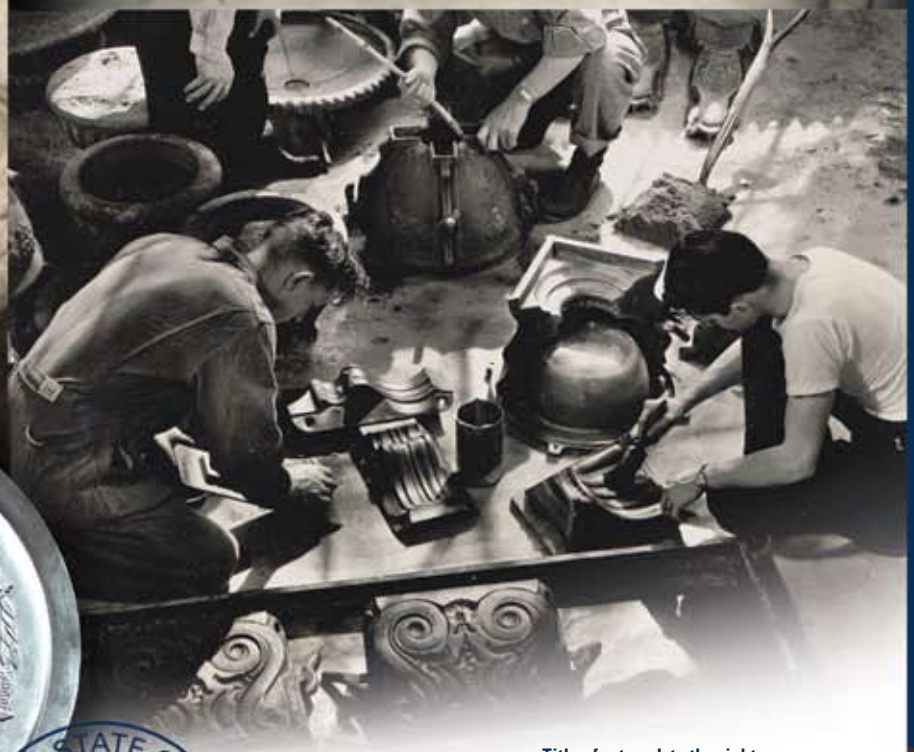
The challenge of attracting students persisted. Even elevation to departmental status in 1918 was not enough to ensure the program's survival. Indeed, after Beyer left in 1919, the department, with only three students, was essentially rudderless for a year. And when Cox took the helm in 1920, it was only as acting head—an "act" he'd perform five years before finally being named to the position permanently in 1925.

It's no exaggeration to cast Cox's tenure in terms of performance, for he brought to Iowa State at least as much showmanship as scholarship. In fact, Cox was not a scientist so much as a potter-engineer, known for his expertise with glazes.

It might not have been science as we'd recognize it, but Cox's turn from engineering and toward the arts did help to keep ceramics afloat at Iowa State. By 1925, the department boasted thirty men formally enrolled in its program—and no fewer than fifty women from other departments working in pottery.

Besides this, the department's relationship to women seldom extended beyond extension itself—literally. "For five years," Cox wrote in the 1925 yearbook, "the Engineering Extension Department has sent out the writer (namely, Cox himself) with a portable potter's wheel and a popular lecture on pottery of interest to Women's Clubs. These have dealt generally with ware of interest to the homemakers, both white table ware and ornamental pottery."

While engineers today might feel that such activities respected neither materials nor the potential of women, we might keep in mind that neither materials nor women were viewed then quite the way they are today. But while the full equality of women would take a few years longer, materials were about to take a giant leap into the future.



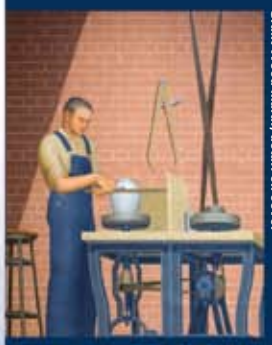
IOWA STATE COLLEGE
May 8–10 1930
VEISHEA • OPEN HOUSE

Title of artwork to the right: Detail of Ceramic Engineering Panel from *When Tillage Begins the Other Arts Will Follow*
Artist: Designed by Grant Wood (American, 1885–1942)
Date of work: 1934
Location: Parks Library on campus
Credit: Commissioned through the federal Public Works of Art Project and the National Youth Administration. In the Art on Campus Collection, University Museums, Iowa State University, Ames, Iowa.

Department Heads—

Samuel W. Beyer
1914–1919

Paul E. Cox
1920–1939



Grant Wood mural, detail on cover

Ceramic Engineering

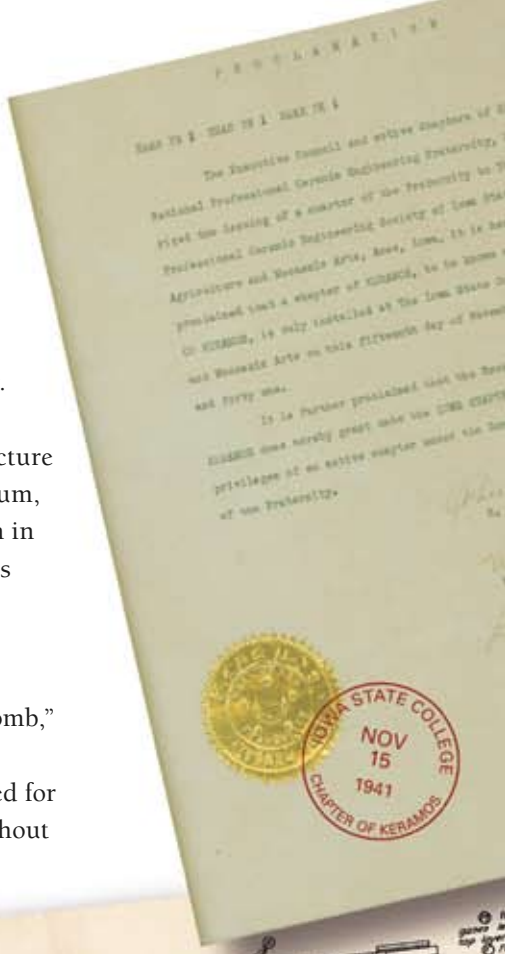
Cox remained in his position until 1939, when he was replaced by Professor C. M. Dodd, who would head the department until 1961. But any chance to "materially" elevate the study of ceramics at Iowa State would have to wait, since the university virtually shut down as students and faculty prepared for war.

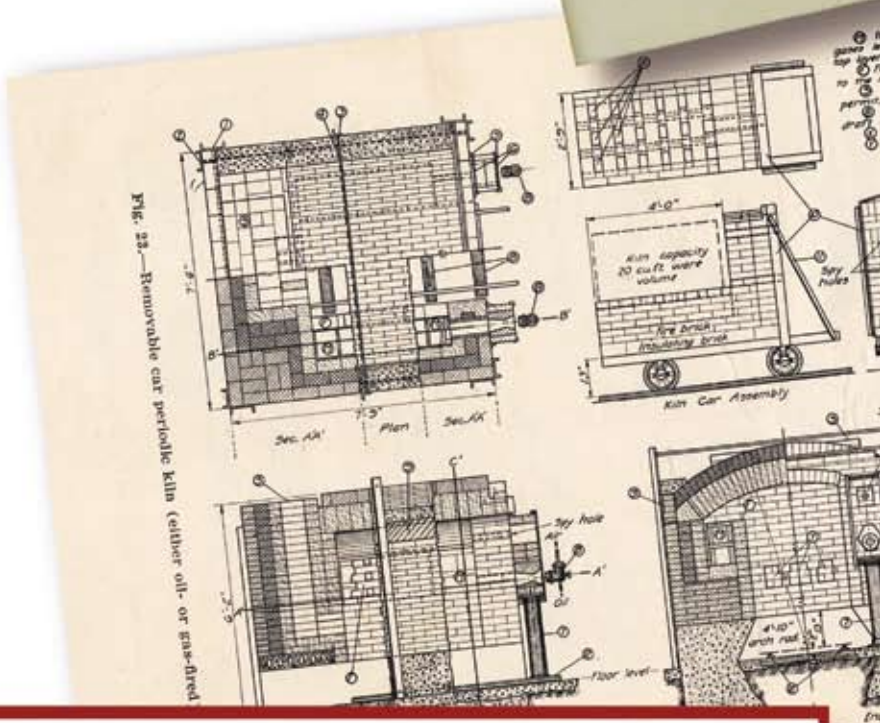
National security could not wait, however, as the U.S. raced Germany to manufacture an atomic bomb. That required processing vast amounts of weapons-grade uranium, and the man for that job was Iowa State chemist Frank Spedding, whose research in rare earth materials laid the foundation for the U.S. Department of Energy's Ames Laboratory—and with it the preeminence of materials science in the College of Engineering.

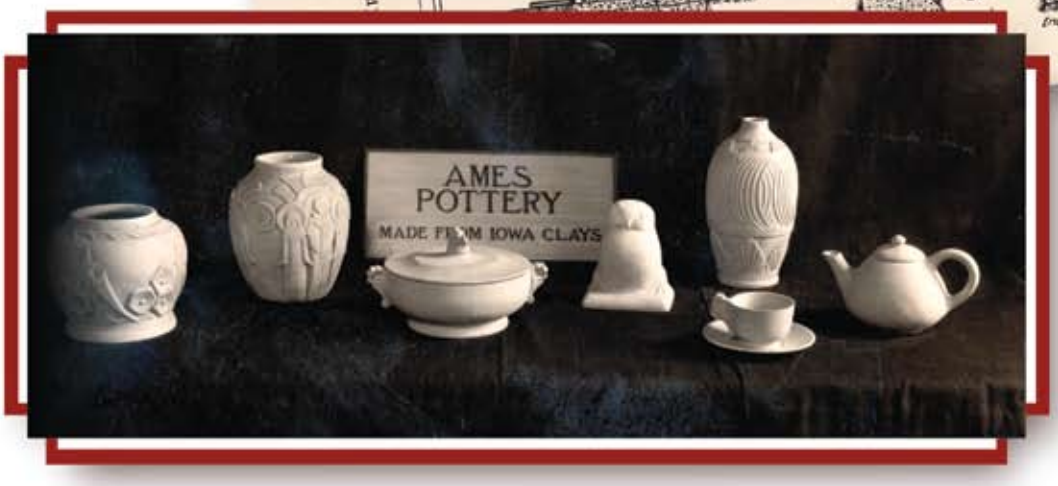
"The critical juncture in materials goes back to the development of the atomic bomb," stresses MSE Distinguished Professor Karl Gschneidner, Jr., who earned his PhD under Spedding in 1957. "It wasn't just physics, and it wasn't just metals. The need for the atomic bomb, radar, and all this other stuff showed that you can't do this without materials."

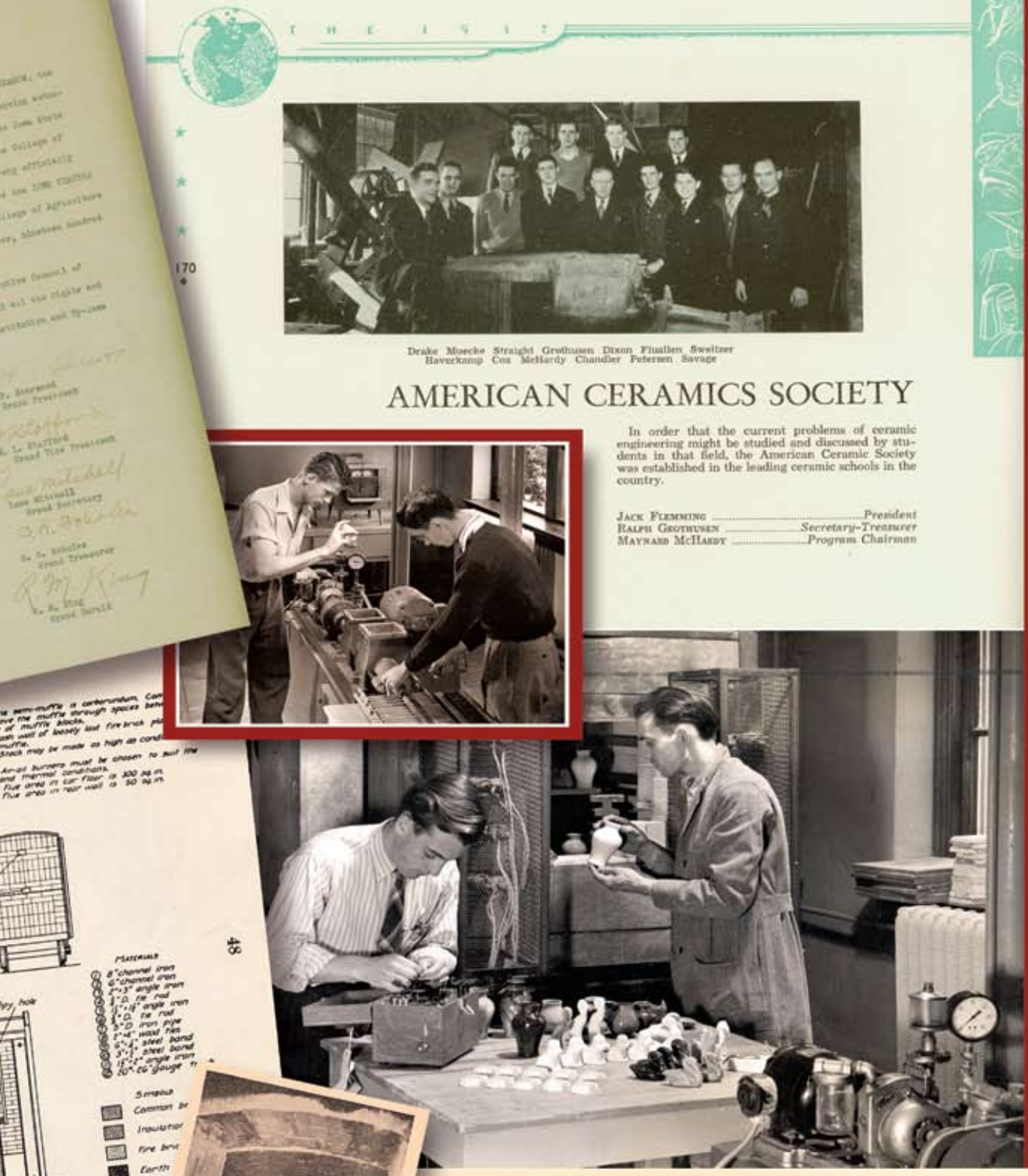
Yet as late as World War II there was no consensus as to what constituted the broader category of materials. Indeed, notes former metallurgy department head Dr. John F. Smith, Iowa State had no metallurgy program before the war, only chemists such as Spedding who were interested in metals.

"Metallurgy as a discipline was not widely understood," Smith offers. And even if it were, the top-secret nature of the Manhattan Project would not permit Spedding or his collaborators to share their work with the wider academic community.









Department Heads—

Paul E. Cox
1920–1939

Charles M. Dodd
1939–1961

In 1936, hot plate tiles were given away at VEISHEA.

Title of artwork at right: Middle panel of Dairy Industry Building
Artist: Designed by Christian Petersen (American, 1885–1961)
Date of work: 1936
Credit: Commissioned by the federal Public Works of Art Project and the National Youth Administration. In the Art on Campus Collection, University Museums, Iowa State University, Ames, Iowa.
(Fired in kiln designed by Paul Cox.)

1946–1955

Ceramic Engineering

While Iowa State ceramists may have produced crucibles for casting uranium ingots at high temperatures, metallurgy and ceramics would develop along parallel tracks for years after the war, tracks that would not intersect until much later. In fact, despite the groundbreaking work of men such as Spedding and his colleague Harley Wilhelm, metallurgy as a department separate from chemistry would not follow the formal establishment of the Ames Lab in 1947 for another 14 years.

However, Dodd's ceramics department, effectively rendered dormant by the war, came roaring back to life with the influx of dozens of returning veterans into the department under the G.I. Bill. By 1948, the revived department had seven graduates—among them one Thomas D. McGee—and by 1950, ceramics awarded 18 degrees. Unfortunately, those numbers tapered off as the veteran "bulge" worked its way through the system, and by the early 1960s the program was again down to single digits in graduates.

Still, significant progress was being made in the intellectual foundations of the discipline. More than his predecessor, Dodd had a technical focus that better lent itself to academic achievement: by the 1950s, MS and PhD graduates began appearing regularly in yearbook rosters, and the field began moving away from its narrow focus on consumer ceramics and other mineral-based products.

"The important products of the future, including high temperature coatings and refractories for rockets and missiles, and many component parts for nuclear reactors, were also shown," noted one account of the department's exhibit at VEISHEA.

By autumn quarter of 1946, there were 25 students enrolled with an expected 30 for the winter quarter. The second-floor glaze-laboratory equipment was moved into the first-floor processing laboratory, and the upper room was converted into a classroom.

1946-1955

1953–1955

Metallurgy

Ceramic Engineering Department Head—

Charles M. Dodd
1939–1961

Metallurgy Department Head—

Harley Wilhelm
1953–1961

1956–1965

Ceramic Engineering

1956–1965

Metallurgy

Equally significant, the program began to graduate the "transitional" scholars and leaders—men such as McGee and Wilder—who would later join their metallurgical counterparts—scholars such as Gschneidner and Rohit Trivedi—to guide the program from its narrow ceramics orientation to focus instead on a broader notion of materials. And for their part, the metallurgists were coming to the same conclusions.

"We were branching into a lot of different materials, so it was only natural to get into bed with the ceramists," observes John Smith, noting that, between the programs of the Atomic Energy Commission and the developing space program, he and his colleagues were increasingly working with a broad variety of materials.

"People realized that the fundamentals of processing metals, ceramics, and even polymers were not that far apart," adds current MSE Chair Mufit Akinc. "The same principles apply: in the end, if you understand ceramics, you understand metals."

That's a position seconded by veteran researchers such as Gschneidner. "There are a lot of similarities between ceramics, metals, and polymers," he offers. "Thermodynamics doesn't change whether you use a metal or a polymer. So the integration of all that was a natural, evolutionary process, not necessarily administrative."

1956-1965

Dr. William Larsen instructs the department's first metallurgy undergraduate student, Gifford Rodine.

Ceramic Engineering Department Heads—

Charles M. Dodd
1939–1961

David R. Wilder
1961–1975

Metallurgy Department Heads—

Harley Wilhelm
1953–1961

O. Norman Carlson
1961–1966

1966–1975

Ceramic Engineering

1966–1975

Metallurgy

Yet administrative issues loomed large in the developing merger of the units. Dean of the College of Engineering David Boylan pushed the integration of ceramics and metallurgy, not so much because of their obvious scholarly and scientific affinity, but because enrollments in both departments were simply too low to sustain them as independent programs. Pooling resources would not only create scientific synergy but would allow the programs to survive—and even flourish.

While hardly a shotgun marriage, the 1975 merger of the ceramics and metallurgy departments was not without its difficulties. As Wilder notes, the new MSE department had 16 faculty variously and jointly supported by Ames Lab, the College of Engineering, the Engineering Research Institute, and the College of Sciences and Humanities (now Liberal Arts and Sciences)—four different funding streams at Iowa State alone.

Added to this was the hangover effect of the Ames Lab's wartime years. During a time of rationing and general scarcity, people working on the Manhattan Project could have virtually anything they wanted for their work—materials, facilities, equipment, travel privileges. According to Wilder, "that developed a separate organization."

Not just a separate organization, but a separate culture as well. As Gschneidner notes, "We have research-oriented people (in Ames Lab). Over in ceramics, people were more teaching-oriented."

1966-1975

1975

Materials Science and Engineering

IOWA STATE UNIVERSITY MERGED IN 1975 MATERIALS SCIENCE & ENG.

Glass blowing was introduced in the 1960s.

Ceramic Engineering Department Head—

David R. Wilder
1961–1975

Metallurgy Department Heads—

O. Norman Carlson
1961–1966

John F. Smith
1966–1970

Monroe S. Wechsler
1970–1975

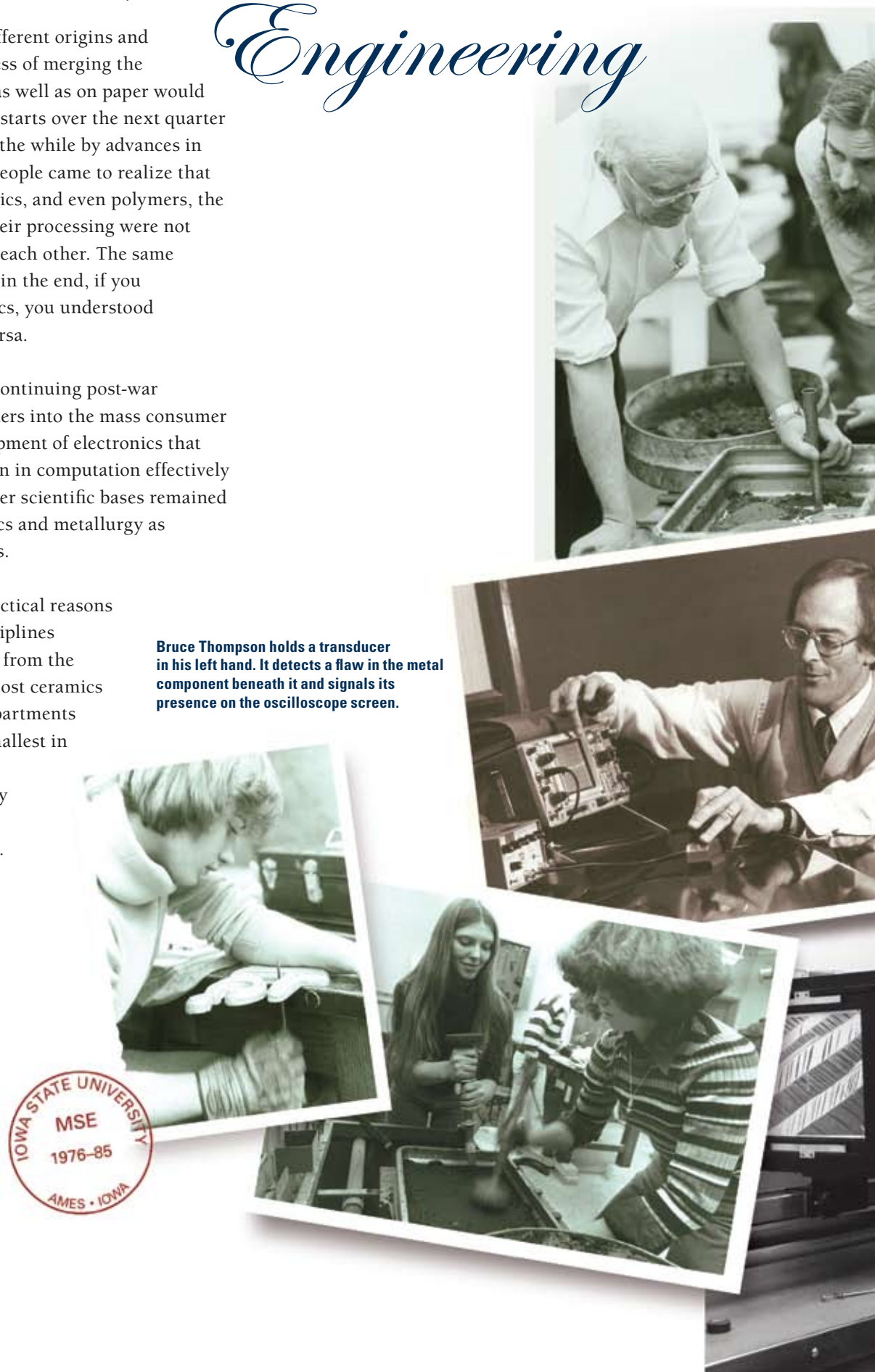
1976–1985

Materials Science and Engineering

Because of their different origins and histories, the process of merging the disciplines in fact as well as on paper would proceed in fits and starts over the next quarter century, driven all the while by advances in the science itself. People came to realize that with metals, ceramics, and even polymers, the fundamentals of their processing were not that far apart from each other. The same principles applied: in the end, if you understood ceramics, you understood metals, and vice versa.

Coupled with the continuing post-war explosion of polymers into the mass consumer market, the development of electronics that enabled a revolution in computation effectively finished off whatever scientific bases remained for treating ceramics and metallurgy as separate disciplines.

And there were practical reasons for joining the disciplines as well, quite apart from the scientific merits. Most ceramics and metallurgy departments were among the smallest in their colleges or universities, so they had much to gain from consolidation.



Bruce Thompson holds a transducer in his left hand. It detects a flaw in the metal component beneath it and signals its presence on the oscilloscope screen.

Department Head—

David R. Wilder
1976–1988

1986–1996 Materials Science and Engineering

Still, like old habits, old divisions die hard. While the two programs were united administratively in 1976, it would be another two decades before this union was fully acknowledged with unified degrees at both the graduate and undergraduate levels, despite a couple of failed interim attempts.

By 1996, graduate degrees in ceramic engineering and metallurgy were discontinued, replaced by the MS and PhD in materials science and engineering, followed by a unified bachelor's degree in 1998. In order to reinforce the identity, undergraduates were required to select two specializations from electronic materials, ceramic, polymer, and metallurgical engineering.

Although the cognitive walls between ceramics and metals didn't fully tumble until the mid-1990s, there could be no denying the success of the merger. By 1996, the combined programs had about 70 students. Now, depending on the year, we have, on average, 180 to 190.

Department Chairs—

David R. Wilder
1976–1988

Krishna Vedula
1991–1995

1996–2005

Materials Science and Engineering

From its origins as a virtual academic afterthought in 1906, today the Department of Materials Science and Engineering stands clearly at the forefront of the College of Engineering, poised with the Ames Laboratory to lead Iowa State's charge into uncharted technologies.

But ask four engineers what that future will be like, and you're likely to get four different answers. Many of us are excited by the promise of technologies that imitate the functioning of nature, as with the efforts of Vladimir Tsukruk's polymers group to mimic the sensory abilities of reptiles. John Smith points to custom-designed alloys exhibiting specific attributes that might be made possible by new methodologies such as Krishna Rajan's combinatorial informatics (page 28). And Gschneidner notes advances in quantum or even sub-atomic computation that will someday help to realize both these visions.

As for Wilder, what excites him about the future is, well, the future—specifically grandson David Lantz, an undergraduate in Iowa State's aerospace engineering department who, he relates, is very much interested in materials. However, Wilder adds that, like so many of his peers in the college, his grandson "doesn't recognize the distinctions between disciplines so much."

For a man whose career was defined in large part by the ultimately successful effort to engineer the bridge between ceramics and metals at Iowa State, the synergy of such a systems approach to engineering perhaps holds the greatest promise of all for the next hundred years.

A Keramos tradition was to have the pledges cast and fire Keramos plaques in Greek lettering glazed in blue and gold.

Hoover Hall was dedicated on October 4, 2003.

Department Chair—

Mufit Akinc
1995–present

1996–charter MSE industrial advisory council

CURRENT

Undergraduate students— 180

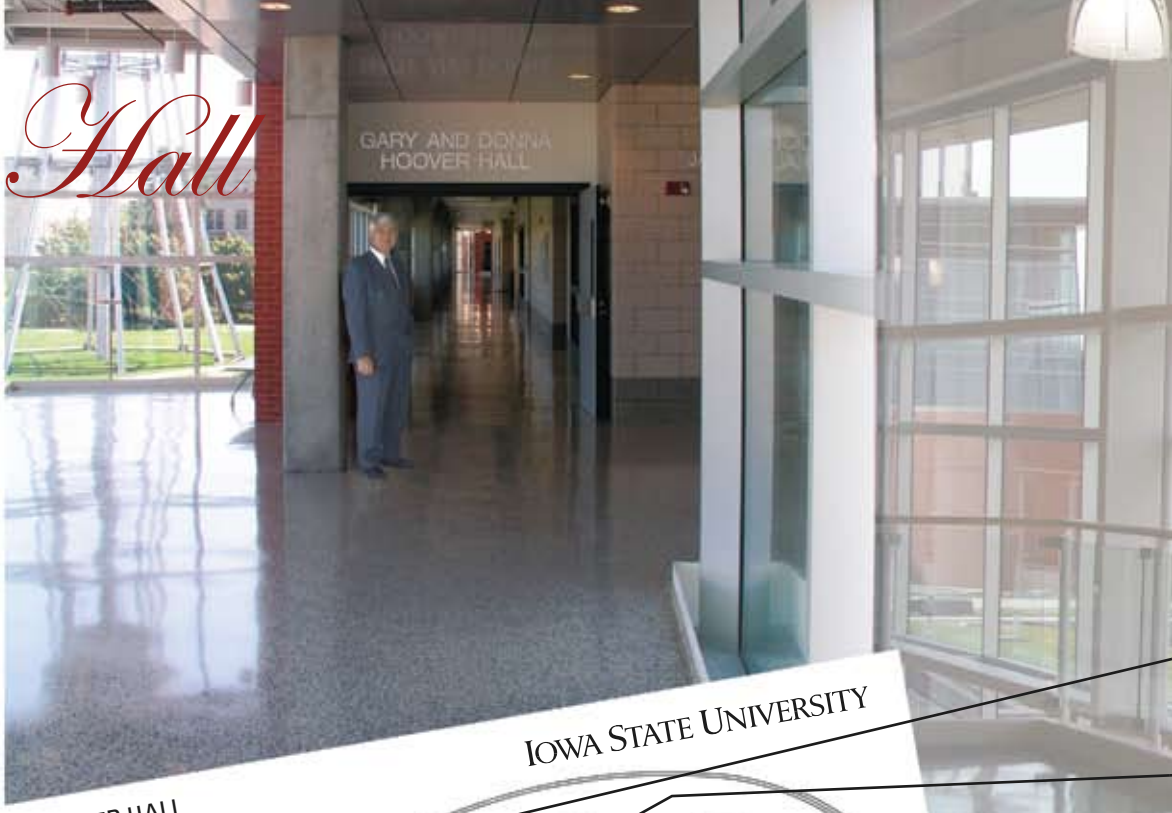
Graduate students — 80

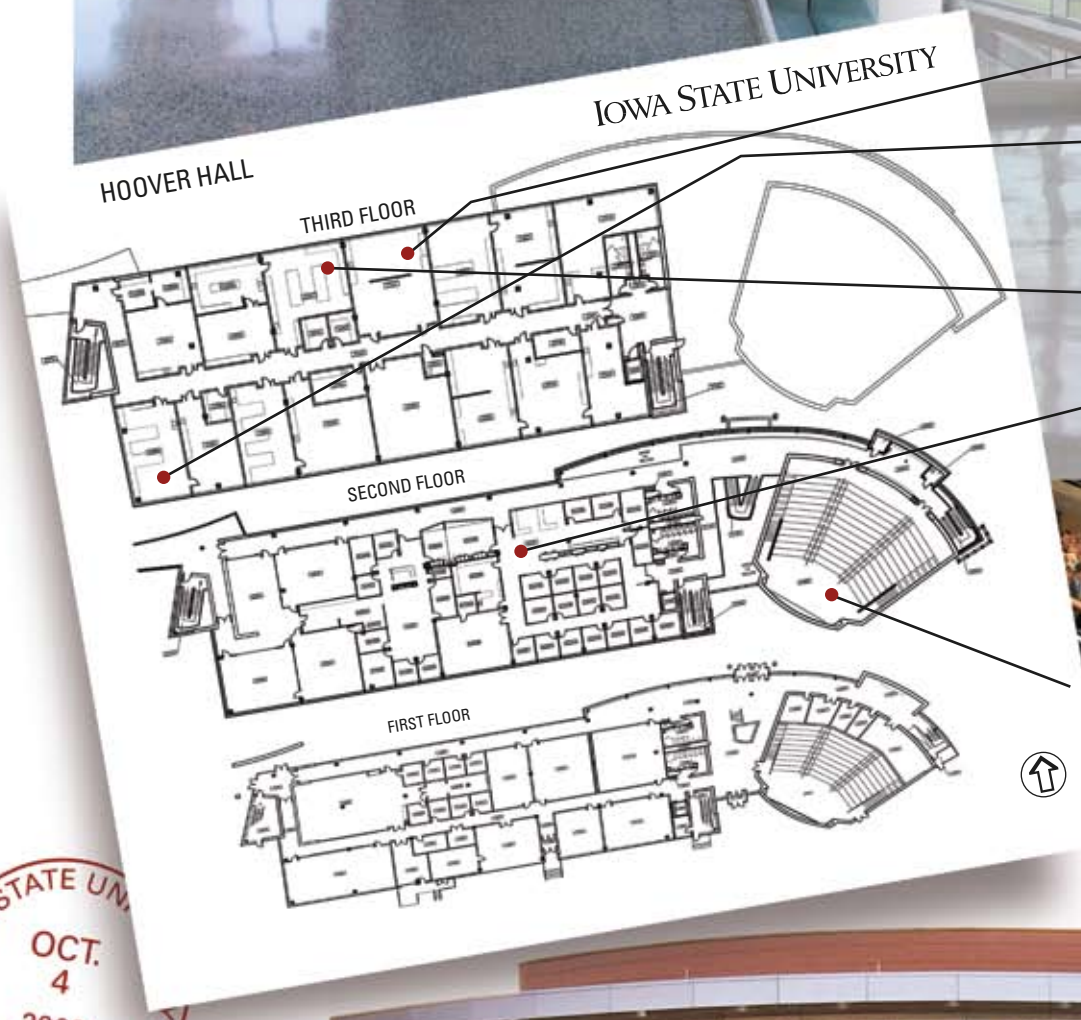
Undergraduate degrees awarded to date— 982

Graduate degrees awarded to date— 531

2003 Hoover Hall

The opening of Gary and Donna Hoover Hall represented the capstone of the Engineering Teaching and Research Complex when it was dedicated on October 4, 2003. A tribute to the support of hundreds of MSE alumni as well as its namesake benefactors, Hoover heralds the second century of materials science at Iowa State.





Hoover Hall as viewed from the building's northeast corner. The sweeping curved glass façade is outlined at the top right of the detailed floor plan, above.

Elements news

MSE Student
Computer Lab
Room 3337

Thermal
Characterization Lab
Room 3364

Kent-Stein Foundation
Auditorium

Student computation lab

MSE main lobby

Materials Synthesis
and Processing Lab
Room 3347

Materials Science and Engineering faculty and staff

2005-2006 Current faculty and staff

Mufit Akinc
Professor and Chair

Iver E. Anderson
Adjunct Professor

S. Bulent Biner
Adjunct Associate Professor

Krista Briley
Secretary

L. Scott Chumbley
Professor

Alan P. Constant
Lecturer

Kristen P. Constant
Associate Professor

Michael G. Conzemius
Associate Professor

Lawrence J. Genalo
Professor and Assistant Chair

Brian Gleeson
Professor

Karl A. Gschneidner, Jr.
Distinguished Professor

David Jiles
Collaborator

Michael R. Kessler
Assistant Professor

Joshua Klesel
Systems Support Specialist

Matthew J. Kramer
Adjunct Associate Professor

Mark J. Kushner
Professor and COE Dean

Zhiqun Lin
Assistant Professor

Surya K. Mallapragada
Associate Professor

M. Hogan E. Martin
Lecturer

Steve W. Martin
Professor

R. William McCallum
Adjunct Professor

Thomas D. McGee
Professor

Ralph E. Napolitano
Associate Professor

Carmen G. Neri
Administrative Specialist

Vitalij K. Pecharsky
Professor

Krishna Rajan
Professor

Alan M. Russell
Professor

Martha Selby
Assistant Professor

Dan Shechtman
Professor

John E. Snyder
Adjunct Assistant Professor

Xiaoli Tan
Assistant Professor

Patricia A. Thiel
Distinguished Professor

R. Bruce Thompson
Distinguished Professor

Rohit K. Trivedi
Distinguished Professor

Vladimir Tsukruk
Professor

Ersan Üstündag
Associate Professor

Lynne Weldon
Secretary

CURRENT

Faculty— 21

Adjunct faculty— 5

Courtesy appointments— 4

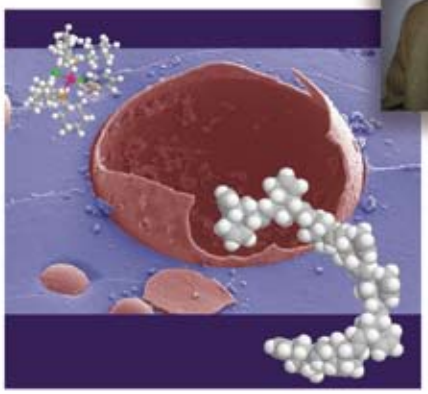
Lecturers— 2

Staff— 4

With two new stars,

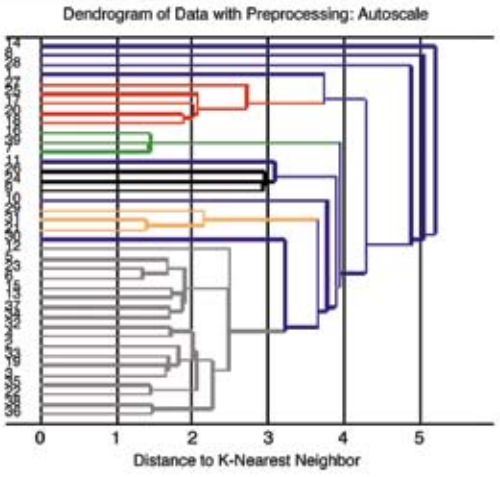
materials science burns even brighter at Iowa State

Michael Kessler



From respected senior scholars **Karl Gschneidner, Jr.** *and* **Rohit Trivedi** *to trailblazing newcomers* **Dan Shechtman** *and* **Ersan Üstündag**, *MSE boasts a roster of luminaries who would be welcome anywhere in the world. Fortunately, it's MSE that's doing the welcoming as it adds two new stars, Krishna Rajan and Michael Kessler, to its already brilliant constellation.*

Krishna Rajan



Michael Kessler joins MSE from the University of Tulsa, where he taught and conducted research since earning his PhD in theoretical and applied mechanics from the University of Illinois in 2002.

The native South Dakotan specializes in the characterization and processing of polymers and polymer matrix composites. Only three years out from the PhD, he is already listed on three patents, has published seven articles in peer-reviewed journals, and has attracted nearly $1 million in external funding.

Much of Kessler's current work draws on his PhD research in self-healing composites, in which liquid monomer healing agents are incorporated into a polymer matrix. Funded in part by a three-year Young Investigator Award from the Army Research Office, the research may one day result in much lighter and stronger armoring for weapons systems and vehicles, as well as civilian applications.

Besides his work in the fundamentals of polymerization, Kessler's other projects include research in resin transfer molding, a process in which a monomer resin is pumped into a fiber-reinforced mold containing a catalyst so that polymerization occurs inside the mold.

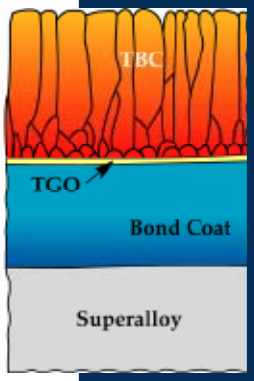
Krishna Rajan comes to the department after 18 years at Rensselaer Polytechnic Institute in Troy, New York, where he established the nation's first program in materials informatics. He brings that pioneering spirit—along with an NSF research center—to MSE, where he's looking forward to joining Iowa State's combinatorial sciences initiative.

"Other universities have strategic initiatives," Rajan notes, "but Iowa State is the only university that picked combinatorial science as a strategic initiative. To me, that means you have a core of people and institutional support for longevity and infrastructure for these things to grow."

MSE faculty win R&D 100 Award

MSE Professor **Brian Gleeson** *and former Adjunct Assistant Professor* **Daniel Sordelet,** *both scientists with the U.S. Department of Energy's Ames Laboratory, have won national recognition for a coating that helps turbine blades hold up better to the heat of jet engines.*

Commercial thermal barrier coating (TBC) deposit onto a Ni-based superalloy gas turbine blade



Schematic illustration of a conventional TBC system on a superalloy substrate

Their discovery—a thermal barrier coating made from a platinum-modified nickel and aluminum alloy—has been recognized with a prestigious R&D 100 Award. This is the 27th R&D 100 Award won by Iowa State University researchers and the first for Gleeson, who is also director of the materials and engineering physics program at Ames Lab. The annual awards have been called the "Oscars of applied science" by the *Chicago Tribune*.

"This is quite an honor to be selected for such a prestigious award," Gleeson said. "I also think winning the award is a credit to ISU and Ames Lab and the excellent support that they provide. This is really a fantastic place to do research."

This year's R&D 100 Awards are featured in the September issue of *R&D Magazine*. The winners were recognized this fall at a banquet in Chicago.

The researchers have been working on the project for about four years. In addition to Ames Lab, the Iowa State project has been supported by more than $1 million from the Office of Naval Research, Wright-Patterson Air Force Base, and the Rolls-Royce jet engine manufacturing company.

"By applying a thermal barrier coating to a turbine blade," notes Sordelet," it is possible to increase the combustion temperature of the engine, which leads to significantly improved efficiency in gas turbines."

Not only will the compositions they've developed allow turbine blades to last longer, Gleeson adds, they will help improve the reliability—and thus the safety—of modern jet engines.

Gleeson and Sordelet are still working on the project, and their coatings are currently being tested by jet engine manufacturers.

Kessler and **Rajan** continued—

Rajan's interest in the field is not grounded in any application area he works in so much as in his conviction that combinatorial science's methodology can lead to the high-speed discovery and development of new materials and processes in the same ways it has for chemicals and pharmaceuticals.

He's aware of the challenge. "The most significant materials discoveries of the past thirty years have been made more by accident than design," Rajan observes. "Nobody's sitting here saying, here's the periodic table, here's a property we want—what do we combine to make that material?"

However, Rajan adds, as engineers increasingly bump up against the limits of existing materials, new materials will be needed to advance aging engineering systems. He feels it's an ideal opportunity for Iowa State to distinguish itself in a crowded field.

"This is a very competitive business," says Rajan, "so we have to build our strength on things that look at existing problems in ways others don't."

Sleepless at the self-service pump:

MSE researchers retool for hydrogen

While the "hydrogen economy" of the 21st century seems a distant dream, the prospect of $6-a-gallon gasoline is a nightmare that makes many American economists—not to mention consumers—wake up in cold sweats.

Fortunately, MSE researchers might have just the prescription for more restful nights.

You may already be familiar with **Steve Martin's** work to develop the hydrogen and oxygen fuel cells for powering tomorrow's vehicles. Less well known—but equally critical—are the efforts of **Vitalij Pecharsky**, who has turned his attention to storage methods that can make hydrogen-powered cars practical, and **Alan Russell**, part of a team that seeks to develop materials for purifying hydrogen to fuel truck and automobile fleets.

As with fossil fuels, hydrogen fuels will require a production and distribution chain to deliver usable energy to consumers. More than simply retooling the current petroleum-based system, however, links in the hydrogen chain will need to be forged from the ground up, starting with the very materials that form those links.

Currently, Russell observes, hydrogen from various sources is purified by diffusing it through slender tubes formed of a palladium-silver alloy: "clean" hydrogen atoms are diffused through the tube walls, while impurities continue downstream. But at $7,000 a kilogram, palladium is far too expensive to produce hydrogen in quantities that would permit its use on a scale comparable to petroleum products.

"It's a real problem," Russell says. "Impurities damage fuel cells, so purification is essential. But there might not be enough palladium in the world to replace gasoline with hydrogen."

Thanks to a three-year, $2.95-million grant from the U.S. Department of Energy's National Energy Technology Laboratory program, Russell has joined a team led by **Robert Buxbaum** of REB Research & Consulting, a Michigan firm that specializes in hydrogen purification technologies. Exploiting Russell's expertise in intermetallic compounds and transition metal alloys, the team hopes to develop affordable alloys for tubes with sufficient strength, ductility, and diffusivity to purify hydrogen in massive quantities.

"We'd like to see one or more new alloys come out of this that people can actually turn into production alloys to lower costs for these processes," Russell adds.

Yet any economies in hydrogen production will do little to wean Americans from imported oil without methods to safely store the fuel. That's a problem Pecharsky has been working on since at least 2000, when a small grant from the Roy J. Carver Trust launched his study of solid-state materials for hydrogen storage.

Those early efforts have now moved to the next level with a $1.6-million grant from the Department of Energy, part of the DOE's $64-million Hydrogen Fuel Initiative.

"Hydrogen storage is a challenge," notes Pecharsky, who is joined on the project by Ames Lab colleagues **Marek Pruski**, **Victor Lin**, and MSE faculty member **Scott Chumbley**. "Unlike propane, which can be easily liquefied, hydrogen cannot—you have to cool it close to absolute zero to liquefy it."

Neither is it practical to transport hydrogen in the form of a compressed gas, adds Pecharsky, as any tank large enough to contain sufficient fuel for a typical 400-mile driving range could weigh upwards of 800 pounds. However, a solid synthesized from lightweight elements such as aluminum or lithium that could store 7 to 10% hydrogen by weight would decrease the bulk of a hydrogen fuel system dramatically.

"If you have a material that holds 10% hydrogen by weight," says Pecharsky, "then to store 5 or 6 kilograms of hydrogen you need only 50 or 60 kilos of a solid, or 120, 130 pounds—which is comparable to the weight of a conventional fuel tank."

One challenge of any such system lies in managing the excess heat produced by the process of recharging the spent solid with fresh stores of hydrogen. In practical terms, then, a distribution system for Pecharsky's technology might involve solid fuel cartridges that, once depleted, would simply be exchanged for fresh ones. The spent cartridges would then be recharged and readied for redistribution under controlled conditions.

That scenario may seem distant, but simple economics are making the technologies of Martin, Pecharsky, and Russell seem less exotic and more inevitable. So if soaring energy prices keep you up nights, take heart: MSE researchers are losing sleep too—and loving it.

"It's exciting to think that if we get it right," Russell remarks, "in the year 2030 the whole world fuel economy could be totally different. That's the kind of thing that gets us scientists out of bed at 5 in the morning."

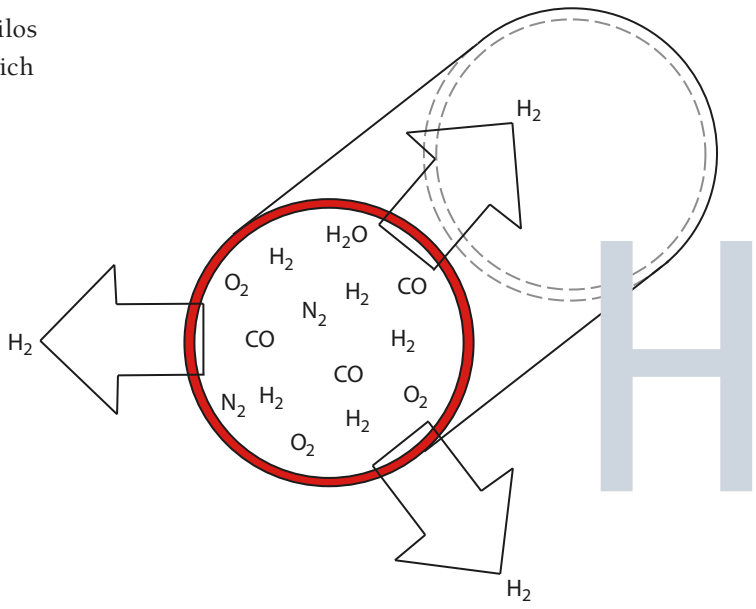
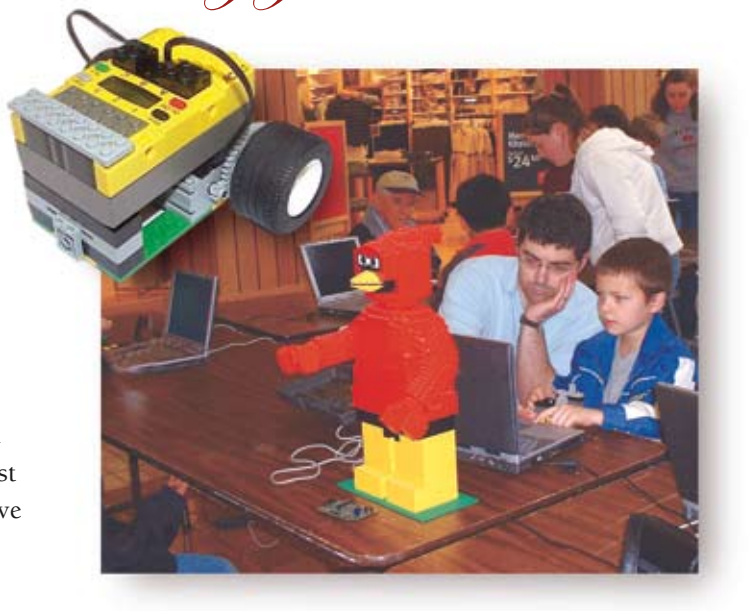


Figure – Hydrogen diffusion membranes allow H atoms to diffuse through the walls of the tubing but prevent other gases from diffusing through the tube wall, thereby purifying the H_2.

Toying with technology~



Politicians, pundits, and even a few academics continually harp on the inadequate preparation of American youth in math and science.

But engineering professors have, perhaps, an even greater interest in exposing young people to math and technology—after all, they're the last teachers many of those kids will have before entering the less forgiving world of work.

In Iowa State's College of Engineering, none have done more to reach kids before they get to college than the faculty of MSE.

Professor **Larry Genalo**, in fact, has practically made a career of getting to kids before they get to Iowa State. Since joining MSE from the Freshman Engineering program in the mid-1990s, Genalo, whose academic degrees are in applied mathematics, has been the driving force behind Toying with Technology, a program that has helped boost enrollments in both MSE and the college as a whole.

According to Genalo, the college became interested in early student development after enrollments fell off in the 1990s. Partnering with the late Dr. **Charles Wright** of the electrical and computer engineering department, Genalo applied for and in 1996 received seed money to launch "Toying with Technology," a title coined by Genalo himself.

Toying with Technology traces its origins to an NSF coalition with a number of other institutions in the early 1990s that focused on teaching mechatronics for senior design projects. Iowa State adapted the program to freshman engineering, then extended it to high school seniors interested in engineering at ISU, using computer interfaces to control Lego robots. "It eventually got to the point," Genalo recalls, "where we said, hey, why can't third-graders do this?"

And not just third-graders, but students at all levels: from fall 1996 to spring 2004, nearly 12,000 kids benefited from outreach sessions at Iowa State, with dozens of practicing teachers coming to campus for summer courses. There is also a full three-credit Toying with Technology course for education majors on campus. "We've had 491 future teachers go through that course since 1996," Genalo notes.

and learning to ExCEL

Genalo's MSE colleague **Scott Chumbley** also believes in engaging not just the kids but their teachers as well through his Extended Classroom for Enhanced Learning—or "Project ExCEL," as it's more commonly known. That approach only makes sense, considering Chumbley's wife Amy is not just Project ExCEL's administrator, but a former high school science teacher herself.

Project ExCEL began in the early 1990s when Chumbley received a grant from the National Science Foundation to turn a scanning electron microscope (SEM) into a teaching instrument for K-12 classrooms. Not content with the limitations involved with bringing students to campus, however, Chumbley seized the opportunity to hitch his program to the rapidly rising star of the World Wide Web.

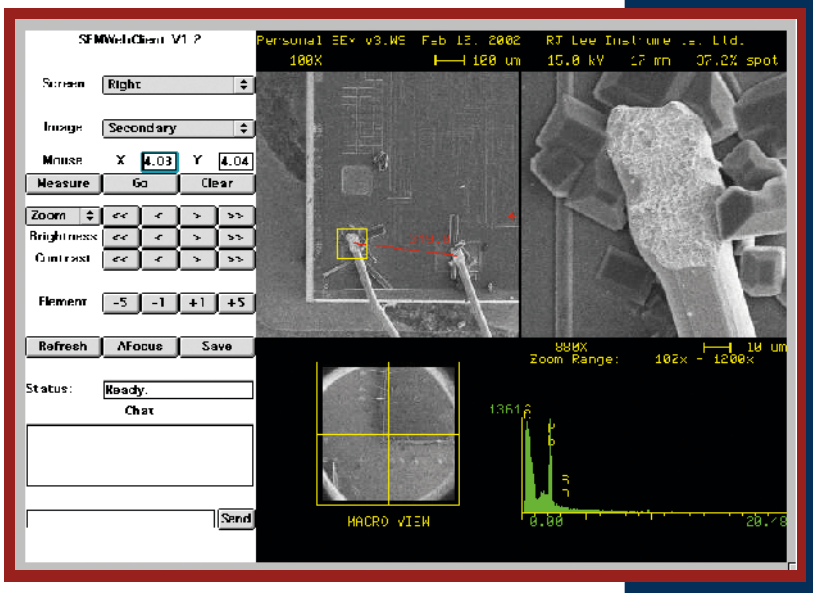
"I thought if we can do it in a classroom, we should be able to do it over the Internet," Chumbley recalls. So he wrote a second grant for another SEM and worked with the SEM's provider to rewrite the software for online use, a model since emulated by a number of other universities.

K-12 teachers can contact Amy Chumbley to arrange one or more sessions for their classes using specimens provided by the program or those sent in by students themselves. During the session, Amy monitors the SEM from the Iowa State campus, switching out samples and troubleshooting if needed, while teachers and students actually control the device using an online interface available on the Project ExCEL Web site.

"Teachers use the SEM to teach about microscopy, comparing what they can see in the classroom through a standard light microscope, then sending the sample to us to compare the view," Amy notes. Samples submitted by students, she adds, run the gamut from insect parts to hair to pencil leads and erasers.

Certainly the Web-based SEM offers a powerful "cool science" factor for the K-12 students and teachers who use it. But equally cool for the Chumbleys is the engagement of young children with science and technology in general—and with materials science and engineering at Iowa State in particular.

"That's why we started this program, as a tool to help recruit students to this department," Chumbley acknowledges. "We've had a lot of students come to MSE from teachers who got to know us because they used this system."



Computer screen image showing the remote console used by schools for Web operation. Students can move and image the sample, conduct online measurements, and determine the chemical constituents using the integrated energy dispersive x-ray spectrometer.

Scholarships offer "materials support" for students

"It's a strength of our department," observes MSE Assistant Professor **Martha Selby**, *"that our graduates go to all sorts of industries."*

That, Selby and other faculty in the MSE department are quick to point out, is due to the needs of virtually every industrial sector for new and improved materials. However, strength in placing graduates in good jobs hasn't always translated into scholarship support from these same industries while students are at Iowa State, a paradox Selby is working hard to resolve.

"Many companies have been very good at supporting scholarships through the college and have hired our graduates," Selby continues. "But when it came to listing majors that could receive the scholarship, they would leave us out. We're often overshadowed by engineering departments with larger numbers of BS graduates."

Selby has been MSE's scholarship coordinator since 1999, a position similar to one she once held for the college in general. The challenge, she says, lies in part with the relative youth of the field of materials science itself compared to other engineering disciplines: while a number of industries acknowledge ceramics and metallurgy as important parts of their operations, for some materials science might seem more of an academic abstraction with limited relevance to their immediate needs.

"It's a communication problem," Selby acknowledges—and one not limited to industry. Older alumni—a primary resource for scholarship support in most departments—whose degrees might be specifically in ceramics or metallurgy may not yet see themselves as part of the larger materials science family.

Nonetheless, Selby points out, MSE students do exceptionally well competing for scholarships on a collegewide basis. Approximately 90 out of 160 students enrolled in the department last year received scholarships, and half of those without scholarship support did not apply.

Selby feels MSE has made strides over the past six years in nurturing the sense of family that results in greater interest and investment in the department on the part of its stakeholders. You can see this, she says, in the annual awards banquet: what started as a small event limited to several dozen attendees—mostly metallurgists—has today become a department-wide celebration including nearly 200 faculty, students, family members, alumni, and industrial supporters.

And, as the department expands its co-op and internship programs, even more industries are exposed to the caliber of students the department educates. "Really, our students are our best advertisement," Selby remarks. "If you get them out there and working, companies are usually very happy with them."

That high quality, she says, is due at least in part to the availability of financial resources that help students remain focused on their primary goal at Iowa State: receiving the best education possible.

In that regard, adds Selby, "scholarships really help."

Scholarship support makes a difference for one Iowa family

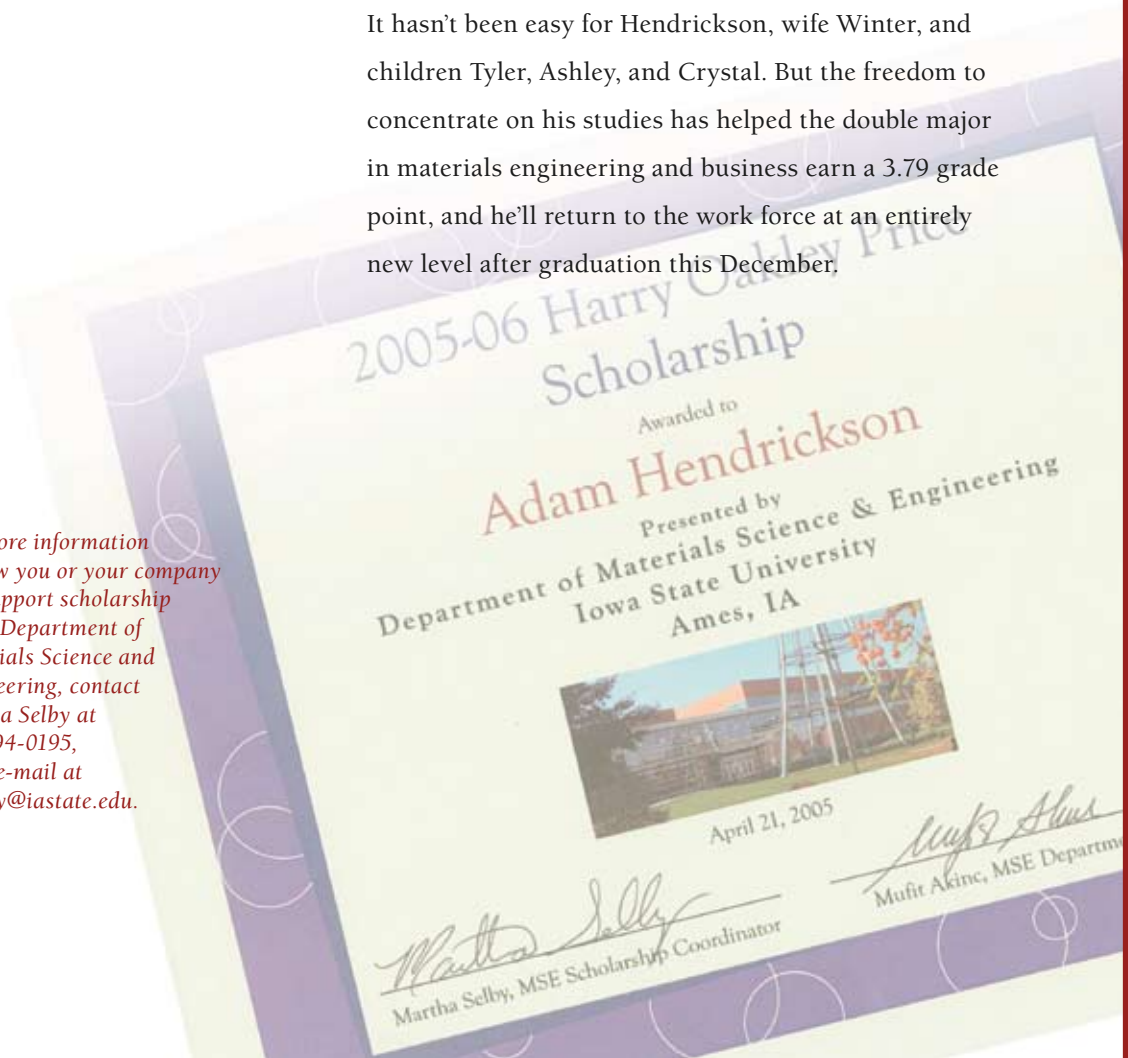
Adam Hendrickson with his wife, Winter, and their children, Tyler, Ashley, and Crystal

Materials matter in MSE. But material support in the form of scholarship aid matters just as much to our students.

Just ask senior **Adam Hendrickson**: the desire for a better life for his family took the Fort Dodge native from a series of random jobs after high school to Iowa Central Community College; yet it was generous financial aid from MSE and the College of Engineering that took him to Iowa State.

"If I hadn't received the scholarship support I did, there's no way I could have come here," acknowledges Hendrickson, who has received the Roy J. Carver and Harry Oakley Price scholarships, among other support.

It hasn't been easy for Hendrickson, wife Winter, and children Tyler, Ashley, and Crystal. But the freedom to concentrate on his studies has helped the double major in materials engineering and business earn a 3.79 grade point, and he'll return to the work force at an entirely new level after graduation this December.



For more information on how you or your company can support scholarship in the Department of Materials Science and Engineering, contact Martha Selby at 515 294-0195, or by e-mail at mselby@iastate.edu.

Banquet 2005

On a night to celebrate, new dean issues challenge

Nearly 200 faculty, staff, students, parents, alumni, and members of MSE's Industrial Advisory Council came together in late April for the department's annual awards banquet.

Notable among faculty awardees were Professor **Larry Genalo** and Professor **Steve Martin**, recognized, respectively, for "Excellence in Teaching" and "Excellence in Research." MSE secretary **Lynne Weldon** was honored for "Excellence in Service" to the department. More than 100 scholarships were presented to MSE undergraduates.

Guest speaker was Dr. **Mark J. Kushner**, who joined the College of Engineering last January as its tenth dean. Kushner's address to the gathering, "The Role of the Land Grant College of Engineering in the 21st Century," was particularly apt for an MSE audience, given our roots, our progress over the last century, and the values upon which the department has always prided itself.

Kushner emphasized four themes in his address, namely access, public good, regionality, and leadership. These, he stressed, are—or at least should be—distinguishing characteristics of the land-grant university.

There can be no denying, Kushner said, the success of the college in terms of the broad public good served by the technologies developed here and our "regionality"—that is, the ability of the college to provide value and services to Iowans and the surrounding region in particular. But with decreasing state appropriations, he suggested, the ability of land grants to serve the public good is increasingly in danger of becoming more narrowly defined in terms of the benefits realized by private citizens able to afford higher education.

"To some degree, land-grant colleges of engineering now fail the access test," Kushner lamented. "The leadership of the majority of our states has decided that a higher education is an individual good, not a public good."

In order to address this failure in leadership, Kushner challenged students, practicing engineers, and especially engineering educators themselves to rethink their ideas of leadership in the 21st century.

"Although engineers from land-grant colleges populate the boardrooms of industry at high rates, these same engineers are nearly absent from leadership roles at high levels of government," Kushner observed. "In a world where engineering technology forms the basis of our entire infrastructure, society can only benefit from having leaders equipped with the understanding and problem-solving skills that an engineering education provides."

Vinay Deodeshmukh – Third Place, Mars Fontana Award, Student Poster Session (best posters in corrosion engineering), Corrosion NACEXPO Conference, Houston, April 2005

Kushner's address to the gathering, "The Role of the Land Grant College of Engineering in the 21st Century," was particularly apt for an MSE audience, given our roots, our progress over the last century, and the values upon which the department has always prided itself.

It was even sweeter the second time around—and second time in a row—when the Iowa State student chapter of Material Advantage won the 2005 Most Outstanding Chapter Award for its activities and organization over the past year. The award was presented at the 2005 Materials Science and Technology Conference in Pittsburgh where a group of 34 students from the chapter was on hand to accept the award. Congratulations (again) to the nation's best!

Material Advantage Chapter, Student World Materials Day contest winner for the chapter's outreach initiatives.

Kristin Schipull—MSE Student Leadership Award

Christopher Hansen—MSE Outstanding Senior Award

For a complete listing of scholarships and other honors presented at the banquet, visit our newly redesigned Web site at http://mse.iastate.edu.

Centennial Issue

MAKING MATERIALS MATTER FOR 100 YEARS

Hoover Hall, dedicated in 2003

1906 - 2006

Materials Science and Engineering

IOWA STATE UNIVERSITY