We Engineer Excellence

The $56 million Materials Science and Engineering Building
Engineers, chemists, physicists and biologists at the
University of California, Riverside (UCR) have allied to produce
a truly interdisciplinary educational program for the 21st century.
Materials Science and Engineering program at the
Bourns College of Engineering offers B.S., M.S. and Ph.D. degrees.

Bourns College of Engineering
at UCR has been the fastest growing engineering program in the UC
system, widely recognized as the best system of public higher education
in the world. The college combines the intellectual and material resources
of the UC system with a uniquely intimate research environment,
fostering frequent faculty-student interactions rarely found at other
universities.

Materials Science and
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Welcome from the

Materials Science and Engineering Chair

Established in 2007 with the Undergraduate (B.S.) program followed by the Graduate (M.S. and Ph.D.) program in 2010, the young Materials Science and Engineering program at the University of California, Riverside, has rapidly gained recognition and was ranked #48 in the 2017 U.S. News and World Report ranking of the Best Materials Engineering Graduate Program in the country. This is a true testament of a truly unique multidisciplinary MSE program.

MSE is an intercollegiate and interdisciplinary program made up of faculty from Departments of Bioengineering, Chemical and Environmental Engineering, Electrical and Computer Engineering, Computer Science and Engineering, and Mechanical Engineering from the Bourns College of Engineering and Biology, Chemistry, and Physics and Astronomy from the College of Natural and Agricultural Sciences. The program provides students with interdisciplinary education related to the development, adaptation and validation of novel materials for a broad spectrum of applications. The Accreditation Board of Engineering and Technology (ABET) accredited B.S. degree curriculum prepares the students for graduate studies/school and careers in a variety of industries, ranging from nanotechnology, electronics, energy generation and distribution, medical and pharmaceuticals, aerospace and automotive. The M.S. and Ph.D. degrees program, open to students from varied undergraduate majors, gives students comprehensive training in fundamental materials subjects to pursue many areas of specialization for rewarding careers in industry, government laboratories and academia.

Our world class faculty from the 8 departments of the two colleges include many elected fellows of professional societies, MRS Medal recipient, and winners of the National Science Foundation (NSF), Department of Energy (DoE) and Department of Defense (DoD) Early Career Awards. Research projects in the program are funded from the industry and federal agencies like NSF, DoD, DoE, etc.

To learn more about the exciting educational opportunities, the disruptive scientific and technological research and the distinguished faculty of the program, I invite you to visit the MSE website at www.mse.ucr.edu.

Sincerely,

Ashok Mulchandani
Distinguished Professor and Chair
Materials Science and Engineering Program
University of California, Riverside
What is Materials Science and Engineering?

When you text your friend, consult your iPhone calendar, turn down your home thermostat remotely, automatically transmit your blood sugar level to your doctor or download tunes to your iPod, you are taking advantage of revolutionary discoveries in materials sciences.

Materials Science – Defined by Scientific Intersections

Materials Science and Engineering is defined by being interdisciplinary. The great breakthroughs of our age are occurring not within any traditional area of inquiry, but at the very intersections of multiple disciplines. These frontiers are not at the system level, not at the device level, but rather at the fundamental level of properties—the materials science level.

The lack of materials with the right properties has long been a barrier to implementing many great engineering ideas. Today, researchers are creating materials at the nano and atomic levels with exotic new properties that will revolutionize nearly every field of endeavor and our way of life. Lighter, stronger, faster, smaller and smoother materials will increasingly smash design and engineering barriers, releasing unforeseen solutions to engineering challenges. In the same way new materials revolutionized computing to allow smaller and smaller chips for mobile and cross-platform applications, new materials will give us innovative ways to generate and store energy, revolutionize thermoelectronics, and diagnose and treat medicine.

The Materials Frontiers – Breaking Engineering Barriers

Why are solar panels not in widespread use? Why is refrigeration so environmentally unfriendly? Basic technologies for solar panels and refrigerators have long been established in industry, but have reached their limit of practical engineering efficiencies.

Materials scientists do nothing short of redefining the way we live and work. Through interdisciplinary research, they explore the fundamental knowledge of new materials to predict, modify and tailor material properties for better performing devices. Advancements in medicine, computer science, energy, consumer products architecture and transportation await breakthroughs at the nano or atomic level—at the materials frontier—for new efficiencies and unheard-of applications.

MSE graduates work in every facet of engineering across many industries and their supporting services, including:

- Manufacturers
- Engineering firms
- Research institutions
- Medical device and pharmaceutical firms
- Energy companies
- Telecommunications
- Legal firms
- Government
The UCR MSE faculty are veterans in materials research and involved in leading-edge inquiry with the nation’s premier technology centers. From inception, the program has represented all the engineering and science disciplines on the campus, creating a bedrock of interwoven research agendas focused on discovering new technologies. Unlike other materials science programs in the UC system or beyond, MSE is interdepartmental design.

MSE students, faculty and alumni are making a mark on the world.

- MSE faculty Ludwig Bartels and Cengiz Ozkan are members the Center for Spintronic Materials, Interfaces, and Novel Architectures (C-SPIN), a national research center focused on developing the next generation of microelectronics. Supported by a five-year, $28 million grant awarded by the Semiconductor Research Corporation and the Defense Advanced Research Projects Agency (DARPA), research at C-SPIN is expected to have an impact beyond the world of computer science and engineering resulting in advances in nanotechnology, materials science, physics, chemistry, circuit design, and many other fields.

- Distinguished Professor of Engineering, Winston Chung Endowed Professor in Energy Innovation and Past Dean of Bourns College of Engineering Reza Abbaschian was instrumental in the creation of the MSE program and the development of the MSE building. He has won numerous awards for his research and service to materials science and engineering, and was awarded the Albert Sauveur Achievement Award for 2013 by ASM International, the world’s largest materials society. The award recognized Abbaschian as an “Outstanding scientist and researcher in solidification fundamentals and materials processing, educator and leader in advancing the materials profession.”

- MSE faculty Alexander Balandin, Roger Lake, Jeannie Lau and Jianlin Liu are part of the $35 million Center for Functional Accelerated NanoMaterial Engineering (FAME), which was established to develop materials and structures that could enable more energy efficient computers, mobile phones and other electronic devices. FAME is one of six new university microelectronics research centers established with $194 million from the Semiconductor Research Corporation (SRC) and the Defense Advanced Research Projects Agency (DARPA). The funding supports the continued growth and leadership of the U.S. semiconductor industry.

- MSE faculty Jing Shi leads a new Energy Frontier Research Center (EFRC) Funded in 2014 by the US Department of Energy. SHINES consists of 14 PIs from 7 institutions (UC Riverside, UCLA, UC Irvine, Johns Hopkins University, Colorado State University, Arizona State University, and University of Texas at Austin) plus two UCR PIs on two seed projects. By engaging strong interaction and collaboration among the graduate and undergraduate students, junior and principal investigators, SHINES aims to develop a fundamental understanding of electron spin ad heat transport as well as the interplay between them in nanoscale electronic materials and devices.
Research at the Inner Limits

The MSE Program at UCR focuses on nanotechnology, materials for energy generation and storage, and sustainability. Major emphasis is given to green technologies of the future and medicine.

**Solar, Thermoelectric, and Energy Storage Technologies**

New materials can allow us to capture a higher percentage of solar power at lower costs, bringing the goal of sustainable energy closer. Imagine the materials of your home, even the paint on the walls, being engineered to collect electricity and upload power to the grid during the day. Material breakthroughs sought by MSE researchers promise stronger, more efficient, smaller and less toxic batteries pushing green power through the night.

Hollow silicon-carbon composite particles can be used as high-capacity anode materials for next-generation lithium-ion batteries.

**Nanomaterials for Medicine**

Imagine having the ability to detect the very first cancer cell in a body. What if you could send a nanoprobe to eliminate that threat before it can divide even once. UCR nanotechnology researchers are looking for ways to deliver drugs exactly where they are needed without affecting surrounding tissue. New materials are also under study to provide staggering advances in biosensor technology.

**Resources for MSE students and researchers are state-of-the-art.**

- Almost 200,000 square feet of laboratories and classrooms
- A fully-equipped $10 million nanofabrication clean room with electron beam lithography, focused ion beam instruments and metrology tools with material and surface analysis capabilities
- Silicon Graphics Altix 4700 supercomputer powered by 64 Intel Itanium 2 processor cores, featuring 128 GB of system memory
- The Central Facility for Advanced Microscopy and Microanalysis for nanoscale characterization of organic and inorganic materials, biological tissue and minerals
- A microfabrication facility
- Faculty labs with metal-organic chemical vapor deposition capabilities, molecular beam epitaxy and micro-Raman characterization equipment
Lightweight Composite Materials

A large part of the carbon, chemical pollutants and toxins that enter the environment today come from the manufacture and fabrication of the materials we use in our industries. BCOE materials engineers are investigating new generations of lightweight composite materials that use less energy and produce less pollution to make. New composites will be tougher and lighter so that less energy is needed to deliver and operate them. Some of the hardest materials in nature are being studied for their engineering secrets. New worlds of fabrication are opening up where molecules of selected compounds, metals and allotropes can be built up in controlled layers to make nanomaterials with previously unimagined properties.

Green Materials

Fuel Cells, one of the best ideas for cheaper, cleaner fuels, are not yet on the market because the essential catalyst, platinum, is more costly than gold. New materials under development at UCR are aimed at making fuel cells more efficient and affordable. Also consider that agricultural waste, yard waste, wood waste and nuisance plants contain huge amounts of chemical energy if we can find the right materials to unlock them. Other MSE research seeks to find new materials to purify our air and water.

The Center for Nanoscale Science and Engineering (CNSE) mirrors the interdisciplinary nature of the MSE program, bringing together scientists from chemistry, physics, biology and engineering, as well as collaborations with external institutions across the nation. As part of the center, a nanofabrication facility provides clean room and semiconductor processing facilities for micro- and nanodevice fabrication. The facility allows for the manipulation of nonstandard materials such as organic and biological molecules and their interface to devices.
Undergraduate Program in Materials Science and Engineering

Students in MSE acquire a solid background in the basic sciences and in materials engineering, with hands-on laboratory experience in nanoscale materials characterization and processing. Graduates are prepared for a variety of careers in fields such as nanotechnology, electronics, computing, the biomedical, automotive and aerospace industries, as well as government agencies and research laboratories.

Students with materials expertise are being hired by companies such as:

- Advanced Micro Devices Inc.
- Applied Materials Inc.
- Boeing
- Cypress Semiconductor
- DowDuPont
- General Electric
- General Motors
- IBM Corporation
- Intel Corporation
- International Paper
- Motorola
- National Semiconductor
- Northrop Grumman Corporation
- Raytheon
- Texas Instruments
- TRW Inc.
- US Steel Corporation
- Western Digital
Graduate Program in Materials Science and Engineering

The M.S. and Ph.D. Programs in MSE at UCR provide fundamental knowledge for the understanding of materials, with the objective of predicting, modifying and tailoring the properties of materials for enhanced performance of devices based on these materials.

Advanced study at the M.S. and the Ph.D. levels allows students to deepen their expertise by choosing one of many areas of specialization. Research labs in our program emphasize work on nanotechnology, materials for energy generation and storage, and sustainability.

Graduates of our program are well suited to work not only for large high-tech corporations that need people specialized in particular disciplines, but also for smaller entrepreneurial companies that need engineers with a broad background. Many companies require engineers with a broad materials background who can perform materials selection, oversee production and/or maintain quality control. Independent testing and consulting companies are also strongly interested in materials and engineering experts.

Materials Science and Engineering benefits from shared research facilities on the UCR campus, such as the following:

- UCR Core Instrumentation Facility
- Microscopy and Imaging Core Facility
- Bioinformatics Core Facility
- W.M. Keck Proteomics Core Facility
- UCR Institute for Integrative Genome Biology
- Analytical Chemistry Instrumentation Facility, with sub-facilities:
  - Nuclear Magnetic Resonance Facility
  - Southern California Mass Spectrometry Facility
  - Small Molecule X-ray Crystallography Facility
  - Optical Spectroscopy (OS) Facility.
- UCR Division of Biomedical Sciences Becton
- Dickinson Fluorescence Activated Cell Scanner

MSE faculty members discovered that graphene, the hottest new material for electronic and sensor applications, has extremely high thermal conductivity, exceeding that of diamonds. They designed and built a graphene transistor, demonstrating a practical application meeting low-noise requirements.

www.mse.ucr.edu
Ion Conducting Block Copolymers, Polymer-Nanoparticle Composite Materials, the design and fabrication of antifouling surfaces and self-healing materials.

Photophysics of photovoltaic materials; photomechanical properties of organic nanostructures; photochemistry in biological tissues.

Investigation and design of surface roughness, surface properties, surface reactivity, in particular with regards to organic materials and metals surfaces.

Porous materials, porous semiconducting materials, catalytic, electronic, and optical materials, templated self-assembly, and targeted drug delivery.

Multifunctional materials based on the $\text{Bn} \ (n \geq 2)$ building block, Rare-earth-free high energy density magnetic materials, multifunctional materials based on the double perovskite structure, hard and superhard materials.

Computational chemistry, Materials chemistry, physical Chemistry.

Electronic, photovoltaic and thermoelectric materials; graphene properties; nanostructured and carbon materials.
Bio-templated materials for electronic, optoelectronic and energy; nanostructured hybrid materials; novel assembly techniques.

Roger K. Lake
Ph.D., Purdue University
Theory of electron transport through materials; computational electronics and optoelectronics; ultra-scaled devices.

Jianlin Liu
Ph.D., University of California, Los Angeles
Semiconductor materials and devices; molecular beam epitaxial nanostructure growth; nanofabrication; solid state lasing and sensing

Ming Liu
Ph.D., University of California, Berkeley
Photonics, optical communication, material science, nano-fabrication

Mihri Ozkan
Ph.D., University of California, San Diego
Hybrid nanoarchitectonics, hybrid photovoltaics and bionanotechnology.

Physics and Astronomy

Igor Barsukov
Ph.D., University Duisburg-Essen
Experimental condensed matter physics, spintronics.

Yongtao Cui
Ph.D., Cornell University
Experimental condensed matter physics, nanoscale physics.

Nathaniel Gabor
Ph.D., Cornell University
Experimental condensed matter physics.

Allen Mills
Ph.D., Brandies University
Experimental solid state and atomic physics

Umar Mohideen
Ph.D., Columbia University
The physical nature of empty space; nanostructure physics; interaction between single molecules or a single assembly of bound proteins.

Jing Shi
Ph.D., University of Illinois
Spin-dependent transport and tunneling; nanoscale magnetism; graphene physics and devices; transition metal oxide thin films and devices.

Harry W.K. Tom
Ph.D., University of California, Berkeley
Optical studies of interfacial magnetism and spin transport; magnetic nanowire devices; optical biosensors; bio molecules at solid/liquid interfaces.

Jory Yarmoff
Ph.D., University of California, Los Angeles
Experimental surface science, nanometer-scale physics, environmental physics.

Peng Wei
Ph.D., University of California, Riverside
Experimental condensed matter physics, mesoscopic quantum physics.

Geology and Geophysics

Harry W. Green, Distinguished Professor
Ph.D., University of California, Davis
Deep earthquake physics and materials science; nonhydrostatic thermodynamics; synthetic and natural ceramics and rocks.

Mechanical Engineering

Reza Abbaschian
Ph.D., University of California, Berkeley
Materials processing, solidification, functionally graded composites; high pressure-high temperature growth of diamond crystals.

Sinisa Cohl
Ph.D., Rutgers
Computational materials science, nanoscience, carbon materials, superconductors.

Shane Cybart
Ph.D., University of California, San Diego
High-transition temperature Josephson devices, superconducting electronics, multiferroic and magnetic oxides, oxide electronic devices.

Sandip Kumar
Ph.D., Pennsylvania State University
Thermo-electro-mechanical coupling in thin films at nanoscale, performance issues with Li-ion battery electrodes and high temperature material characterization

Chen Li
Ph.D., California Institute of Technology
Geophysics, structure and transportation properties of energy materials under high pressure.

Suvendu Mathaudhu
Ph.D., Texas A&M University

Lorenzo Mangolini
Ph.D., University of Minnesota
Plasma processing of materials, nanoparticles and quantum dots, silicon nanostructures.

Cengiz Ozkan
Ph.D., Stanford University
Bottom-up fabrication of bio-nano systems; chemical vapor deposition of nanostructures, graphene, nanowires and photovoltaics.

Masaru Rao
Ph.D., University of California, Santa Barbara
Novel materials; fabrication processes; devices for biomedical applications (cardiovascular, diabetes, cellular engineering, etc.).

Kambiz Vafai
Ph.D., University of California, Berkeley
Multiphase transport, transport through porous materials and biological membranes, thermal design and modeling.

Richard Wilson
Ph.D., University of Illinois at Urbana-Champaign
Electronic, magnetic and thermal transport phenomena.

Guanshui Xu
Ph.D., Brown University
Solid mechanics; mechanical behavior of materials.

Join us at the materials frontiers.
Visit our Web site, call us with questions or schedule a visit to our campus.
www.mse.ucr.edu
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The 1,200-acre Riverside campus is located between Los Angeles, Palm Springs and San Diego. Ontario International Airport is 20 miles to the west. Desert resorts, snow-capped mountains and the Pacific Ocean can be reached in an hour’s drive. The city is well-known for its Mediterranean climate, affordable housing and the landmark Mission Inn. Riverside has evolved from a turn-of-the-century agricultural colony into a hub of higher education, technology, commerce, law, finance, and cultural attractions including a symphony orchestra, a ballet company and a variety of museums. For more information go to www.ucr.edu.