I. Overview

The Bourns College of Engineering (BCOE) proposes the establishment of a Bachelor of Science degree entitled *Materials Science and Engineering*. This degree program will be administered by the Materials Science and Engineering (MSE) Program Committee:

<table>
<thead>
<tr>
<th>MEMBER</th>
<th>DEPARTMENT</th>
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<tbody>
<tr>
<td>Alexander Balandin, Chair</td>
<td>Electrical Engineering</td>
</tr>
<tr>
<td>Cengiz Ozkan</td>
<td>Mechanical Engineering</td>
</tr>
<tr>
<td>Nosang Myung</td>
<td>Chemical and Environmental Engineering</td>
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<tr>
<td>Mart Molle</td>
<td>Computer Science and Engineering</td>
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<tr>
<td>Valentine Vullev</td>
<td>Bioengineering</td>
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</table>

The MSE Program Committee, consisting of the MSE Program Chair and one representative of each department in the Bourns College of Engineering, will have the responsibility for approval and management of the Materials Science and Engineering courses within the curriculum. In the early phase of the Materials Science and Engineering Program, the teaching faculty will be drawn from the College of Engineering with the approval of the Dean and the Chairs of the respective departments. The MSE program will be interdepartmental. In this sense, no department will act as a single host department to MSE major students.

The courses included in the MSE major curriculum will have either specific MSE subject abbreviation or the department subject abbreviation, e.g., ME, CEE, etc. The courses can also be cross-listed, e.g., ME/MSE. Each College of Engineering department may offer a “focus” area within the MSE program by designating a set of technical electives (TE), which emphasize a certain aspect of materials science and engineering.

During the first two years the students take general education courses (mathematics; physics; chemistry; breadth requirements) and the lower-division courses offered by the participating departments. A dedicated MSE course offered during the freshman year (MSE 1: Fundamentals of Materials Science and Engineering) will introduce the students to the basics of materials science and engineering. During the third year the students will take the materials core courses (MCC). MCC will be offered jointly by all departments. There is no strict division of how many courses are taught by each department. Some departments, which have faculty with the relevant expertise and existing courses, may teach more than others. MCC have been selected to maximize the use of the existing courses (with ME, EE, CEE, CHEME, ENVE, CSE, BIEN subject abbreviations) while covering the topics essential for a successful MSE program.
II. The Major

The B.S. degree in Materials Science and Engineering is offered jointly by the five participating departments of the Bourns College of Engineering.

The educational objectives of the MSE program are to prepare students (i) to be employed as materials engineers or in related engineering, science or managerial positions, using and improving their skills based on the demands of the job; (ii) to enter graduate or professional degree programs; (iii) to be effective team members; and (iv) to be responsible engineers, professionals or scientists who demonstrate ethical and professional responsibility and continue to learn through variety of educational experiences.

The MSE program outcomes are graduates equipped with (i) an ability to apply knowledge of the scientific and engineering principles underlying major elements of materials engineering, i.e., structure, properties, processing and performance of materials; (ii) an ability to design and conduct experiments relevant to materials science and engineering, and to analyze and interpret experimental data; (iii) an ability to identify, formulate and solve materials selection and design problems; (iv) an ability to work in multidisciplinary teams; (v) an appreciation of professional and ethical responsibility and importance of continued learning after graduation; (vi) an ability to communicate effectively; (vii) a basic understanding of the impact of engineering on society, including economy and the environment; (viii) an elementary understanding of contemporarily issues in materials science and engineering.

Major Requirements for the Bachelors of Science in Material Science and Engineering are as follows:

Lower-division requirements (68 units):

a) MATH 009A (4), MATH 009B (4), MATH 009C (4), MATH 010A (4), MATH 010B (4), MATH 046 (4)
b) CHEM 001A/01LA (5), CHEM 001B/01LB (5), CHEM 001C/01LC (5)
c) PHYS 040A (5), PHYS 040B (5), PHYS 040C (5)
d) CS 030 (4)
e) EE 001A/01LB (4)
f) ME 010 (4)
g) MSE 001 (2)

Upper-division requirements (52):

a) CHEM 112A (5)
b) CEE 135 (4)
c) CHE 100 (4)
d) EE 138 (4)
e) ENGR 180 (3)
f) ME 110 (4), ME 114 (4), ME 156 (4)
g) MSE 160 (4), MSE 161 (4), MSE 175A (4), MSE 175B (4)
h) STAT 155 (4)
i) Technical Electives: (20): There is a requirement of 20 units of technical electives, chosen with the approval of a faculty advisor. The purpose of these electives is to add depth and breadth to the major and direct a student along a specific materials focus area. The four courses can be selected, in consultation with an advisor, from the following list: BIEN140A/CEE140A; BIEN140B/CEE140B; CEE147; EE133; EE136; EE137; EE139; ME113; ME116A; ME 116B; ME138; ME153; ME180.

III. Justification

Definitions and Background

Materials Science and Engineering (MSE) is concerned with the study of the structure, properties and applications of materials. The proposed MSE Program at UCR aims to provide fundamental knowledge for understanding of materials with the objective of predicting, modifying, and tailoring the properties of materials to achieve enhanced performance of the materials and devices based on these materials.

The foundations of materials science and engineering are the basic sciences of physics, chemistry, and mathematics. An engineer working with the great variety of materials responses at the electrical, optical, magnetic, mechanical, and chemical levels must have a solid scientific foundation and breadth of basic knowledge from the physical sciences and engineering.

The interdisciplinary nature of the proposed program at UCR is ideally suited to address this requirement. The proposed MSE program is truly interdisciplinary, cutting across departmental and collegiate lines. The faculty from various departments and with different backgrounds will participate in the program. BCOE already has a substantial number of faculty members who carry out experimental, theoretical and computational research in materials science and engineering. The proposed MSE program will be complementary to the existing programs and will add to the BCOE strengths. The creation of the MSE program is synergetic with the campus nanotechnology efforts and investments. The MSE program at UCR will be very different from the existing materials programs in other UC campuses and nearby universities. It will be the only undergraduate program that involves all departments of the College of Engineering. Typically, MSE programs are resident within a specific department. The highly recognized interdepartmental MSE program at UCSD is limited to the graduate students only. Other UC campuses have separate materials departments. The arrangement proposed at UCR is intended to emphasize the interdisciplinary nature of the field and encourage interdepartmental cooperation.

The estimated number of MSE major students over the first two years is around 40-50. During the first year we expect that some currently admitted students (sophomores and/or juniors) will transfer to the program. The introduction of the MSE degree is expected to help with the retention at the college and campus levels. During the second year of the program we plan to have around 20-30 freshmen directly entering MSE program. The estimates for the number of MSE majors are based on the BCOE enrollment data for other majors.
The graduates of the MSE Program will benefit from the unique research facilities existing and currently under development at UCR. These include the materials synthesis and characterization resources available in the Department of Bioengineering, Department of Chemical and Environmental Engineering, Department of Electrical Engineering and the Department of Mechanical Engineering. The existing Center for Nanoscale Science and Engineering (CNSE) and Central Facility for Advanced Microscopy and Microanalysis (CFAMM) are additional positive factors for the MSE program development. Modern materials science and engineering involves substantial computational component, i.e., computational materials science. The MSE graduates will benefit from the computational resources available in the Department of Computer Science and Engineering, Department of Electrical Engineering, and the campus-wide computational facilities.

The Need for the MSE Program

Many applications today require broad-based materials knowledge. A materials engineer may specialize in a specific class of materials (magnetic materials, nanostructured materials, polymers, biological materials, etc.) or a specific area of materials science (electrical properties, mechanical properties, materials processing, materials testing, etc.), but should possess a broad background in materials science and engineering. Increased emphasis on cost, weight, and size reduction, while still improving product performance, creates challenges for monolithic materials, and opportunities for composites, nanostructures and other new materials. Miniaturization of components frequently is limited by the interactions of dissimilar materials at a microscopic and nanometer scale. A materials engineer must be able to optimize the overall performance of complex systems involving several materials.

One of the best examples of the increased role of the materials science and engineering and the fact that many innovations in today’s world are happening at the materials level is recent announcement (January 2007) by Intel, the world’s largest chip maker, that it overhauled the basic building block of the information age, paving the way for a new generation of faster and more energy-efficient processors. According to the company researchers the advance represented the most significant change in the materials used to manufacture silicon chips since Intel pioneered the modern integrated-circuit transistor more than four decades ago (see, for example, PhysOrg.com feature at http://www.physorg.com/news89109741.html). The drastic increase in the chip speed and energy efficiency was made possible due to the introduction of the new materials (“high-K” dielectric and metal gate) into the chip design and technological process.

In many industries, several materials may be competing for the same market (e.g., polymer composites versus metal in aircraft structures, ceramic versus metal in engine components). In these applications, a materials engineer must be able to make a decision in selecting the best materials or combination of materials. The latter requires a fundamental understanding of the properties and performance of each of the competing materials.

The increasing global competition for raw materials and energy resources make the MSE major a particularly relevant and timely. According to the National Science Board (NSB) Science and Engineering Indicators 2006 statistics, the US high-technology trade balance is negative. US trade in goods with high-technology content, which includes advanced materials and products
based on advanced materials, is also negative. Substantial efforts in educating a workforce with interdisciplinary expertise in MSE are required to correct this situation.

The important resource needed for work and research in materials science and engineering is trained scientific and engineering manpower. Education and research in materials science and engineering differ from those in other fields because they span the full spectrum from basic sciences to practical applications. Thus, it is highly desirable to have a dedicated MSE program in this field. The introduction of the interdepartmental MSE program is expected to help in promotion of innovation and creating a culture that produces new ideas and allows one to capitalize on these new ideas. A materials engineer who has taken time to learn about a spectrum of subjects offered by different departments should be well positioned to succeed after completing his or her degree.

There is strong industrial commitment to materials research, especially applied research. Materials characterization is an area with many job opportunities in California and nation-wide. The US government increasingly supports research and education in materials science and technology. For example, some recent National Science Foundation (NSF) initiatives include the International Materials Institutes (IMI), Materials Processing and Manufacturing (MPM), Instrumentation for Materials Research (IMR), Materials Research Science and Engineering Centers (MRSEC), and many others. The goal of IMI program is to advance fundamental materials research by coordinating international research and education projects involving condensed matter and materials physics; solid state and materials chemistry; and the design, synthesis, characterization, and processing of materials to meet global and regional needs. The MPM Program advances the fundamental knowledge base that is needed for the realization of desired product attributes through the application of the systematic integration of processing-material-performance relationships. MPM also supports research activities that incorporate connectivity of this materials processing knowledge to sensing systems for process control. MRSEC program supports interdisciplinary materials research and education while addressing fundamental problems in science and engineering. These centers foster active collaboration between universities and other sectors, including industry, and they constitute a national network of university-based centers in materials research. Other government agencies have their own program in support of materials science and engineering.

The broad technical base of the MSE degree prepares graduates for employment in a wide range of industries, including electronics, data-storage, automotive, medical products and aerospace, as well as for graduate school in engineering and science. Graduates of this program will be particularly well suited to work for smaller, entrepreneurial companies that need materials engineers with a broad background, rather than people specialized in particular fields. Many companies involved in manufacturing require engineers with this broad materials background who can specify materials selection, oversee production, or maintain quality control. In addition, independent testing and consulting companies may be strongly interested in MSE program graduates. Engineering managers must be able to direct engineers and scientists with varied backgrounds. The described career options require the ability to communicate with different materials disciplines and to make sound engineering decisions based on knowledge from the different disciplines.
Description of the MSE Courses

The MSE committee has developed the following five new MSE courses. All MSE courses have already been approved.

**MSE 1: Fundamentals of Materials Science and Engineering**
Introduction of properties and applications of different types of materials essential for various areas of engineering. Discussion of the relationship between structure and properties as well as processing of the materials. Illustration of a wide range of properties required for different types of applications.

**MSE 175A: Senior Design**
Preparation of formal engineering reports and statistical analysis on a series of problems illustrating methodology for various branches of applied materials science and engineering. Covers the entire design process: design problem definition, generation of a design specification, documentation, design review process, prototype fabrication, testing and calibration, cost estimation, and federal guidelines. Requires a term project and oral presentation.

**MSE 175B: Senior Design**
Preparation of formal engineering reports and statistical analysis on a series of problems illustrating methodology for various branches of applied materials science and engineering. Covers the entire design process: design problem definition, generation of a design specification, documentation, design review process, prototype fabrication, testing and calibration, cost estimation, and federal guidelines. Requires a term project and oral presentation.

**MSE 160: Nanostructure Characterization Laboratory**
Structure of materials at the nanoscale, including semiconductors, ceramics, metals, and carbon nanotubes. Relationships among morphology, properties, and processing. Primary methods of characterization including scanning electron microscopy, scanning probe microscopy, x-ray diffraction and transmission electron microscopy. Elementary discussions of x-ray, vibrational, and electron waves in solids and introductory diffraction theory.

**MSE 161: Analytical Materials Characterization**
Analysis of the surfaces of materials via ion, electron and photon spectroscopy. Rutherford back scattering, secondary ion mass spectroscopy, electron energy loss spectroscopy, Auger electron spectroscopy, X-ray photoelectron spectroscopy, photo-luminescence, extended X-ray absorption fine structure, Fourier transform infrared spectroscopy and Raman spectroscopy. Sputtering, high-vacuum generation and focused ion beam milling.
V. Approvals:

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<thead>
<tr>
<th>APPROVAL</th>
<th>DATE</th>
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<tbody>
<tr>
<td>Approved by the MSE Committee on:</td>
<td>March 5, 2007</td>
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<tr>
<td>Approved by the Faculty of the College of Engineering on:</td>
<td>March 13, 2007</td>
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<tr>
<td>Approved by the College of Engineering Executive Committee on:</td>
<td>March 12, 2007</td>
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<tr>
<td>Approved by the Committee on Educational Policy on:</td>
<td>March 21, 2007</td>
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### Suggested Course Plan for a UC Riverside Major in MSE

**Materials Science and Engineering 07**  
(Catalog Years 2007)

<table>
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<th><strong>Fall Quarter</strong></th>
<th><strong>Winter Quarter</strong></th>
<th><strong>Spring Quarter</strong></th>
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<tr>
<td><strong>First Year</strong></td>
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<tr>
<td>ENGL 1A</td>
<td>ENGL 1B</td>
<td>ENGL 1C or ISC*</td>
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<td>English Composition</td>
<td>English Composition</td>
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<tr>
<td>MATH 9A</td>
<td>MATH 9B</td>
<td>MATH 9C</td>
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<tr>
<td>First Year Calculus</td>
<td>First Year Calculus</td>
<td>First Year Calculus</td>
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<tr>
<td>CHEM 1A/ILA</td>
<td>CHEM 1B</td>
<td>CHEM 1C</td>
</tr>
<tr>
<td>General Chemistry</td>
<td>General Chemistry</td>
<td>General Chemistry</td>
</tr>
<tr>
<td>MSE 1</td>
<td>ENGR 92*</td>
<td>CS 30</td>
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<tr>
<td>Fundamentals of Material Science</td>
<td>Freshman Seminar</td>
<td>Intro to Comp Science &amp; Eng</td>
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<tr>
<td><strong>Second Year</strong></td>
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<tr>
<td>MATH 46</td>
<td>MATH 10A</td>
<td>MATH 10B</td>
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<tr>
<td>Differential Equations</td>
<td>Multivariable Calculus</td>
<td>Multivariable Calculus</td>
</tr>
<tr>
<td>PHYS 40A</td>
<td>PHYS 40B</td>
<td>PHYS 40C</td>
</tr>
<tr>
<td>Physics (Mechanics)</td>
<td>Physics (Heat/Waves/Sound)</td>
<td>Physics (Electricity/Magnetism)</td>
</tr>
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<td>BREADTH</td>
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<td>ME 10</td>
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<tr>
<td>Humanities/Social Sciences</td>
<td>Biological Sciences</td>
<td>Statics</td>
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<tr>
<td>CHEM 112A</td>
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<td>EE 1A/ILA</td>
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<td>Organic Chemistry</td>
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<td>Engineering Circuits Analysis</td>
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<td><strong>Third Year</strong></td>
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<td>ME 114</td>
<td>ME 110</td>
<td>ME 156</td>
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<tr>
<td>Intro to Materials Science &amp; Eng</td>
<td>Mechanics of Materials</td>
<td>Mechanical Behavior of Materials</td>
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<tr>
<td>BREADTH</td>
<td>CHE 100</td>
<td>CEE 135</td>
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<tr>
<td>Humanities/Social Sciences</td>
<td>Engineering Thermodynamics</td>
<td>Chemistry of Materials</td>
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<tr>
<td>EE 138</td>
<td>BREADTH</td>
<td>MSE 160</td>
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<tr>
<td>Electrical Properties of Materials</td>
<td>Biological Sciences</td>
<td>Nanostructure Characterization Lab</td>
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<tr>
<td>ENGR 180</td>
<td>TECHNICAL ELECTIVE</td>
<td>MSE 175B</td>
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<tr>
<td>Technical Communications</td>
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<td>Senior Design TECHNICAL ELECTIVE</td>
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<tr>
<td><strong>Fourth Year</strong></td>
<td><strong>STAT 155 (Fall) or STAT 100A</strong></td>
<td><strong>MSE 175B</strong></td>
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<tr>
<td>Probability &amp; Statistics for Engineers</td>
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<td>Senior Design TECHNICAL ELECTIVE</td>
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<tr>
<td>MSE 161</td>
<td>MSE 175A Senior Design</td>
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<tr>
<td>Analytical Materials</td>
<td>TECHNICAL ELECTIVE</td>
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<tr>
<td>Characterization</td>
<td>BREADTH</td>
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Notes

Humanities/Social Sciences/Biological Science courses fulfill the breadth requirements specific to the College of Engineering. The Biological Science course must contain a laboratory component. Technical Electives are courses in MSE, or related fields, which explore specific topics. A list of Technical Electives and Breadth Requirements will be available on the College of Engineering Student Academic Affairs Office website: www.engr.uic.edu/studentaffairs
March 15, 2007

TO: Eugene Nothnagel, Chair of the Committee on Educational Policy

FROM: Reza Abbaschian, Dean

I am pleased to submit the attached document for the establishment of an undergraduate Materials Science and Engineering (MSE) program in Bourns College of Engineering. The MSE program will concentrate on fundamental and engineering principles dealing with structure, properties, performance and characterization of engineering materials. As you know, most top engineering schools offer MSE degrees through stand alone materials departments, or combined with a chemical or mechanical department. For BCOE, in part because of the relatively small size of our faculty, we believe it is best to offer a degree program that is college-wide, and involves all of our five departments.

Participating faculty interests and backgrounds are diverse; therefore, the college-wide program will allow us to treat MSE as a field, rather than as a discipline, which integrates with all engineering disciplines. Based on my previous experience as chair of a highly ranked MSE department, I believe the integration with other engineering disciplines will make our graduates extremely marketable. This is due to the fact that many current engineering issues deal with manufacturing specific materials. For example, companies such as Intel will choose MSE students with a concentration in electrical engineering who will have more electronics experience, while DuPont will choose those from chemical engineering who have more processing exposure. Similarly, companies dealing with medical implants will choose MSE students with the concentration in bioengineering, etc.

The MSE program will have a program chair. I am pleased to mention that Professor Alexander Balandin has agreed to accept this responsibility. An MSE program committee, consisting of the MSE program chair and one representative from each department in BCOE will have the responsibility to approve and manage the Materials Science and Engineering courses within the curriculum. The teaching faculty will be drawn from the College of Engineering with the approval of the dean and the department chairs. As such, all departments will be partnering in the program, and will collaboratively support the new program.

The MSE program will be provided with the necessary staff resources and financial support to become successful. Initially, the program will have a staff member who will report to the MSE program chair, and serve the program committee as needed. Additional staff members will be provided as the program grows so that it can function similar to the other degree programs in the College. All other support functions such as student services, accounting, purchasing, recruitments, contract and grant administration will be accomplished through the College and department as appropriate. Obviously, the MSE program will have its own operational budget for office supply, office staff and incidental expenses. The laboratories will be handled by the departments offering the MSE course. Additional laboratories and offices will be provided as needed through the partnering departments.
Our ultimate goal is to establish a graduate program as well, soon after the undergraduate program is launched. The graduate program, however, is envisioned as a campus-wide degree program involving several departments from BCOE, CNAS and CHASS.

In summary, I strongly believe the proposed MSE program will be unique; it will set us apart from other schools in the nation. The program will also provide a suitable platform for the integration of the faculty research programs. Moreover, the program will provide the necessary recognition for the College in its quest for excellence in teaching, research and service. Therefore, I fully support the recommendations of the MSE program committee, the BCOE Executive Committee, and BCOE faculty to form the new MSE undergraduate degree program.

cc: Ellen Wartella, Executive Vice Chancellor & Provost
    Tom Cogswell, Chair, Academic Senate
    Teodor Przmysinski, Chair, BCoE Executive Committee
    Alex Balandin, Program Chair, MSE
Prof. Alexander A. Balandin  
Department of Electrical Engineering  
University of California - Riverside  
Riverside, CA 92521 USA

Dear Prof. Balandin,

Your proposal to establish a Materials Science and Engineering (MSE) undergraduate program at UC Riverside is very worthwhile. Materials Science and Engineering is a highly interdisciplinary subject these days, and is appreciated by many other disciplines of science and engineering as being an essential part of undergraduate education. The proposed MSE Program at UCR is aiming to provide important basic knowledge for understanding of materials and to stimulate students to think about how to model/predict/improve materials properties toward enhanced engineering and device applications.

The basis of recent trend of nanotechnology is nanomaterials, and hence your newly proposed MSE undergraduate program will certainly help to guide the students on the significance of nanotechnology and nano-bio technology, and what materials scientists can contribute in these fields. The Program appears to be complementary to the existing programs.

I would like to express my strong support for your proposed MSE undergraduate program at UC Riverside.

Sincerely yours,

Sungho Jin, Ph.D.  
Member, National Academy of Engineering  
Distinguished Professor of Materials Science and Iwama Endowed Chair  
Director, UCSD Materials Science & Engineering Program  
Department of Mechanical & Aerospace Engineering  
University of California, San Diego  
9500 Gilman Drive, La Jolla, CA 92093-0411

(T) 858-534-4903, (F) 858-534-5698, (e) jin@ucsd.edu.  
(web) http://maeweb.ucsd.edu/~jin/
Professor Alexander A. Balandin  
Department of Electrical Engineering  
University of California - Riverside  
Riverside, CA 92521

Dear Professor Balandin,

I am writing to support the proposed Materials Science and Engineering Program at UC Riverside. Materials Science and Engineering is a vital area for California’s continued technology leadership in the rapidly globalizing economy. In many fields that California has world leadership, including electronics, optoelectronics, biomedical, … there is great demand for well trained and versatile materials scientists.

UCR’s proposed program, which draws from faculty from at least five departments, will provide the diverse and balanced training necessary for future materials scientist. The program is well conceived and structured.

I strongly support this activity.

If you have further questions, please do not hesitate to contact me.

Sincerely,

[Signature]

James S. Speck  
Chair, Materials Department

March 13, 2007
March 12, 2007

Alexander A. Balandin, PhD
Professor, Department of Electrical Engineering
University of California, Riverside
Riverside, CA 92521

Dear Prof. Balandin:

I think it is a wonderful idea for the Bourns College of Engineering to start an interdepartmental undergraduate program in Materials Science and Engineering (MSE). A solid Materials Science background is critical to improved research. Let me give you an example from my field.

In the 1980s and the 1990s, there was a fierce competition between GaN and ZnSe for use in blue light emitting diodes (LEDs) and laser diodes (LDs). In the end GaN proved to be the better choice, in spite of its high dislocation density (order of $1 \times 10^9/cm^2$). As is so often the case, the determining factor in achieving superior device performance proved to be the choice of material. This is why I think it so important for Universities to support and encourage Materials education and research.

Materials are such a fundamental part of Engineering, and a new interdepartmental MSE program at UC-Riverside would be the perfect way for students to broaden their materials knowledge, learning from faculty members who specialize in different disciplines. I strongly recommend that UC-Riverside start an interdepartmental Materials Science and Engineering undergraduate program.

Sincerely,

Shuji Nakamura
Professor of Materials and Electrical & Computer Engineering (ECE)
Director, Solid State Lighting and Display Center
University of California, Santa Barbara