602: MATERIALS SCIENCE AND TECHNOLOGY

In Workflow

1. Administrator Review (sladd@uoregon.edu)
2. OTP Initial Review (rcb@uoregon.edu)
3. AS Dean Initial Review (ebaldwin@uoregon.edu)
4. CH Curric Coord Final Review (koscho@uoregon.edu)
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Approval Path

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   Satomi Ladd (sladd): Approved for Administrator Review
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   Carolyn Vogt (carolynv): Rollback to Initiator
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6. Thu, 08 Feb 2024 17:43:24 GMT
   Ron Bramhall (rcb): Approved for OTP Initial Review
7. Thu, 08 Feb 2024 22:50:01 GMT
   Ellen Baldwin (ebaldwin): Approved for AS Dean Initial Review
8. Thu, 08 Feb 2024 23:13:43 GMT
   Michael Koscho (koscho): Approved for CH Curric Coord Final Review
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    Carolyn Vogt (carolynv): Rollback to Initiator

New Program Proposal

Date Submitted: Tue, 03 Dec 2024 05:25:05 GMT

Viewing: 602 : Materials Science and Technology

Last edit: Tue, 03 Dec 2024 05:25:03 GMT

Changes proposed by: jpaulose

General Information

Give a brief (1-2 paragraphs) overview of the proposed credential, including its disciplinary foundations and connections, its focus and learning objectives for students, and the specific degree (e.g. bachelors, masters, doctorate) and/or credentials (e.g. major, certificate, minor, concentrations) to be offered. This should be based largely on your descriptions in the following sections but it should be shorter than their combined length. Moreover, it should use language that is capable of communicating your ideas to audiences increasingly distant from your academic field as your proposal moves through the review process.

We propose a BS in Materials Science and Technology. This major will focus on the properties of materials needed for modern technology, and how they relate to the underlying physical and chemical structure.

The overall learning objective is to understand the thermodynamic, kinetic, transport, electromagnetic, quantum and chemical bonding properties of materials and how these properties can be controlled in the production of materials. There will be options for students to specialize in different sub-areas within this general framework.

Materials are the functional components of modern technology – electrodes for rechargeable batteries, semiconductors, conductors, and insulators in electronics for classical and quantum computers, polymers/plastics, sensors, and much more. Materials scientists invent new materials and study the connections between the underlying atomic/molecular structure of a material, its properties, its processing methods, and its performance in applications. Despite the central role of Materials Science in modern technology, and Oregon industries that need materials science workforce (semiconductors, sports apparel, advanced wood products, energy and energy storage, green buildings, etc.), no Oregon university (public or private) currently offers an undergraduate degree in Materials Science or a related area.

Academic chemistry and physics faculty working in aspects of materials science at the University of Oregon are well-funded and prolific publishing and patenting. Internationally, materials scientists work, alongside engineers and basic scientists, on some of the most pressing societal technology issues, for example surrounding clean energy production and storage.

The University of Oregon has a history of materials science education and research through the Materials Science Institute (MSI). MSI faculty founded the graduate internship program, launching technology careers through accelerated, industry-internship-based masters programs. MSI faculty created the Center for Advanced Materials Characterization in Oregon (CAMCOR), elevating both research at the UO and providing service and access to industrial partners. MSI faculty launched the Oregon Center for Electrochemistry, bringing the first graduate program in Electrochemical Technology to the USA to train the critically needed R&D workforce for clean energy storage, elevating research and innovation impact by partnering with industry, and have already won prestigious competitive center-level funding from NSF, DOE, and DoD.

We now propose a strategic educational expansion in an integrated education, research, and innovation program in Materials Science and Technology to address key education gaps and address high-tech workforce needs in the State of Oregon, while augmenting and accelerating research and innovation at the University of Oregon. The program re-envisions materials science education at the BS level to meet modern demands, tightly integrating foundational physics and chemistry with computation, data science, programming, and engineering. The core strategy in creating the program provides maximal synergy across existing and new efforts to minimize financial investment to launch and provide a sustainable model for growth.

Each MSTC major will choose a research/technology track after their first year and be mentored by a specific faculty member toward research and internships as an undergraduate. After taking common core curriculum along either a Chemistry of Materials or Physics of Materials emphasis (requiring the addition of six new courses at the 200-400 level in MSTC), each MSTC student will take technology-sector-specific coursework in their 4th year (in 400 level courses, or graduate level courses by petition, that also serve existing and new materials science master's programs, making the new major very cost efficient while providing much specialization).

In a upcoming proposal connected to the new MSTC major we will propose a MSTC AMP programs that specifically create the integrated 4+1 tracks. Although these tracks are mentioned at times in the supporting documentation, they are not part of this MSTC major proposal which can also stand and operate alone.

Primary Proposer

Jayson Paulose

Email

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Is there a co-proposer for this proposal?

Yes

Co-proposer(s)

Name	Home Unit
Benjamin McMorran	Physics
David Johnson	Chemistry
Hailin Wang	Physics
Paul Kempler	Chemistry/ OCE
Carl Brozek	Chemistry

Home department

Chemistry

College

Arts & Sciences, College of

Additional Department Affiliations

Department
Physics

Level

Undergraduate

Program Type

Bachelor's Degree

Primary Location

UO main campus

Program Delivery Format

Traditional classroom/lab

Does the program represent a collaboration of two or more university academic units?

Yes

Proposed Identification

Full Title

Materials Science and Technology

What's your desired effective term?

Fall 2025

Fall term is the default term unless an alternative is specifically requested and approved.

Relationship to Institutional Mission and Statewide Goals

How is the program connected with the UO's mission, signature strengths and strategic priorities?

This new MSTC program addresses key institutional priorities including Provost initiatives in The Environment and in Data Science, in providing career-relevant training, in elevating innovation activities, and in synergizing with research and education to elevate the impact in both.

We believe the model outlined above will be transformative for many areas of research at the University of Oregon. Other core areas with tremendous opportunity include those connected to existing internship masters programs in the Knight Campus Internship Program (originally developed by Chemistry and Physics faculty in the Materials Science Institute and including tracks in polymer science, semiconductor science, optical science), and critical new areas like quantum materials and computing, micro- and nano-mechanical systems (NEMS/MEMS), advanced materials synthesis, materials data science and computation, catalysis science and technology, among others that could be developed by physics, chemistry, and/or new faculty hires in a new materials science department. There are strong UO faculty in these areas where the addition of key TTF and non-TTF hires, and implementation of the above model/roadmap, would be transformative to the teaching/research/innovation ecosystem at Oregon, as it has been in Electrochemical Technology.

How will the proposal contribute to meeting UO and statewide goals for student access and diversity, quality learning, research, knowledge creation and innovation, and economic and cultural support of Oregon and its communities?

Materials are the functional components of modern technology – electrodes for rechargeable batteries, semiconductors, conductors, and insulators in electronics for classical and quantum computers, polymers/plastics, sensors, and much more. Materials scientists invent new materials and study the connections between the underlying atomic/molecular structure of a material, its properties, its processing methods, and its performance in applications. Despite the central role of Materials Science in modern technology, and Oregon industries that need materials science workforce (semiconductors, sports apparel, advanced wood products, energy and energy storage, green buildings, etc.), no Oregon university (public or private) currently offers an undergraduate degree in Materials Science or a related area.

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We now propose a strategic educational expansion in an integrated education, research, and innovation program in Materials Science and Advanced Technology to address key education gaps and address high-tech workforce needs in the State of Oregon, while augmenting and accelerating research and innovation at the University of Oregon.

The program re-envisions materials science education to meet modern demands, tightly integrating foundational physics and chemistry with computation, data science, programming, and engineering. The core strategy in creating the program provides maximal synergy across existing and new efforts to minimize financial investment to launch and provide a sustainable model for growth.

How will the proposal meet regional or statewide needs and enhance the state' capacity to:
• improve educational attainment in the region;
• respond effectively to social, economic and environmental challenges and opportunities; and
• address civic and cultural demands of citizenship?

Despite the central role of Materials Science in modern technology, and Oregon industries that need materials science workforce (semiconductors, sports apparel, advanced wood products, energy and energy storage, green buildings, etc.), no Oregon university (public or private) currently offers an undergraduate degree in Materials Science or a related area.

The MSTC major will integrate core efforts work to address DEI.

Specifically, the MSTC program incorporates:

i Active learning: MSTC courses will be designed from the outset with a flipped architecture. That is, basic content delivery will be via high-quality pre-recorded videos and reading assignments, with in-person in class time dedicated to active learning, group work, board work, etc. exploring the complex topics in depth and addressing mis-understandings or gaps in understanding based on the individual backgrounds of the students in any particularly course. This incorporates growth mindset and values/ethics as core principles embedded in the planned MSTC program.

ii Research immersion courses. Boettcher created a first-year research immersion course at UO (CH399, to become CH 329 regularized) as part of his Cottrell Scholar Teaching Award in 2015 and this course has grown and continued in the chemistry department (now taught by Prof. David Johnson). The research immersion course has practically served as a fast-track for first-year undergraduates into research groups as it prepares students to attack unstructured problems, applying logic and knowledge learned in class, in a team-based setting. In the proposed MSTC curriculum research-immersion lab is one of the required first-year courses.

iii Integration of research experiences and internships each summer. While not required for graduation, the MSTC degree program will support and encourage summer research and internship placement. Multiple studies show that retention in STEM is substantially increases by being involved in research. We will leverage our own research programs at UO, our industry partnerships, and our network of international contacts to find positions and support MSTC majors in this endeavor.

iv Direct societal impact. The technology focus areas are some of the most important for the prosperity of human civilizations, like materials for renewable energy. Having a clear purpose through STEM education leads to better retention. We will also incorporate diverse role models through our hiring practices as well as via invited speakers and internship hosts.

Student Demographics.

Applied technology-focused STEM majors, as MSTC is, attract a more-diverse student body than the basic physical sciences. Anecdotally, this due to the direct connection to careers as URM students are often also have less accumulated wealth in their family to support them through education. As an example, we point to our Electrochemical Technology MS program in which over 50% are from groups underrepresented in science and engineering and where we know our industry partners are particularly eager to hire from these groups and at high salaries. In the 2022 cohort currently on internship earning $83k/y (https://electrochemistry.uoregon.edu/masters-internship-program/class-of-2022/), eight of the students identified as female and four were from other types of groups under-represented in science. The program appears particularly attractive to first-generation college students and those from lower socioeconomic statuses due to the focus on high-paying careers and the cost-efficient accelerated program structure (see for example data and discussion in DoI: 10.1128/jmbe.v20i3.1775). We expect MSTC to be a compelling choice for URM and first-generation college student due to the direct connection to high paying engineering-related technology careers and the strong connection to the associated accelerated MS programs.

Beyond the data from the UO MS programs, there is strong evidence at the national level that the engineering student body is more diverse than the physical sciences (65% white versus 75% white for physical science in 2015, see data from the National Center for Education Statistics). Materials science and engineering is further one of the most diverse of the engineering sub-disciplines and is growing among the fastest in terms of diversity (see data from the APS below). For example, where chemistry is adding black chemistry students slower than the overall average growth rate of the major, Materials Engineering is not only growing overall at nearly twice the percentage rate of chemistry, but the black materials engineering majors are growing 40% faster than the major as a whole.

Program Description

Is there a core set of required courses?

Yes

What is the core set of required courses and what is the rationale for giving these courses this prominent role? What are the central concepts and/or skills you expect students to take from the core?

Core courses will be MSTC 231, 232 (first year) and MSTC 431, 432, 441, 442 as described below. These 6 new courses are sequential and then there are options for specialty focus in the fourth year of the program.

The first year curriculum MSTC 231 and 232 provides a rigorous, but approachable, framework to build a deep understanding of the physics, chemistry, and applications of advanced materials in modern technology. The foundational concepts in thermodynamics, kinetics, transport, and chemical bonding are introduced in the context of these applications where there is high career opportunity now and in the coming decades. With this introduction and framing, the goal is for students to be able to better absorb and retain the chemistry, math, and physics courses they are also taking in their first and second year because they have a good understanding of how the chemistry, math, and physics applies in exciting technology.

The heart of the new program are the MSTC 431 and 432 courses and the MSTC 441 and 442 courses.

In MSTC 431 Thermal Physics of Advanced Materials the students learn how the properties and structures of materials are governed fundamentally by the laws of thermodynamics - that is, what are the equilibrium properties of materials and how is that determined by all the various energies in Nature? This course focuses on how concepts of thermodynamics, familiar to the student from a prerequisite physics or chemistry course (PHYS 352 or CH 411), can be applied to understanding materials phases and properties. Specific concepts covered include chemical potential, free energy as work, chemical thermodynamics, electrochemical potential, phases and phase transformations, Boltzmann distributions, and partition functions to connect statistical mechanical concepts with macroscopic observables.

In MSTC 432 Kinetics and Transport in Advanced Materials, the students apply more advanced concepts to understand materials outside of equilibrium, i.e. when materials processes like phase changes or transport of electrons are ions are driven by gradients in energy. This course focuses on kinetic and rate processes, following the thermodynamics concepts covered in the previous course in the sequence. The course begins with concepts of thermodynamically reversible and irreversible process and how those relate to entropy and entropy production. Transport by diffusion, rates of chemical reactions, and materials processes nucleation and growth and morphological evolution in solids are covered in the context of modern technology-relevant examples.

In MSTC 441 Electronic, Optical and Magnetic Properties of Materials Part I; The students build a deep understanding of materials technology at the quantum level - i.e. thinking about electronic structure in terms of electron wavefunctions, Bloch waves, etc., and using use of VASP or other DFT calculations to predict basic properties. In the first part of this two-course sequence (MSTC 441), the student will study the significant role played by geometry and chemical composition in determining general material properties and explore how this structure conspires with quantum physics to govern the mechanical, thermal, and electrical properties of condensed matter, including the emergence of semiconducting behavior and superconductivity.

In MSTC 442 Electronic, Optical and Magnetic Properties of Materials Part II, the student will extend their knowledge to magnetic, dielectric, and optical properties, and apply this knowledge to understand semiconductor devices (transistors, photovoltaics, diode lasers, etc.), nuclear magnetic resonance (NMR), spin-based quantum bits, and nanomaterials. This course thus is motivated by the need to understand and controllably manipulate the properties of materials which has led to revolutionary technologies affecting nearly every facet of human life. For example, a deep, practical understanding of semiconductors catalyzed the age of microelectronic devices that are at the heart of modern computing, smart phones, pacemakers, and cars. Future advancements in areas as diverse as energy, medicine, and quantum computing will require working foundational knowledge of materials. But what exactly determines the properties of a material, such as its color or whether it conducts electricity or heat, and how tunable are these properties? This course teaches students how to apply fundamental physics and chemistry to answer such questions, while simultaneously strengthening fundamental understanding.

The students will be expected to take three upper division or graduate materials science, chemistry or physics courses in their fourth year on top of the courses outlined above. Students can also create a custom collection of courses to tailor to their interests, for example if they are PhD program bound and desire a broad background. Well-prepared students will have room in their curriculum to take more specialized courses, and potentially to take graduate courses that count towards a Masters' degree in UO's sector-leading applied science MS programs.

What is the relationship between upper-division courses and the lower-division curriculum? For example, are fundamental principles introduced in the lower division and then applied to increasingly complex problems at the upper-division? This vertical architecture is common in the sciences, but is by no means universal. In the humanities, a more horizontal structure is often appropriate. For example, students might read and analyze literature at each level (100-400), but do so with increasing sophistication and the capacity to draw on a widening array of literary forms and ideas.

The fundamental principles in materials science are introduced in the lower division and then applied to increasingly complex problems at the upper-division classes. The introductory curriculum MSTC 231 and 232 was developed to provide a rigorous, but approachable, framework to build a deep understanding of the physics, chemistry, and applications of advanced materials in modern technology. The foundational concepts in thermodynamics, kinetics, transport, and chemical bonding are introduced in the context of these applications where there is high career opportunity now and in the coming decades. With this introduction and framing, the goal is for students to be able to better absorb and retain the chemistry, math, and physics courses they are also taking in their first and second year because they have a good understanding of how the chemistry, math, and physics applies in exciting technology. The upper-level courses build deeply on this framework and the required chemistry and physics foundational courses.

All courses use common data and computation software, e.g. Python, to build deep integrated competence and ability in data, programming, and computation.

Are there specific course-to-course prerequisites that help students extend or link ideas or are the intellectual connections among courses in your major more general?

The major includes both modes of intellectual growth. Some courses are tied to specific prerequisites: for instance, the upper-level MSTC 431/432 sequence builds on ideas that students would see in PHYS 351 or CH 441, either of which must be taken before MSTC 431/432. The foundational MSTC 231/232 is required to provide scaffolding for the ideas in the upper-level MSTC 431/432/441/442.

Other intellectual connections in the curriculum are more general, with several courses suitable for being taken concurrently within the new courses (e.g. MSTC 431/432 and MSTC 441/442) as well as the physics and chemistry courses (the 300 and 400-level PHYS/CH sequences that are required or recommended in the program build on the sophistication and overall physics/chemistry knowledge of 200-level and 300-level courses).

The MSTC major is constructed to be rigorous and push the students to become leaders in their field leveraging advanced/honors/majors' classes in chemistry and physics, and advanced math classes through linear algebra and differential equations, in addition to the core MSTC curriculum and classes associated with a the student's chosen technology specialization.

Are there tracks or concentrations within the credential? If so, do these start from a common core or are they differentiated from the beginning?

The foundational courses in the program form a common core: 200-level physics and chemistry courses; the new MSTC 231/232 sequence, and CH 329 Research Immersion course. These are taken by all students. Students who enter UO with preparation for 100-level math and chemistry courses will complete the foundation in their first two years, whereas students entering at 200 level will be able to complete the foundation in their first year.

Upon completion of the foundation courses, students will apply into the program and will choose a Chemistry of Materials or Physics of Materials emphasis. This will be differentiated by the 300-level and 400-level courses taken by the students in years 2 and 3: each emphasis will follow a subset of the typical second-year and third-year course sequences taken by students in the respective (PHYS or CH) major. However, flexibility is built into the program and students with adequate preparation can petition to mix courses from the Physics and Chemistry emphases as long as all prerequisites are met. Regardless of emphasis, all students in the major will take the Materials Science and Technology core courses (MSTC 431/432 and MSTC 441/442) in their third or fourth year, building on the expertise in fundamental physics, chemistry, and materials science developed up to then.

In their final year, MSTC students will choose upper-division electives that allow them to tailor the major towards a specific industrial sector (semiconductors, energy technologies, organic materials, etc.) if desired. However, students are not required to focus on any particular sector and are free to choose electives across subject areas as long as they meet the prerequisites. Every student will be assigned a faculty mentor who will provide guidance with choosing the electives most suited to their career/academic goals.

Course of Study

Programs are required to display their curriculum in grid format to meet degree guide specifications. Proposed curriculum should include course numbers, titles, and credit hours.

Course of Study

Materials Science and Technology Major Requirements

Code	Title	Credits
Foundation courses		
MSTC 231	Fundamentals of Materials in Technology I	4
MSTC 232	Fundamentals of Materials in Technology II	4
CH 224H–226H	Honors General Chemistry [1]	12
PHYS 251–253	Foundations of Physics I [2]	12
PHYS 290	Foundations of Physics Laboratory [3]	3
CH 329	Course CH 329 Not Found Regularized version of CH 399, General Chemistry Research Immersion Laboratory taught in the chemistry department for last few years, proposal started on this as well	3
MATH 251–253	Calculus I-III	12
Upper-Division Required Courses		
PHYS 351	Foundations of Physics II	4
or CH 411	Physical Chemistry	
CH 341	Majors Track Organic Chemistry I	4
MATH 256	Introduction to Differential Equations	4
MATH 281	Several-Variable Calculus I	4
PHYS 352	Thermal Physics and Statistical Mechanics I	4
or CH 342	Majors Track Organic Chemistry II	
or CH 412	Physical Chemistry	
PHYS 353	Thermal Physics and Statistical Mechanics II	4
or CH 343	Majors Track Organic Chemistry III	
or CH 413	Physical Chemistry	
PHYS 391	Physics Experimentation Data Analysis Laboratory	4
or CH 337	Organic Chemistry Laboratory	
or CH 417	Physical Chemistry Laboratory	
PHYS 481	Design of Experiments	4
or CH 348	Organic Chemistry Laboratory for Majors	
or CH 418	Physical Chemistry Laboratory	
MSTC 431	Thermal Physics of Advanced Materials	4
MSTC 432	Kinetics and Transport in Advanced Materials	4
MSTC 441	Electronic, Optical and Magnetic Properties of Materials I	4
MSTC 442	Electronic, Optical and Magnetic Properties of Materials II	4
MATH 341	Elementary Linear Algebra	4
MATH 282	Several-Variable Calculus II	4
or PHYS 389	Mathematical Methods	
or MATH 421M	Partial Differential Equations: Fourier Analysis I	
or CS 210	Computer Science I	
Upper Division Physics or Chemistry Elective Courses Courses will typically be aligned with a technology focused MS degree, but are not required to be associated. A separate AMP proposal will be submited for the Materials AMP connected to create the 4+1 programs. Students can also petition to enroll in graduate classes associated with MS degrees while not enrolling in the future AMP.		12
Total Credits		**118**

1. Students can petition to count CH221-223 instead.
2. Students can petition to count PHYS 201-203 or equivalent instead
3. Repeated three times, once per quarter; can petition to count PHYS 204-206 instead or equivalent at other institution.

Expected Learning Outcomes for Students and Means of Assessment

Only one learning outcome should be listed per row. Additional fields are added once a row has been filled.

Principle Learning Outcome (Concept or Skill)	Part of curriculum where this learning outcome introduced	Part of curriculum where this learning outcome developed	How student learning for this outcome will be assessed
Learn and critically apply basic concepts in chemical bonding to understand the three-dimensional solid-state structure of different classes of materials, particularly of crystalline solids and how structure is determined experimentally with diffraction methods. Describe basic defects structures in solids at the atomic and microstructure scale and how they are quantified and assessed in technologically relevant materials	MSTC 231 and MSTC 232	MSTC 431 and MSTC 432	In class assignments, reports, homework, examinations, project posters
Describe how basic classes of inorganic and organic materials are made and processed for applications in renewable energy, health, sustainable building, and computing; particularly understanding the structure and defect concepts governing the mechanical properties of materials, like hardness, strength, stress-strain behavior, plastic deformation, in structural and engineering applications.	MSTC 231 and MSTC 232	MSTC 431 and MSTC 432	In class assignments, reports, homework, examinations, project posters
Understand how diffusion processes are driven by gradients in chemical potential and how those relate to materials synthesis, failure, and function.	MSTC 231	MSTC 431 and MSTC 432	In class assignments, reports, homework, examinations, project posters
Understand the basic thermodynamics of, and how to apply, phase simple unary and binary phase diagrams, while formulating fundamental thermodynamic definitions of work, heat, reversibility and apply these relationships to technological applications such as batteries, photovoltaic power, fuel cells, thermoelectric power, and sensors	MSTC 231	MSTC 431 and MSTC 432	In class assignments, reports, homework, examinations, project posters
Understand how materials thermodynamics defines electrochemical equilibration in energy storage systems and governs optical and magnetic properties of materials.	MSTC 231	MSTC 431 and MSTC 432	projects and homework

Gain high-level competency in modern programming languages for data manipulation and analysis through use in homework sets and projects. Be able to use basic programming to model diffusion and kinetic processes, for example with Monte-Carlo simulations and by solving sets of partial differential equations	MSTC 231 and 232	MSTC 431, 432, 441, 442	In class assignments, reports, homework, examinations, project posters
Understand the basic structure and defect concepts governing the electrical properties of materials, like conductivity, in computing applications.	MSTC 232	MSTC 441, 442	In class assignments, reports, homework, examinations, project posters
Understand the basic structure and defect concepts governing the magnetic properties of materials, like diamagnetism, paramagnetism, and ferromagnetism and applications for example in electric motors, magnetic information storage, and quantum information science.	MSTC 232	MSTC 441, 442	In class assignments, reports, homework, examinations, project posters
Understand how microscopic kinetic pictures of materials reactions gives rise to key processes in technological systems, for example electrode reactions, nucleation and growth, and interface and crystal grain behavior with time	MSTC 432	technology specific electives	In class assignments, reports, homework, examinations, project posters
Understand charge carrier transport in solids, including diffusive and drift current, and difference between holes and electrons and apply these concepts to understand the operation of basic semiconductor electrical and optical devices, including the pn-junction, the MOS capacitor, and the MOSFET transistor and the basics of how semiconductor devices are made via lithography and planar processing.	MSTC 442	technology specific electives	In class assignments, reports, homework, examinations, project posters
Understand how wave diffraction leads to collective behavior such as bands and band gaps and how this is connected to the quantization of elastic waves in solids, and how quantization manifests in the thermal, electronic, and magnetic properties of solids.	MSTC 441	technology specific electives	In class assignments, reports, homework, examinations, project posters
Technology specific fourth year specialization topics	undergraduate/graduate AMP coursework	possible BS internship	In class assignments, reports, homework, examinations, project posters; May lead to BS +MS

Understand how spin determines the magnetic properties of matter the effect of electronic and phononic structure on the optical properties of condense matter.	MSTC 442	technology specific electives	In class assignments, reports, homework, examinations, project posters
Gain laboratory competence in materials science and ability to work individually and with teams on solving unstructured problems.	CH 329	possible BS internship	laboratory reports, presentations

Expected Learning Outcomes (Will Appear in Catalog)

	Learning Outcomes
1	Materials Science and Technology majors will be able to connect the atomic and molecular structure of materials to their properties, understanding based on the foundations of physics and chemistry, how to design and test materials for advanced applications in energy, computation, transportation, bioengineering, mechanical applications and more. They will learn and apply modern techniques in data, programming, and computation to solve problems and develop technology specializations that launch their career in industry, national laboratories or academia.

Accreditation

Is or will the program be accredited?

No

Please explain why accreditation is not being sought:

There is no appropriate accreditation for this program that is targeted in new areas of technology and not represented well by the classical materials science and engineering degree program at all other universities.

Need for this Credential

What is the anticipated fall term headcount over each of the next five years?

Fall Term Headcount = number of students enrolled in the program as of Fall term.

Year 1	Year 2	Year 3	Year 4	Year 5
20	50	90	140	170

What are the expected degrees/certificates over the next five years.

Number of Degrees:

Year 1	Year 2	Year 3	Year 4	Year 5
			20	30

How did you arrive at the above estimates? Please provide evidence. (e.g. surveys, focus groups, documented requests, occupational/ employment statistics and forecasts, etc.)

Our target enrollment is 20 incoming new major students in Fall 2024, 35 in Fall 2025, and 50 in Fall 2026. At steady state in 5-10 years we target a major enrollment in MSTC of >100 BS graduates per year. This number is estimated in the following way. At the University of Washington (UW), the “Materials Science and Engineering” major must compete with 10 other engineering majors at UW and another in-state Materials Science and Engineering major at Washington State University. UW Materials is a small department of about 20 faculty many of which have primary appointments in chemical engineering, physics, or chemistry. Our hypothesis is, because of the unique career and technology focus of the proposed UO MSTC degree coupled with no competition from existing engineering-like undergraduate degrees at UO or Materials Science focused degrees anywhere in the state of Oregon, that we can double the number of majors in the UW program. To do this we will also use recruiting strategies that directly engage high school students, counselors, and teachers and we will not rely solely on the admissions office to advertise our program. We are already starting this effort for the electrochemistry AMP program approved last year and we have built and email database of all Oregon science teachers and counselors. We also applied for funding to host them on campus for a workshop this year.

For reference, Oregon State University has >8,000 engineering majors. Our target enrollment should be relatively easy to achieve with a mix in-state, out-of-state, and international students that currently don’t consider UO due to the lack of technology/engineering focused education programs. As we grow the number and diversity of technology-specific materials science tracks the number of majors can continue to grow substantially, presenting new challenges that will likely require investment in faculty lines.

Other evidence for demand is the success of our technology-specific masters internship program tracks.
The Electrochemistry technology MS track has grown from 8, to 21, to 26 students over its first three years, demonstrating demand in technology areas. We can use the metrics for salary (avg. $83k/yr after 6-month specialized courses that MSTC students would take as well) and placement rate (100%) as evidence for recruiting bachelor's students into the associated MSTC program and preparing them for the applied MS programs at UO.

What are the characteristics of students you expect this program to attract (e.g., resident/out-of-state/international; traditional/ nontraditional; full-time/part-time)? Will it appeal to students from particular backgrounds or with specific careers in mind?

Many students never consider UO, despite its image as an attractive, innovative, and cutting-edge university, because we don't offer engineering or technology-focused programs at the BS level. MSTC is fundamentally a response to this, combining the best aspects of engineering, physics, chemistry, and data/programming, and leading to exceptional career prospects. We see the primary challenge will be in that the program grows too fast to support it with the faculty we have at UO currently.

We expect MSTC to be a compelling choice for URM and first-generation college student due to the direct connection to high paying engineering-related technology careers and the strong connection to the associated MS programs.

What are possible career paths for students who earn this credential? Describe and provide evidence (e.g. surveys, focus groups, documented requests, occupational/employment statistics and forecasts, etc.) for the prospects for success of graduates in terms of employment, graduate work, licensure, or other professional attainments, as appropriate.

We expect to be able to replicate the successes of our related professional masters' programs, and in fact expect many of these students to directly enter these programs. These programs currently have nearly 100% job placement at high salaries for master's internship students in materials science related areas.

Describe the steps that have been taken to ensure that the proposed program(s) does not overlap other existing UO program(s) or compete for the same population of students. [Provide documentation that relevant departments or areas have been informed of the proposal and have voiced no objections.]

The program has been formally voted on in both chemistry and physics and discussed at length with the associate dean for science and the dean of CAS.

Some recurring worries that we address are:

Will a new materials science degree program lead to less students majoring in chemistry and physics?:

We see this as unlikely for several reasons. For comparison, there are >8,000 engineering students at Oregon State University across all engineering majors (https://engineering.oregonstate.edu/enrollment-summary-2019). Despite this, Oregon State University graduates more Chemistry (~50/year) and Biochemistry and Molecular Biology (~80/year) + ~16/year in Biochemistry and Biophysics majors than does the University of Oregon (combined Chemistry and Biochemistry, ~50 per year). Oregon State also graduates similar numbers of Physics majors (~30/y). This is despite both Chemistry and Physics being, by research metrics, not as strong departments at OSU relative to UO departments. Our hypothesis is that simply many more students interested in science and technology go to OSU because of the much larger diversity of programs available and that by creating the proposed Materials undergraduate degree, with key career focused technology pathways of current high relevance, we will also attract many more science students that end up liking basic science more than more-applied materials science.

Who will teach the classes? Won't that affect hiring in chemistry and physics?:

Currently in both chemistry and physics there are competing interests from groups of faculty that would like to see hiring in technology-related areas (for example electrochemical materials, solid state physics / hard condensed matter and devices etc.) and those that prefer hiring in other areas. The core goal with the new materials major is to bring in more tuition dollars so that there truly is an increase in the number of research-active faculty. If the major is successful, we aim to create a separate *Materials Science department* that would be filled with faculty joint-appointed between Materials and Chemistry or Materials and Physics, and the funding for a small number of new faculty lines will come from the new Materials majors tuition (practically, although there is no transparent budget model at UO, provost/deans direct funds as they see fit). So the outcome is ideally that UO can hire a small number of new technology-focused faculty in Materials, that connect and are joint appointed to basic sciences, while allowing the basic sciences to focus on areas of most importance to the existing departments. Current faculty could even choose to be joint appointed in a new Materials department eventually, opening up lines in basic sciences. Pragmatically, we will make use of research professors like those in the Oregon Center for Electrochemistry with engineering PhD backgrounds, adjuncts from technology industry, overload teaching by motivated CHEM and PHYS faculty, and possible retired faculty in Eugene (maybe Steve Kevan) to kick start the program.

Do we have space for such a new program?:

Yes and no. At the outset, when it is small, the classes will be taught by existing faculty in chemistry and physics as well as research professors that may be hired using flexible resources from the Oregon Center for Electrochemistry. As it grows the Materials program and any new faculty hires will unavoidably compete for space with science departments (including chemistry and physics, but also likely others like biology and psychology). However, we do strongly believe the creation of a new degree, with multiple emphases and technology tracks connected directly to Oregon and USA workforce development, will allow the UO to win more funding for new buildings from the State of Oregon and private sources. The aim certainly is to grow the research, education, and innovation work done at UO, not redirect basic science resources and effort.

List any existing program(s) that are complemented or enhanced by the new major.

Program(s)
Chemistry, Physics, KCGIP MS internship programs

Program Integration And Collaboration

Are there closely-related programs in other Oregon public or private universities?

No

If applicable, explain why collaborating with institutions with existing similar programs would not take place.

There are no closely related programs at the University of Oregon or any other Public or Private Oregon University. Oregon State University has programs focusing on macroscopic engineering concepts as opposed to materials science. OSU does offer a Materials Science Minor which covers related material. PSU offers a Mechanical and Materials Engineering degree, but the coursework is is not that of Materials Science and is focused on mechanical engineering and primarily structural materials. We do not currently envisage collaborating with these programs.

Describe the potential for impact on other institution's programs.

N/A no competitive programs in the state of Oregon

Please contact the Office of the Provost for instructions prior to contacting another institution about this program proposal.

If the program's location is shared with another similar Oregon public university program, provide externally validated evidence of need.

N/A

Resources Required to Offer the Program or Move to New Location

List any faculty who will have a role in this this program, indicating those who have leadership and/or coordinating roles. For each individual, indicate status with respect to tenure track (TT or NTT), rank, and full-time or part-time.

Faculty Name	Faculty Classification and Rank	FTE	Role
Shannon Boettcher	TT – Full	full	Faculty
Paul Kempler (research asst. prof)	Professor of Practice	full	Faculty
Andreas Stonas	NTT Protem	half	Faculty
Gary Harlow (research asst. prof)	Professor of Practice	full	Faculty
David Johnson	TT – Full	full	Faculty
Benjamin Aleman	TT – Associate	full	Faculty
Benjamin McMorran	TT – Associate	full	Faculty
Matthias Agne (new hire)	TT – Assistant	full	Faculty
Carl Brozek	TT – Assistant	full	Faculty
Chris Hendon	TT – Associate	full	Faculty
Jayson Paulose	Associate Professor	full	Faculty
Hailin Wang	TT – Full	full	Faculty
Richard Taylor	TT – Full	full	Faculty
Kurt Langworthy	Officer of Administration (OA)	full	Advisor

Please describe the adequacy and quality of the faculty delivering the program, including how the mix of tenure-track, career and pro tem faculty are strategically used to ensure effective delivery of the curriculum.

We have assembled a diverse and stellar team across all ranks both TTF, NTFF, and OA appointments to launch this program. The faculty hail from both chemistry and physics and have substantial experience starting and managing program connected to technology for example through the MS program in Semiconductor Science (KCIP) and the Electrochemical Technologies internship program (through OCE).

What is the nature and level of research and/or scholarly work expected of program faculty that will be indicators of success in those areas?

The TTF faculty all have thriving highly federally funded research programs. New faculty in this area, particularly those connecting to applied research and technology, are expected to thrive here at UO delivering outstanding training to graduate students and connecting to industry partners and attracting substantial federal, state, and private research funding.

Describe how students will be advised in the new program.

In addition to advising through Tykeson, each MSTC major will be mentored by a specific faculty member toward research and internships as an undergraduate. The faculty mentor will advise the student on choosing upper-level electives to match their career and academic goals, as well as guidance on undergraduate research during the academic year and in the summer.

Describe the staff support for the proposed program, including existing staff and any additional staff support that will be needed.

The program will make use extensively of CAS shared services support model to launch the major, although once the program/major grows we do anticipate need a professional program director.

Are special facilities, equipment, or other resources required as a result of this proposal (e.g., unusual library resources, digital media support,

The program will need basic access to laboratory teaching space, typical for introductory chemistry and physics. A budget for materials and basic equipment use in CAMCOR will be needed of roughly $1,000 per student. We also aim to find external support for undergraduates to pursue a research experience during their first summer here at UO.

Financial Sustainability

What financial resources are needed to support this proposal? Identify the resources currently available as part of existing UO programs or reallocations within existing budgets. Are additional resources needed?

Here are our expectations about the resources needed to teach the curriculum.

AY 2025/2026: This is the first year of the program where we have a target incoming class of majors of 20 and only two new classes (MSTC 221 and 222) to teach. We will teach these classes with existing faculty listed in this proposal, augmented by the new Environment Initiative hire in chemistry or other NTTF as needed that are already hired or in the pipeline to be hired. We will require resources to replace the instruction these faculty would do in their home department on an ongoing basis. We will work to find summer internships for each MSTC major to do research at UO or to work on an industry supported internship.
Total MSTC majors = 20.

AY 2026/2027: This is the second year of the program where we have a target incoming class of majors of 35 and still only the same two new classes to teach. We will teach these classes with existing faculty listed in this proposal, augmented by the new Environment Initiative hire in chemistry or other NTTF as needed that are already hired or in the pipeline to be hired. The second year MSTC students will be taking courses in physics, chemistry, math and fulfilling general university requirements. We will work to find summer internships for each MSTC major to do research at UO or to work on an industry supported internship.
Total MSTC majors = 50

AY 2027/2028: This is the third year of the program where we have a target incoming class of majors of 50 and we will be now teaching not only MAT231/232 to the first-year students but also the four new advanced courses (MAT431/2 and MAT441/2) to the third-year students. We will teach these classes with existing faculty listed in this proposal, augmented by the new EI hire or other NTTF as needed that are already hired (or in the pipeline to be hired). We will need new faculty (either TTF or NTTF) to teach these four new courses. To backstop and seed fund these efforts we have access to discretionary and gift funds available to the Oregon Center for Electrochemistry. We will work to find summer internships for each MSTC major to do research at UO or to work on an industry supported internship.
Total MSTC majors = 90

We have already discussed the budget with Dean Poulsen as indicated below.

"From: Chris Poulsen <poulsenc@uoregon.edu>
Sent: Tuesday, January 31, 2023 2:11 PM
To: Shannon Boettcher <swb@uoregon.edu>
Cc: Hal Sadofsky <sadofsky@uoregon.edu>; Sherri Nelson <sherrin@uoregon.edu>; Melissa Baese-Berk <mbaesebe@uoregon.edu>; Jamie Bufalino <bufalino@uoregon.edu>
Subject: CAS support of MAT proposal

Dear Shannon,

Thanks for your patience as we considered your proposal for the creation of a Material Science and Advanced Technology major. The vision for the new major and the potential opportunities it may create for our undergraduate students are exciting and compelling. We would like to see it move forward and support doing so.

In addition to the new major, your proposal also requests other costly commitments, including faculty lines, replacement instruction, and GEs, that we can't make at this time. The major is promising, but student interest at the levels you predict are unproven and may take time. It's also not clear whether the new major will lead to new enrollments in CAS or cannibalize students in existing majors, namely Chemistry and Physics. Further, though there is gaining momentum for developing applied and material sciences in support of the CHIPS act, neither the state nor the university has yet made formal commitments to doing so. Without additional state or university support, including faculty lines and an increase in undergraduate enrollment, CAS is unable to independently fill your requests.

Given these uncertainties, we support a more measured approach to launching the interdisciplinary major, in which support will grow as the major does. (This is typically how resources are allocated in the college.) At this time, CAS will commit to the following in support of the major:
1. The college supports the formation of a new interdisciplinary major in Materials Science and a new Materials Science Program, which will administer the major. The college will facilitate timely evaluation of the major by the CAS Curriculum Committee.
2. The college will provide GE positions to support MAT courses, as it does courses across CAS, from its general-fund GE allocation.
3. The college is receptive to hiring tenure-track faculty in Materials Science and will recommend the Materials Science proposal from Chemistry as a high priority hire. Proposals for future TTF lines may be requested through the IHP process and via a CAS department (Chemistry and/or Physics).
4. The Materials Science Program will receive administrative support through Shared Services ASU 6. The college is committed to providing excellent administrative support through Shared Services for all units.
I hope this demonstrates CAS's commitment to and enthusiasm for the Material Science and Advanced Technology major. As always, I'm available to answer any questions or discuss concerns you may have. Please feel free to share this email with your co-proposers.

Best regards,
Chris "

List Collaborating Units

Academic Units
chemistry, physics, KCGIP

Provide a plan that shows how long-term financial viability of the program is to be achieved, addressing anticipated sources of funds, the ability to recruit and retain faculty, and plans for assuring adequate library support over the long term.

Business Plan Description

We expect this unique program to bring new undergraduates to the and thus to "grow the pie". So the revenue will be the tuition collected by the university. If the major remains on the smaller side (20 degrees per year) the main costs will be the costs of running the six new courses per year. This is considerably below the revenue associated with 20 new student per year.

If the program grows to the maximum size we imagine (100 or more new students per year), the costs will grow as well (additional GE support), but the revenue growth for the university will be much larger.

The existence of this major will also contribute to more interest in relevant courses in Chemistry and Physics and will make the university more attractive to prospective faculty in Chemistry, Physics and Materials Science.

Describe your plans for development and maintenance of unique resources (buildings, laboratories, technology) necessary to offer a quality program.

Faculty will maintain robust research programs as well as the shared research/teaching space, which could be part of CAMCOR, needed to run the program.

What is the targeted student/faculty ratio? (student FTE divided by faculty FTE)

We expect the new courses to be about 20 students. Larger enrollments will be possible if we expend more GE resources.

What are the resources to be devoted to student recruitment?

We have already developed a state-wide email list including science teachers and counselors across Oregon. We will use this list to educate the state about our new highly impactful program structure and recruit new students.

Thus we will use recruiting strategies that directly engage high school students, counselors, and teachers and we will not rely solely on the admissions office to advertise our program. We are already starting this effort for the electrochemistry MS program approved last year and we have built an email database of all Oregon science teachers and counselors. We also aim to receive funding to host teacher workshops on materials science and technology on campus.

If grant funds are required to launch the program, how will the program be supported upon termination of the grant?

none required, though this program offers the possibility to make us much more competitive to received funding for technology workforce development, for example through the CHIPS and Science Act, and more that are likely in the near future.

Other Program Characteristics

Must courses be taken for a letter grade and/or passed with a minimum grade to count toward the proposed program? If so, please list the courses and the requirements of each. Note: Although there is variation in detail, UO undergraduate majors typically require that most of the courses be taken for a letter grade (not "pass/no pass") and that the grade be C- or better.

The physics, chemistry, math and core materials courses must be taken for a letter grade and passed with a C- or better.

Master's programs require at least 24 credits to be taken for a letter grade, but individual programs may require a higher number. There are no specific graded credit policies for doctoral and certificate programs; each program should determine what is appropriate within their discipline.

How much course overlap will be allowed to count toward both this programs and some other credential a student might be earning (a minor, certificate, or another program)? If there are specific credentials with overlap limits, please list those and the limits. For Accelerated Master's Program proposals, include in this section the proposed credit allocation structure for graduate credits taken as an undergraduate, i.e., how many graduate credits may count only toward the master's degree and how many may be used to clear requirements for both the bachelor's and the master's.

None anticipated currently. In future, we anticipate possible Accelerated Masters Program proposals that will build on the success of the undergraduate program, but course overlap decisions will be made if/when these future proposals are created.

Does your proposal call for new courses, or conversion of experimental courses into permanent courses? If so, please list courses in the text box below and indicate when they will be submitted to UOCC for approval:

All being entered in New Courses via Courseleaf in May 2023
MSTC 231 Fundamentals of Materials in Technology I
MSTC 232 Fundamentals of Materials in Technology 2
MSTC 431 Thermal Physics of Advanced Materials
MSTC 432 Kinetics and Transport in Advanced Materials II
MSTC 441 Quantum Mechanics and the Electronic, Optical and Magnetic Properties of Materials I
MSTC 442 Quantum Mechanics and the Electronic, Optical and Magnetic Properties of Materials I

Will admission to the program be limited?

No

Will students be required to apply for entry to this program?

Yes

What are the conditions for admission?

We propose that the MSTC major is applied to after the foundational courses have been completed (at the end of a student's first or second year), when they choose a chemistry or physics of materials emphasis as well as a research advisor/mentor.

This allows students to experience both basic-science courses in chemistry/physics and materials courses and MSTC 231-232, then make an informed choice based on interests to continue in MSTC, PHYS, or CHEM. We predict the new MSTC major to be a draw for new students that otherwise wouldn't come to UO. By bringing these new students to UO, MSTC is likely to increase numbers of Chemistry or Physics majors as happens at other schools with engineering programs. Therefore, we expect the new programs to help grow the basic science major enrollment in physics and chemistry.

Interested students can apply to the MSTC major at the end of year 2 (or earlier for well-prepared students). For automatic admission, they need a GPA of 3.0 or better in the foundation courses in physics (PHYS 201/2/3 or 251/2/3 + lab), chemistry (CH 221/2/3 or 224/5/6H + lab), and materials science (MSTC 231/232) and to have demonstrated teamwork capability by taking CH 329. If the grade requirement is not met, students may petition for admission through additional review as described in 'admission procedures' below.

Please describe admission procedures (Will Appear in Catalog)

Students will be required to apply for admission into the MSTC major after completing the foundational course sequences in physics (PHYS 201/2/3 or 251/2/3 + lab), chemistry (CH 221/2/3 or 224/5/6H + lab), materials science (MSTC 231/232), and the CH329 Research Immersion course. Students will be asked to provide their academic transcript, their choice of physics or chemistry emphasis, and potential research/industry area of interest as part of the application.

The requirement for admission is achieving a GPA of 3.0 or better in the foundational courses. Students not meeting this requirement, but with a strong academic record that demonstrates steady progress towards acquiring the quantitative and critical thinking skills necessary for success in the program, can petition for admission to the program through additional review. In addition to application materials listed above, applicants will be asked to provide a CV; short essay responses to prompts that aim to evaluate their clarity of purpose and dedication with regard to academic/career goals, ability to overcome obstacles, and ability to tackle open-ended research questions; and references from 1-2 instructors in the foundational courses. Applications will be evaluated by a three-member committee with members drawn from chemistry and physics faculty.

Residency Requirements (Will Appear in Catalog)

None. Students are typically expected to take the core MSTC courses and the 4th year elective courses here at University of Oregon.

Attach Additional Files

Re_ Materials Science Undergraduate MajorApproval for Subject Code.pdf
revised MAT proposal and courses 12-24-22.pdf
CAS + chem + physics Materials program.pdf
MatSci Sample Academic Plans 20241112.pdf
MSTC Major Reqs and Checklist 20241202.pdf

Reviewer Comments

Satomi Ladd (sladd) (Thu, 04 May 2023 14:41:34 GMT): Rollback: Rollback request from Shannon.

Carolyn Vogt (carolynv) (Fri, 23 Jun 2023 18:08:13 GMT): Rollback: Per Hal S to edit

Satomi Ladd (sladd) (Mon, 03 Jul 2023 15:10:12 GMT): Rollback: Per request from Shannon

Carolyn Vogt (carolynv) (Wed, 30 Oct 2024 22:01:07 GMT): Rollback: Per UGC and Jayson Paulose to edit.

Carolyn Vogt (carolynv) (Wed, 13 Nov 2024 17:11:06 GMT): Rollback: per Jayson to edit

Carolyn Vogt (carolynv) (Mon, 02 Dec 2024 20:31:05 GMT): Rollback: per Jayson

Key: 602