Materials Science and Engineering
2020-2025 Strategic Plan

<u>Vision statement</u>

Innovate. Educate. Materials that Matter.

<u>Mission statement</u>

Develop leaders in materials science and engineering, generate scientific discoveries, and enable new technology opportunities that serve 21st century societal needs through educational innovations, ground-breaking research, entrepreneurial pursuits, and community outreach.

<u>Background</u>

Materials Science and Engineering at Penn State encompasses a diverse set of teaching, research, and service efforts aimed at creating world-class engineers and scientists with safety and community as top priorities. During Fall 2019, MatSE leadership (Kimel, Maria, Mauro, Robinson, Sinnott) convened to develop discussion topics as part of the 2020-2025 MatSE strategic plan. The outcome of this was eight themes to guide the department in the coming years: Research, Teaching, Service, People, Safety, MatSE Across Borders, Facilities, and Development. Subsequently, the faculty and staff came together on January 21, 2020 to build the roadmap for MatSE based on these themes. Over the course of the day, faculty and staff developed and voted on a series of goals, objectives, and tasks that best represented our values within the MatSE community. The process led to a broad range of input that was subsequently distilled into three over-arching goals:

Goal 1: Sustain and promote a world-class and innovative MatSE graduate and undergraduate educational experience.

> World-class education mandates excellence in teaching, research, service, people, and safety.

Goal 2: Champion high impact research that addresses society's current and future needs.

> Advance cutting-edge facilities, incorporate new ideas, and reinforce MatSE core competencies, embedded within a robust safety culture.

Goal 3: Foster and grow MatSE community and culture.

> A collective sentiment of well-being, inclusion and mutual support amongst the faculty, staff, students, and departmental stakeholders is tantamount to our success.

Goal 1 - Sustain and promote a world-class and innovative MatSE graduate and undergraduate educational experience.

A MatSE education at Penn State is marked by strong faculty/student interaction, hands-on experimentation, and cutting-edge technologies and pedagogies. Sustaining this excellence in an increasingly diverse, information-centric, and virtual world requires adaptation to these social and technological trends while sustaining a strong educational foundation.

- **Preserve and deepen the core MatSE competencies** highly valued in the department by annually evaluating the health and status of the core curriculum in thermodynamics, kinetics, and crystal chemistry. Annual evaluation of the core course status will be undertaken by the Curriculum and Assessment (C&A) Committee. Implementation: 2020, and onward.
- **Create unwavering support for underrepresented students** by establishing a new MatSE administrative position, such as Director or Associate Head for Diversity and Inclusion; formalize a "MatSE Student Council" to ensure transparency and provide input to department decisions that impact students; valorize inclusion efforts (e.g., Women in the Sciences and Engineering, EnvironMentors, Millennium Scholars) in annual faculty evaluations; incorporate diversity and inclusion teaching modules into graduate (Professional Development) and undergraduate (Freshman Seminar) courses to develop students' cultural awareness and competence; dedicate a fall seminar to cultural awareness and invite MatSE 590 seminar speakers from diverse backgrounds that serve as active role models for the MatSE community; and finally, create a task force to identify and recruit talented underrepresented students. Implementation: 2020-2025.
- **Establish a new laboratory education paradigm** in the core undergraduate curriculum by creating hands-on, team-based experimental learning modules integrated into class lectures. The C&A Committee will draft a procedure that supplements lecture material, reinforces learning outside the classroom, and brings the abstract to the concrete. Implementation will be overseen by the Head and Associate Head for Undergraduate Education. Implementation: 2020-2022.
- **Make data science and computational materials science a key outcome of the core undergraduate education** by implementing theory and computation into each MatSE course, as guided by C&A committee recommendations. It will be integrated early in the curriculum, with increasing application complexity as students matriculate, culminating in capstone and senior thesis experiences that include both theory and experiment. Implementation: 2021-2024.
- **Make safety part of the undergraduate and graduate education** by expanding the successful "MatSE Safety Minute" across the curriculum; organizing safety-focused outreach events at Penn State (e.g. The Materials Safety Olympics); and creating a course on personal and occupational safety. Implementation: 2020-2021
- **Develop undergraduate professional skills** through a suite of undergraduate courses and internship opportunities aimed to enhance communication skills, ethics and engaged scholarship. Undergraduate students will be trained to communicate as a professional engineer, in an ethical manner, while building a foundation for seeking out and participating in educational opportunities. The department will establish and expand connections with academic, industry and national lab partners for improved student internship placement that provides opportunities for students to actively practice skills learned in the classroom. Implementation: 2021-2022.
- **Develop comprehensive graduate and undergraduate online learning resources** to ensure instructional resilience, educational continuity, and accessibility across all programs for students and faculty. The Head will work with faculty and the Dutton Institute to create a course-specific online information repository that enables students to explore interests, address weaknesses, and ensure MatSE educational consistency across Penn State. Implementation: 2020-2024.

- **Establish transparency in graduate student departmental exams** by clarifying guidelines and expectations and decision-making processes that apply to students and faculty for the qualifying and comprehensive exam. Ensuring that all parties feel properly served during these important (and often stressful) decision points in graduate education is our desired outcome. Implementation: 2021.

Goal 2: Champion high impact research that addresses society's current and future needs.

Materials research is a broad, interdisciplinary enterprise with robust participation from numerous STEM disciplines. Retaining MatSE ownership of materials research (internally and externally) in this competitive climate requires a proactive plan that combines the roles of leadership and support. We (1) Identify and pursue sustainable and translational research areas representing 21st century societal needs; (2) create partnerships that coalesce the needed expertise to lead them; and (3) commit resources to advance infrastructure and recruit essential talent. While this goal necessitates an expansion into new research areas, we will simultaneously retain our academic identity through balanced investments in the core competencies that define MatSE as identified by the Faculty, on a rolling basis.

- **Develop materials-centric data science infrastructure** that enables materials discovery, informs formulation design, and expedites materials synthesis and formation (e.g., 2D growth, 3D printing) using real-time data analytics on evolving data sets and high-throughput experiments. The Department Head will work with ICDS, relevant Centers, and faculty to implement. Implementation: 2021-2025.
- **Establish MatSE as a key enabler in next generation quantum materials at Penn State** by relentless innovation in correlated electron materials, 2-dimensional materials, superconductors, plasmonic materials, high-entropy crystals, and heterogeneous integration. The Department Head will actively engage with university initiatives, such as the "Quantum @ Penn State", to capture two or more hires in quantum materials and devices. Implementation: 2021-2023.
- **Advance next generation nanoelectronics** by hiring one faculty member and promoting research focused on next generation functional electronic materials and novel integration geometries such as transparent electronics, flexible electronics, and energy harvesting and storage devices. Implementation: 2021-2025.
- **Develop a sustainable materials research portfolio** featuring responsible sourcing and life-cycle engineering informed by the challenges of scaled manufacturing, all while leverage new capabilities in machine-learning-informed processing. Engagement with the MRI and Sustainability Institute will enable implementation. Implementation: 2021-2025.
- **Advance soft materials research** by emphasizing research focused on materials exhibiting dynamic, responsive, and reversible structural changes; polymers with advanced properties and functions; and multifunctional polymer nanocomposites. Emphasis will be on hiring a polymer simulation and theory faculty and establishing a MatSE-lead center that solidifies the soft-matter community across the university. The department head will work with the MRI, IEE, and faculty to implement. Implementation: 2021-2025.
- **Elevate safety in research** by improving communication, increasing safety-centric interactions, encouraging safety discussions at faculty meetings, and spearheading a digital initiative to create searchable standard operating procedures for effective sharing of safety protocols. Implementation: 2021-2025.
- **Create and lead strong campus-wide partnerships essential to MatSE's targeted research goals.** MatSE leadership and faculty will partner with natural partners such as Huck, MRI, AREC, IEE, ICDS, CDP, PSIEE, the Sustainability Institute, and PSIEE to make and support infrastructural investments, co-hires, and seed-funding that is responsive to emerging research priorities across the institutes and shared facilities. Implementation: 2021-2025.

Goal 3: Foster and Grow the MatSE Community and Culture

The prosperity of MatSE at Penn State is founded in maintaining and expanding a strong synergistic network within and across traditional organizational boundaries. The way we conduct education and research, administer the department, and function as a unit depends on the well-being our people. We therefore have an obligation to implement strategies to ensure all members of our community are valued contributors to our collective success. We must strive to recruit the best, most diverse set of broad-thinking students, staff, and faculty from across the globe to join our community. These objectives aim to build a united materials research and education community with contributors across traditional borders of departments, colleges, and institutions.

- **Promote Cultural Diversity** by actively recruiting underrepresented groups at all levels of the department (student, staff, faculty) representative of national demographics, sponsoring department activities and group events that celebrate diversity and inclusion, and connecting our diverse groups with resources to promote wellbeing. Implementation: 2020-2025.
- **Implement a structured mentoring plan** for tenure-track and fixed-term faculty and staff. The convergence committee shall establish a document of best practices for professional development, voted on by the faculty and implemented by the Department Head, with emphasis on guiding tenure-track faculty from Associate to Full Professor, promoting fixed-term faculty, and staff retention. Under their guidance, and taking into account career stage, technical overlap, and personality, tenured and senior fixed-term faculty and senior staff will form mentoring teams that are available to advise at all levels for all community members. Implementation: 2021.
- **Make STEAM part of the MatSE culture** by developing stronger research connections across the University to promote the arts and a strong MatSE presence in the EMS Museum. We will also grow data visualization efforts and dedicate resources towards connecting the arts and sciences by virtue of glass blowing, ceramic arts and metal working. Development efforts should evolve around these three themes. We facilitate students to pursue double degrees with MatSE and STEAM fields across the University. Implementation: 2021-2025.
- **Build strong coalition with key alumni and industry** through a substantial boost in development activities to be competitive with our peer institutions. The aim is to double the number of named professorships, fellowships, and laboratory and study rooms over the next five years. Implementation: 2021-2025.
- **Recognize and promote faculty, staff, and student achievements** via award nominations and press releases to broadcast excellence of our MatSE community members nationally and internationally. Expand the MatSE recognition committee to include students and staff and create an awards list to pursue by faculty, staff, and students. Implementation: 2021-2023.
- **Celebrate departmental community** through a set of activities that strengthens our togetherness and camaraderie. During "normal times," this will include small faculty and staff gatherings throughout the semesters, i.e., a departmental potluck; MatSE 'merchandise' design contests; a summer picnic; and an annual family oriented MatSE tailgate. During times of social distancing, this will be accomplished through gatherings such as virtual monthly town halls to inform students of current events, virtual faculty and staff happy hours, and virtual MatSE game nights. Implementation: 2021-2025.
- **Promote basic humanity 101 across the materials community** to address issues with disadvantaged students and staff, and institute means to remedy them. This includes connecting them with resources to assist with their emotional well-being, providing help in cases of financial distress when possible, and ensuring that adequate distant learning tools are available in situations where internet connectivity and computer tools become essential to conduct learning and perform their functions. Implementation: 2021-2025.