Course Description: Advanced materials are critical to improve performance, safety, and sustainability of air flight and space exploration in extreme environment. This course will provide the survey of engineering knowledge on existing and future advanced materials for aerospace applications. Class participants will first learn about common aerospace materials (metal alloys, ceramics, and polymer composites); how these materials satisfy the tight performance requirements and withstand extreme environment. Second, the participants will study the origins of their unique properties: atomic bonding and packing, grains and boundaries, interfaces/interphases, and micro-structuring. Third, novel material design (nanocomposites and metamaterials), mostly in the nano and micro scales, and how their micro-structures drive their advanced properties will be discussed, together with their current challenges in applications (scalable fabrication and certification).

Goals: This class will prepare students to evaluate and characterize novel aerospace materials in relation to realistic applications.

Objectives: After taking this class, students will be able to
- Understand and use the material selection criteria for different aerospace applications
- Characterize material properties and behaviors
- Correlate material properties in the macro scale and structures in the nano/micro scales and their scaling effects
- Evaluate the potentials and limitations of advanced materials in terms of performance, fabrication, and certification

Times and Location: Tuesdays and Thursdays 10:35-11:50am, 308 Boucke

Instructor: Dr. Namiko Yamamoto, nuy12@psu.edu, x7-5775, 232A Hammond

Office Hours: TBD in the first day of class. Outside class and office hours, the students are encouraged to communicate with the instructor through emails; I plan to reply within 48 hours.

Prerequisites or Concurrent: EMCH315 or equivalent. Engineering undergraduate-level knowledge of materials science and solid mechanics are expected. Please discuss with the instructor if unsure.

References: No textbook is assigned for this class, but relevant references are listed below. The book titles with underlines will be on reserve at Engineering Library (325 Hammond), and the book titles with * mark is available online through the library website.
- Ashby and Jones. *Engineering Materials 1, An Introduction to their Properties and Applications.* Butterworth Heinemann

Other References
- Plasticity: *Bacon and Hull. Introduction to Dislocations.* Pergamon Press, 1984
- Fatigue and Creep
- Polymer Sciences
- Ceramics
- Metals

**Course Web Page:** PSU Learning Management System CANVAS

**Grading:**

<table>
<thead>
<tr>
<th>Component</th>
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<tr>
<td>Homework Assignments (4 assignments)</td>
<td>25%</td>
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<tr>
<td>Midterm</td>
<td>25%</td>
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<tr>
<td>Topical paper</td>
<td>20%</td>
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<tr>
<td>Final Exam (take-home)</td>
<td>30%</td>
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<td>Class participation</td>
<td>+ 3%</td>
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Homework is due in the beginning of the class, and late submission will not be accepted. The topical paper is a report on a selected topic of advanced materials; the students will collect relevant references, critically review them, and summarize state-of-the-art understanding and future prospective of the topic. The grading scale is given below; this is subject to change.

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**Course Topical Outline (16 weeks):**

**Review of Aerospace Engineering Design**
- Material selection
- Ethics

**Mechanical Behaviors and their Origins**
- Atomic packing and bonding of condensed matters
- Elasticity
- Anelasticity
- Plasticity and Creep

**Aerospace Materials: Design, Fabrication, and Characterization**
- Grains and interfaces/interphases
- Metal alloys
- Polymers and composites
- Ceramics

**Advanced Materials: Engineering in Multiple Scales**
- Case studies: nano-engineered materials, bio-inspired materials, metamaterials
- Existing challenges: scalable manufacturing, certification, unknowns
Academic Integrity
The University defines academic integrity as the pursuit of scholarly activity in an open, honest and responsible manner. All students should act with personal integrity, respect other students’ dignity, rights and property, and help create and maintain an environment in which all can succeed through the fruits of their efforts (refer to Senate Policy 49-20). Dishonesty of any kind will not be tolerated in this course. Dishonesty includes, but is not limited to, cheating, plagiarizing, fabricating information or citations, facilitating acts of academic dishonesty by others, having unauthorized possession of examinations, submitting work of another person or work previously used without informing the instructor, or tampering with the academic work of other students. Students who are found to be dishonest will receive academic sanctions and will be reported to the University’s Office of Student Conduct for possible further disciplinary sanctions (refer to Senate Policy G-9).

Accessibility
Penn State welcomes students with disabilities into the University's educational programs. If you have a disability-related need for reasonable academic adjustments in this course, contact the Office for Disability Services (ODS) at 814-863-1807 (V/TTY). For further information regarding ODS, please visit the Office for Disability Services Web site at http://equity.psu.edu/ods/. In order to receive consideration for course accommodations, you must contact ODS and provide documentation (see the documentation guidelines at http://equity.psu.edu/ods/guidelines/documentation-guidelines). If the documentation supports the need for academic adjustments, ODS will provide a letter identifying appropriate academic adjustments. Please share this letter and discuss the adjustments with your instructor as early in the course as possible. You must contact ODS and request academic adjustment letters at the beginning of each semester.

Non-discrimination Policy
The University is committed to equal access to programs, facilities, admission and employment for all persons. It is the policy of the University to maintain an environment free of harassment and free of discrimination against any person because of age, race, color, ancestry, national origin, religion, creed, service in the uniformed services (as defined in state and federal law), veteran status, sex, sexual orientation, marital or family status, pregnancy, pregnancy-related conditions, physical or mental disability, gender, perceived gender, gender identity, genetic information or political ideas. Discriminatory conduct and harassment, as well as sexual misconduct and relationship violence, violates the dignity of individuals, impedes the realization of the University’s educational mission, and will not be tolerated. Direct all inquiries regarding the nondiscrimination policy to Dr. Kenneth Lehrman III, Vice Provost for Affirmative Action, Affirmative Action Office, The Pennsylvania State University, 328 Boucke Building, University Park, PA 16802-5901, Email: kfl2@psu.edu, Tel (814) 863-0471.

Syllabus Statement
This syllabus is subject to change based on the needs of the class. Changes, if any, will be announced in class. Students will be held responsible for all changes.