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# Mechanical Characterization Instrumentation for Multi-Material Systems

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# RCEU 2022 Project Proposal

## Project Title

Mechanical characterization instrumentation for multi-material systems

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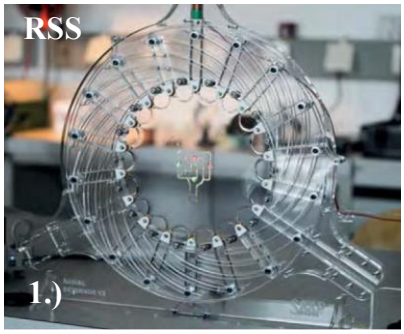
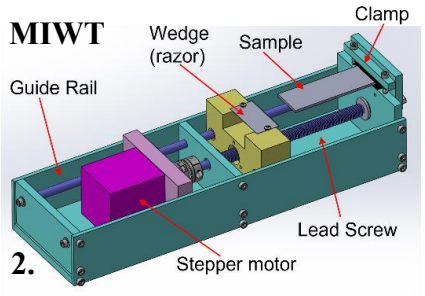
## I. Project Description




There exists a need for different devices to perform mechanical characterization measurements of next generation material systems. These characterization needs are found in the growing fields of flexible electronics, electronic packaging, and composites. The goal of this project is to model, fabricate, and demonstrate the use of a mechanical characterization system such as those described subsequently.




Flexible electronics have different testing requirements compared to traditional materials and call for mechanical characterization systems capable of large strains, multi-directional stretching, and monotonic/cyclic testing to mimic real-use conditions. A system with these capabilities is the **Radial Stretch System (RSS)**. This characterization system is new, open-source, cost-efficient, table-top sized, and radially stretches material to create equibiaxial deformation. Strain sensors in flexible electronics behave differently when subjected to uniaxial vs biaxial strain states, therefore it is crucial to characterize these electrical devices using testing methods that mimic real-world use conditions.

Fracture that occurs between dissimilar materials such as those found in microelectronics, composites, and flexible electronics is also extremely important. This measurement can be conducted with a **Motorized Interfacial Wedge Tester (MIWT)**. The MIWT is a system that measures interfacial fracture toughness based on the crack length that results from pushing a wedge of constant thickness between two bonded materials. This system is simple, cost-efficient, table-top sized, and the advisor has experience with the design. Examples of the system's applications include characterizing various adhesives and adhesion promoting layers (e.g., ALD and conventional thin films) used in aerospace/automotive composites and flexible electronics.

## II. Student Duties, Contributions, and Outcomes

*a. Specific Student Duties* - The student will create a CAD model of the selected characterization device (ex. RSS, MIWT, or similar device). The device designs that are to be considered are based on existing/opensource systems and will be modified for the specific use of the device, materials available, and off-the-shelf components commercially available. The student will select raw materials and off-the-shelf components such as fastners, bearings, gears, and incorporate them in a CAD model. The device will be fabricated using processes such a 3D printing, laser cutting, and machining. The project will conclude with the assembly of the device and demonstration of its operation.

*b. Tangible Contributions by the Student to the Project* - The student participating in this research project will be creating a measurement device that can be used by other students and research



1.) Schausberger et al., "Cost-Efficient Open Source Desktop Size Radial Stretching System With Force Sensor," *IEEE Access*, 2015, doi: 10.1109/ACCESS.2015.2433398.
2.) Yuxin Chen, Nicholas J. Ginga, William S. LePage, Eric Kazyak, Andrew J. Gayle, Jing Wang, Robin E. Rodríguez, M. D. Thouless, and Neil P. Dasgupta. *ACS Applied Materials & Interfaces* **2019** *11* (46), 43573-43580. DOI: 10.1021/acsami.9b15193

groups to obtain valuable data on the mechanical behavior of materials. The measurement device will generate data that can be used in research proposals, research articles, and referenced by others. This data can aide in decisions regarding material selection and geometry of devices to improve their performance and can also be incorporated into computer models to improve accuracy. The measurement instruments proposed are directly applicable to a wide range of engineering fields with growing interest including flexible electronics, electronic packaging, composites, and bonding of dissimilar materials.

c. *Specific Outcomes Provided by the Project to the Student* - The creation of the types of mechanical characterization systems presented in this proposal (i.e., RSS and MIWT) offer a great opportunity for students to experience the main components of the design engineering process while addressing a need in the field of mechanics of next generation materials. In the classroom, students typically conceive and implement their designs on paper or by modeling on computer, but in this project, the engineering process will be taken further to fabrication and demonstration of final system's operation. Experiencing these last steps of the engineering design process aide in giving students the full set of skills and knowledge to tackle future open-ended desgin problems where they start with a set of system requirements and end with a working device. The experience of connecting the design with manufacturing is extremely valuable to undergraduates. While experiencing these knowledge-based outcomes, students will also obtain skills-based outcomes such as CAD modeling of individual parts and assemblies, creating mechanisms, general fabrication (i.e., 3D printing and machining), and conducting measurements to characterize material behavior.

## III. Student Selection Criteria

Students should be enrolled in the MAE department, have taken MAE370 and MAE211 with a successful modeling project and experience with the creation of several different unique Solid Edge assemblies, have an interest and aptitude with fabrication, 3D printing/making things, and demonstrate good communication skills. Beneficial to have access to the UAH machine shop.

## IV. Project Mentorship

During this project the student will be mentored on the topics and skills needed to complete the project as well as topics needed in general to conduct research. The project will begin with a timeline of major project milestones. The student will meet with the advisor regularly throughout each week for guidance, topic lessons, and updates. Project related lessons can include machine design, existing component integration, material selection, effect of manufacturing on design, necessary training of tools, and experimental data analysis. Topics and skills related to successfully conducting research in general will also be covered, including literature searches, literature reviews, and presenting technical information. The student will also be included in regular meetings with engineers at other institutions conducting research on similar topics of material. This will increase the student's exposure and professional network for future opportunities.