INDUSTRIAL SOLUTIONS LABORATORY

Company Information

Company Name	*ASML*	**Date Submitted**	*04/17/2023*
Project Title	*Precision Mechanics – High load capability, fully adjustable, high precision, General Use Case bolted interface* ***(ASML_FUSION5)***	**Planned Starting Semester**	*Fall 2023*

Senior Design Project Description

Personnel

Typical teams will have 4-6 students, with engineering disciplines assigned based on the anticipated Scope of the Project.
Please provide your estimate of staffing in the below table. The Senior Design Committee will adjust as appropriate based on scope and discipline skills.

Discipline	Number	Discipline	Number
Mechanical	3-4	Electrical	1
Computer		Systems	

Company and Project Overview:

ASML is the leading photolithography tool supplier to the semiconductor industry. We engineer, design, build, market, install and maintain the machines that print the majority of the semiconductor chips used in computers, cellphones and elsewhere.

ASML's headquarters are in The Netherlands, where the main engineering and integration site is located. The company also has two large hardware engineering and production sites in the US: Wilton CT (ASML US), and CA (Cymer). Cymer produces the light sources that enable the lithography process. This includes Deep Ultraviolet Lasers (193nm wavelength - light path in air and water) and the Extreme Ultraviolet Light Source (13nm wavelength – light path in very low pressure hydrogen). ASML US in Wilton produces all variants (including DUV and EUV versions) of several major modules of the TWINSCAN® Lithography machine: The Reticle Stage, the Reticle Handler, and several optical modules, including Wafer Alignment, Wafer Level Sensing (topology mapping), and Actinic Light Uniformity Compensation. All EUV modules are designed to operate in ultra-clean vacuum environment. In addition, Wilton also produces the optical module of the YIELDSTAR® in-line wafer inspection tool.

This Student Project will be sponsored by the Mechanical Development Group of ASML US Wilton CT, and will target one of the mechanical issues that are intrinsic to our capability to keep up with an aggressive roadmap, where our machines have to perform at ever decreasing error levels to enable printing ever smaller features on chips. The issue is the precise and stable positioning of critical elements of our machines.

Fall 2023: This is planned to be the fifth and final phase of the series of studies on high load capability precision mechanical mounts. The students will learn from the achievements of the previous four teams and inherit the hardware the teams have created. They will also benefit by interacting with the FUSION 4-Spring 2023 team and take advantage of the one-semester overlap for knowledge transfer purposes.

Project Requirements:

The students, in consultation with advisors at UNCC and ASML, shall:

Acquire a basic understanding of typical precision mechanics positioning devices, such as kinematic mounts and of precise adjustment/stable locking devices, such as micrometer screw driven stages and bearing slippers. Also study any other precision mechanics devices of possible interest for this project. The students will also learn how to implement and use position sensors to accurately measure relative displacements in test samples.

The main goal will be to capitalize on the designs created by the previous teams. Consider how well previous designs have met each specific requirement, select the best features of prior designs, plus new features to address any shortcomings, and combine them into a new design that is practical to implement and service in ASML machines, easy to manufacture at reasonable cost and meets most other criteria that apply to a "fully industrialized" design.

Spring 2023 – Specific Requirements:

In general, the previous teams (Fusion 1 through 4 teams) have made very good progress towards an industrialized and practical design, incorporating the learning from previous projects into their design. We fully expect that by the end of the Spring 2023 semester the present team, Fusion 4 we will have created, built and tested a prototype that ASML can use in our machines with very little adaptation.

However, there are some use cases where the Fusion 4 design would not be very effective. For example:

- Vertical interfaces.
    - The design relies on pouring epoxy in situ to create liquid →solid bushings that lock in the X-Y-RZ adjustments.
    - This will work best and be cost effective when the interface and plates are horizontal, but would be ineffective when the interface is vertical or at a large angle relative to gravity.

- About 75% - 90% of the interfaces in our machines are or can be treated as horizontal (rough estimate)

- Use of shims for out of plane (Z, RX and RY degrees of freedom) adjustments.
    - The design will provide smooth continuous and stable adjustment for in-plane adjustment (X, Y and RZ degrees of freedom),
    - However for Z, RX and RY adjustments it would require iterative use of shims, which is more expensive, time consuming, requires high skill, and only provides discrete adjustment (not continuous).
    - About 50% - 75% of the adjustable interfaces in our machines require only in plane (X, Y, and RZ) adjustment (rough estimate)

Therefore, we propose that the next group of students improve or alter the Fusion 4 design to be suitable for non-nearly-horizontal interfaces and more enabling of out of plane adjustments (without shims). The design would likely to be more expensive than the Fusion 4 design, and that would be acceptable. Therefore, in practice, it seems likely that ASML would use the "Special Use Case" Fusion 4 design for the majority of our "standard" applications (horizontal interfaces, in-plane adjustment only), and the "General Use Case" design to be developed by the new student team for the remaining or "exceptional" applications.

It is envisioned that by the end of this new project phase (that is at the end of spring 2024), a design that fundamentally and practically solves the cited shortcomings of the Special Use Case design will have been developed, and that a proof of concept/prototype will have been built and tested by the new student team.

Engineer prototypes of the General Use Case industrialized design

Down-select to best design

Design the prototype

Order all purchased components.

Build the prototype.

Demonstrate and test the prototype.

Write a report, including test results, lessons learned, recommended improvements, and conclusions.

Expected Deliverables/Results:

- Conceptual design(s) according to the above.

- Concept Design Review (CDR) of the above to be attended/approved by the sponsor.
- Final proof of concept design(s), including specifications, calculations, models, BoM, etc.
- Prototype Design Review (PDR) of the proof(s) of concept to be attended/approved by the sponsor.
- Working prototype of the industrialized design
- Final report including test results and outline of way forward.
- Periodic progress reviews with the sponsor (suggested weekly ~ 1 hour),
- PDR and CDR meetings
- All sponsor meetings virtually on Zoom, or equivalent platform.

Disposition of Deliverables at the End of the Project:

Prototype hardware, software, results, etc. shall be presented to the public in full detail at the EXPO.
Prototype may remain at UNCC after completion of the project, for re-use in follow-on ASML-sponsored projects.

List here any specific skills, requirements, specific courses, knowledge needed or suggested:
Skill/knowledge/interest:

- Mechanical Engineering with a strong interest in precision mechanics.
- *Mechanical Engineering with Finite Element Analysis skills (structural, thermal).**
- *Mechanical Engineering with manufacturing (machining) skills.**
- *Mechanical Engineering with test set-up and general lab skills.**
- *Electrical Engineering with electronics circuits skills**

A the outset of the project, ASML requires no specific knowledge beyond acceptable academics in Engineering. However, the individual(s) must be willing to dedicate substantial effort towards "on the job" learning in the areas outlined above.

Each student will be required to sign an ASML Non-Disclosure Agreement.