Professional Leave Report Cover Sheet

Name: Zoulikha Mouffak

Department: Electrical & Computer Engineering

College: Lyles College of Engineering

Leave taken: X Sabbatical Difference in Pay Professional Leave without Pay

Time Period: X Fall

Spring

Academic Year

Other

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Sabbatical Report

I was granted a sabbatical leave during the fall of 2020 to dedicate all my time to the device engineering lab that we recently furnished with multiple high tech equipment purchased with a DOD grant. My goal was to focus on the advancement of research and hands on senior- and graduate-level projects, and develop the new lab, master the operation of all equipment, and ultimately provide a rich experimental research platform for our students. I also planned to develop a new course; "Semiconductor Process Technology", and the related lab experiments that use the same equipment. While the pandemic situation made it difficult to fulfill all objectives, I still managed to complete the majority of goals.

The following are the objectives set initially in my proposal and highlighted accomplishments.

a. **LAB DEVELOPMENT:** This part included: equipment setup, manual writing, and testing and gaining expertise in using all lab equipment, but most importantly these 4 tools (where attention is needed):
    i. Suss Microtec mask aligner system and spin coater. **(50% completed)**
    ii. MTI Furnace System **(80% completed)**
    iii. Reactive Ion Etching SAMCO tool **(100% completed)**
    iv. COSMO thermal evaporation system **(100% completed)**

b. EXPERIMENTS:

- Mask Aligner: Using different photoresists, a large number of photolithography experiments will be run to determine the best exposure time/energy and the appropriate resist deposition recipes including spin time and speed, soft and hard bake times and temperatures (I could not run all experiments planned because I had no students. Not only very few students were willing to work in the lab, but also the administrative procedure to let them have access to the building and use the lab was extremely complicated. I ended up having one student approved only and the three remaining students could never get full clearance). So only 50% of the work was done on the mask aligner.
- Furnace: The furnace is supposed to work both as an annealing tool and as a chemical vapor deposition (CVD) deposition tool (using vacuum and introducing gasses such as Oxygen for SiO2 formation on Si samples). We brought this tool to full operation for annealing, but not for CVD. The CVD function of the furnace was harder to accomplish. I trained my student on using the computer interface to write annealing recipes, and monitor the process. We have used this tool extensively to anneal samples for a research project.
- Reactive Ion Etch system: I trained my student on the etch process, and we set up Silicon and SiO2 etch recipes to achieve clean etch profiles.
- Thermal evaporation: We discovered that this tool had several unsolved issues when used for Aluminum deposition. I had about 12 virtual meetings with the tool manufacturer experts to control the evaporation process and master the Aluminum deposition process. I trained my student on using it and we tested both baskets and boats for crucibles. The Aluminum deposition is now mastered but with a short crucible lifetime, which we are working on improving in a research project.

c) **RESEARCH WORK**: The plan was to fabricate and test semiconductor structures, however due to the situation that had to change. My only student who was approved to start using the lab in the middle of the semester has been working on a research project that he hopefully will present at the Fresno State Annual Symposium.
   - Issue addressed in the project: crucibles in the Kurt Lesker Thermal evaporation tool break soon after the evaporation starts due to aluminum diffusing to the electrodes at high temperature and reacting with tungsten.
   - Research idea: strengthen the crucible by coating it with a layer of graphene, which will also remove the Al diffusion/wetting issue as well as prevent it from reacting with tungsten.
   - Results: This project is still ongoing. From the results so far, there is improvement in the performance of graphene-coated crucibles compared to the regular ones.

d) **NEW COURSE DEVELOPMENT:** I developed a new course entitled: "Integrated Circuits Fabrication", 3 units including an experimental lab part. The course will introduce students to the Integrated Circuits fabrication, covering the theoretical background and application of major process fabrication operations, such as doping, oxidation, etching, photolithography, metal deposition, and electrical characterization. The course will have a lab part that will include an experiment for each major operation. There are five lab experiments incorporated in this course, where processes such as oxidation, wet etch, doping as well as measurements such as sheet resistance, and I-V and C-V analysis will be introduced. Many of the processes can only be done thru demonstration. This course will be an elective and can serve as a graduate course as well, with extra work for graduate students. I sent the syllabus of the new course to the ECE faculty for review last at the end of fall 2020. It was recently included in the weekly department meeting agenda, and I discussed the content with my colleagues. I was asked to connect the course outcomes to the ABET outcomes, among other minor changes in the syllabus. **(Course development completed 100%)**

e) **SAFETY:** I started my sabbatical by taking care of the lab safety. I worked with the facilities safety team (EHS&RM) to assess the potential dangers of using chemicals in the lab including the use of Hydrofluoric acid (HF). They provided links to safety training related to handling of waste, UV light, and injury and illness prevention. The training modules were required for students to come use the lab, but they couldn't access the training provided for unknown reasons at the time, which delayed their lab access to be issued. Besides providing the safety training students need to go through to be allowed to use the lab. I have also created warning safety signs that I posted at the doors, and acquired a hazardous spill kit **(this part was 100% completed, however we need to improve it)**

CONCLUSION

Overall, I developed most of the parts I needed to develop in the lab, but there is still many items unaccomplished because I was on my own most of the time due to the pandemic restrictions. The only student working with me in the lab now was only allowed to start in the middle of the fall semester.

Zoulikha Mouffak 4/3/2021