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BOARD # 406: NSF INCLUDES Research Experience and Mentoring (REM) Program for FuSe Interconnects: Enabling Transitions into the Microelectronic Ecosystem (WIP)

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NSF INCLUDES Research Experience and Mentoring (REM) Program for FuSe Interconnects: Enabling Transitions into the Microelectronic Ecosystem

Abstract

The NSF INCLUDES Future Semiconductors (FuSe) Interconnects: Enabling Transitions into the Microelectronic Ecosystem REM Program supported a collaborative ideation workshop with research PIs, industry members, and Inclusive Engineering Consortium faculty. The workshop was focused on increasing the microelectronic talent pool. The research plan intentionally positions engaging experiences at essential transition points throughout the microelectronic curriculum by embedding microelectronic-centered design opportunities in a collaborative cohort of students, academic mentors, industry mentors, and faculty at different locations. The experiences are co-designed, co-delivered educational modules from all stakeholders aimed at increasing the interconnection of personal interest, creativity, fundamental knowledge, and skills through the inspiration of design-based pedagogy. This effort will answer questions that affect the wide distribution of knowledge in the microelectronic field including: What is the minimum microelectronic and semiconductor practical skillset for undergraduate students to feel competent and confident before entering research or industrial experiences in the microelectronic area? How does this confidence in practical skills motivate deeper theoretical understanding? How do open-source (free or reduced price) design tools compare to proprietary software for creativity, system-level understanding, fundamental understanding, and industry readiness? What are the tradeoffs? How can co-curricular activities fulfill the above needs in a cheaper and more flexible way to widen participation at schools without resources to fabricate devices?

Introduction

The FuSe: Interconnects with Co-Designed Materials, Topology, and Wire Architecture, a collaborative research program (Rensselaer, Notre Dame and Cornell), was established to co-design materials solutions and wire architecture to overcome the interconnect resistivity bottleneck in future computer chips. At the heart of the research approach is collaborative design by researchers with synergistic expertise in different locations supported by industrial stakeholders (Intel, IBM, Ericsson, and Samsung). Collaborative design continued with a workforce development ideation workshop. On March 15th, 2024, the ***FuSe Workshop – Interconnecting the Next Generation Semiconductor Workforce from Thinkers to Doers to Innovators*** was held in Tucson, Arizona at the Electrical and Computer Engineering Department Head Association (ECEDHA) conference. Technical Research PIs and associated industry members worked together with the 25 representatives from the IEC and IEF to ideate opportunities to engage students in the microelectronic ecosystem. The IEC is a well-established network of core members from 21 Historically Black Colleges and Universities (HBCUs) and other Minority Serving Institutions (MSIs) and 15 affiliate members from Predominantly White Institutions (PWIs). The IEF is the student-facing arm of the IEC with a Pathways to Success program that combines internship experiences with holistic, structured mentorship. The resulting research plan embeds microelectronic-centered design opportunities in a collaborative cohort of students and faculty at different locations. The mentorship structure keeps students and faculty engaged across schools in a cohort. The cohort then becomes the mentors for the

next in a sustainable cycle. The goal is to reduce barriers to semiconductor careers and research by 1) intentionally demystifying the microelectronic ecosystem with system-level design opportunities to deepen fundamental engineering knowledge [1-5] empowering excellence with skill development in between learning experiences (courses, internships) that align practical knowledge with fundamental knowledge, 3) encouraging focus by eliminating financial need with scheduled paid opportunities throughout the experience, 4) embedding multi-level mentorship with engaged faculty, graduate students, and peers in a defined cohort.

Background on Workshop with Equitable Ideation Tools

The ***FuSe Workshop – Interconnecting the Next Generation Semiconductor Workforce from Thinkers to Doers to Innovators*** invited MSI, PWI, and industry perspectives to create new experiences that help students gain skills, knowledge, and confidence to pursue microelectronics as their focus. The theme of the workshop was centered on important transition points in their matriculation. Faculty pre-selected their top two transition options based on interest or experience: 1) High school to first-year student at a 4-year college 2) 2-year college to 4-year college 3) Core engineering courses to specific sub-area within major and 4) Undergraduate to graduate. The one-day, 6-hour workshop began with a technical panel conducted by industry members in the microelectronic ecosystem along with FuSe Interconnects research PIs to introduce core technical concepts and challenges. The following question and answer session set the context and scope for the ideation working groups based on the four transition options. Invited panelists joined groups of MSI and PWI faculty during the GAPA (Goals, Activities, Products, and Assessment) ideation process in which prompts are given within short/dedicated times (i.e. 5 to 10 minutes each). To facilitate an efficient, equitable, and effective working group ideation session, this GAPA process, created by Olin College, was modified to co-create ideas for workforce development proposals [2]. The workshop concluded with a "Hot Idea" wall to determine which ideas were ready to pilot in the short term and which could be written in a proposal. The results of this work became the NSF INCLUDES supplemental proposal within a few weeks of completing the workshop. Thus, the program is a pilot of ideas to implement, review, ideate, and iterate to improve the experiences in future years.

NSF INCLUDES FuSe Interconnects Transitions REM Program Participants

The NSF INCLUDES Future Semiconductors (FuSe) Interconnects: Enabling Transitions into the Microelectronic Ecosystem REM Program emphasizes, co-delivered, co-created design experiences to gain interest, basic skills, and concept connections in the 2nd or 3rd year of matriculation. A cohort of mentors that include faculty and graduate students, is aligned with a cohort of students from both HBCUs and PWIs.

Participant Mentorship Structure

Co-delivery of Design Ideation and Skills Development modules are embedded within existing 2nd year courses (Basic Analog Electric Circuits, Basic Digital Circuits, and Introduction to Electronics) in hybrid/remote modality for all students to experience. A select group of students (6 in total- 3 from HBCUs/MSIs and 3 from PWI(s)) are chosen for the continuation to a summer internship with pre- and post- internship mentorship and training. Collaborators RPI and Notre Dame have the same structure of participants. Thus, the total numbers are: 6 IEC-HBCUs (Howard, Tuskegee, UMES, North Carolina A&T, Prairie View A&M, and FAMU/FSU), and a

total of 12 students with pre-internship travel. Additional students are welcome to join hybrid sessions. Academic mentors: HBCU Faculty and PWI Faculty and affiliated graduate students in the microelectronic research area jointly mentor the selected 2nd or 3rd year undergraduate students. Industry mentors engage with students through the existing IEF Pathways program before and after the internship. The cohort of students funded by this proposal become student mentors for the next generation of undergraduate students in the microelectronic ecosystem.

Mentorship Activities

1. Structured mentoring: the research participants are provided with technical training that prepares them for the research activities and professional development training to prepare them for a productive career in the M&S sector.
2. Hands-on research activities: the technical activities focus on design, analysis, fabrication, and testing of microelectronic and electronic systems. In all of these activities, hands-on experiential learning is emphasized.
3. Cohort building to strengthen STEM identity: our yearlong common technical and professional development activities foster cohesion of the research cohort.

NSF INCLUDES FuSe Interconnects Transitions REM Program Plans

Technical Training

Technical training for the research participants will take place in the academic semesters of Fall 2024 and Spring 2025. The purpose of the technical training program is to provide the participants with the technical skills necessary to (i) prepare for summer internship experiences, and (ii) find and succeed in future research opportunities. Components of the technical training program and their scheduling are provided below. ***All technical training are done in a hybrid/remote format with the exception of cleanroom training. Travel to the FuSe Interconnects R1 institution follows before internship experience.***

Cleanroom training: The participants will have access to training in RPI or Notre Dame Cleanroom facilities. A 10-day training program provides an overview and hands-on experiences in the cleanroom for topics that include cleanroom safety, lithography, deposition, etching, metrology, and vacuum technologies. The cohort of students for HBCUs/MSIs travel to PWIs for this training and mentees meet each other and mentors in person during this experience. Modules for all workshops and training are curated on the existing online platform for the Mercer XLab in Notion.

Professional Development

Professional development training for the research participants is aimed at providing them with a broad range of skills that extend beyond their academic knowledge, thereby enhancing their employability and adaptability in the profession. As the participants are at different stages of their academic careers, we differentiate some of the training materials for junior and senior mentees, as outlined below.

Inclusive Engineering Foundation Professional Growth Webinars: The IEF offers students professional growth webinars that are an invaluable tool for college students to develop the power skills they need to succeed in the real world. Webinars include: Women in Engineering: Pathways

to Career, Refining Skills for ECE Industry, The Art of Communication, Financial Health & Wellness and others to support student lifelong goals.

Entering Research: The content of this training program is developed by RPI Leadership Development based on the book *Entering Research* by Branchaw, Butz, and Smith [8].

Cohort Building Activities and Networking

These activities are central to fostering a supportive and collaborative research environment. We believe that these activities will help the participants in forming their STEM (particularly Microelectronic and Semiconductor (M&S)) identity and provide positive experience that increases program retention.

Graduate Mentor/Mentee Open Shop Hours: mentees have opportunities to continue their design experiences as they relate, get advice on aspects of internship experience and submission throughout the semester.

Faculty and Graduate Mentor Joint Professional Development: The cohort of faculty and graduate mentors across universities learn tools and best practices together to help guide students through design activities. Thus far, "The Power of Shifting Perspectives" discussion was created and facilitated by the RPI Center for Leadership. The TinyTapeOut walkthrough session followed to ensure each faculty is familiar with upcoming activities. These sessions repeat as needed for questions, feedback, and design activity planning.

Industry visit: During the Pre-Internship Experience Accelerated Cleanroom Training on the RPI campus in the early summer, we will provide firsthand exposure to the cutting-edge processes and technologies driving the industry, offering students the chance to connect classroom theory with real-world applications. RPI already has strong ties with local M&S industry, e.g., GlobalFoundries, and regularly organizes student visits to the fabrication facilities. We will organize similar visits for the research participants in this program.

Challenges

- Identifying and selecting mentees took longer than expected, pushing initial conversations with mentees as a cohort after midterms of the first semester.

- As with any multi-university, multi-state project, finding the best meeting platform and mutually workable meeting schedules has been difficult, with some things working better than others. Meeting together synchronously in hybrid format works best for most faculty. Alignment of schedules across universities is navigated by recording meetings, providing open hours, and creating online modules of pertinent information. Open shop hours by graduate students and/or faculty mentors need a regular, predictable schedule.

- Industry cannot guarantee internship positions for students in specific programs. To significantly increase the probability of hire, this FuSe Interconnects Transitions Program focuses on giving participating students the skills and experiences that will make them attractive candidates for internships. However, it has been difficult for industry to provide clarity on the student experience that will help them be noticed except for GPA.

- A dedicated non-faculty staff member responsible for assessment of all activities would augment the project by creating effective pre- and post- activity surveys along with qualitative interview data throughout the experience. Both faculty mentors and students should be interviewed to better reflect challenges, needs, and successes.

Conclusions and Next Steps

The collaborative and equitable ideation process in the FuSe Workshop to create better workforce development educational experiences resulted in a cohesive multi-university funded program through NSF INCLUDES. A kickoff meeting, Faculty/Graduate mentorship training meeting, and initial meeting with mentees occurred in the Fall semester. Challenges thus far included creating asynchronous methods of conveying information for a few participants with schedule conflicts; industry members and faculty mentors must find mutually acceptable ways to evaluate student experiences and skills beyond GPA; and finally, the experience of mentors and mentees should be studied by a staff member external to the program to acquire the best feedback about all aspects of the piloted work. Immediate next steps include the TinyTapeOut design module and feedback meeting with Faculty/Graduate mentors.

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