NSF INCLUDES: Collaborative Research: Advancing Semiconductor Education through Expansion and Diversification (ASEED)

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Introduction

The new era of advanced computing driven by artificial intelligence (AI) has changed our daily lives as well as brought new challenges. The demand for faster, smaller, and more efficient electronic devices continues to grow. Semiconductor research and development (R&D) are essential to answer the call. Indeed, the Chips & Science Act[1,2,3] has articulated a national vision aimed at upholding the United States' leadership position within the semiconductor industry. In response, both academia and industry have displayed a resolute commitment to support this endeavor through collaborative and innovative efforts[4,5,6]. It is noteworthy that the Principal Investigators (PIs) from each ASEED institution also serve as lead PIs for the Apple NSI and Intel-SERP grants. With strong and sustained industry support, these institutions have established a solid foundation for semiconductor education and research across three states. Building upon this foundation, the ASEED team aims to extend collaboration and share their vision with more small institutions to strengthen research and educational infrastructure across all stages of chip design.

Aligned with ASEED's **overarching goal** of addressing the challenges faced by small institutions in semiconductor research and education, the project emphasizes expanding access and equipping students with advanced, industry-relevant skills. The research foundation of ASEED is formed by three major topics in the semiconductor fabrication and very large scale integration (VLSI) chip design. Each collaborating institution pilots one topic:

1) 2D semiconductor nanomaterials[7,8,9,10,11,12,13,14] (Central State University);

2) AI chip design[15,16,17,18] (Prairie View A&M University);

3) GaN-Based Ultra-Wide Band Gap (UWBG) semiconductor device fabrication and testing[19,20,21,22,23,24,25] (Alabama A&M University).

The education will thrive from the above-mentioned research topics with course enhancement and certificates offering. During the past project year, the ASEED team organized a series of seminars to disseminate their research and educational outcomes. The team also engaged with community colleges and high schools to share training modules and provide professional development opportunities. In addition, ASEED offers students multiple learning pathways, including summer workshops, undergraduate certificates, areas of concentration, and graduate-level credentials. This article highlights the range of training opportunities developed through the ASEED project, which the authors hope to share with peer researchers and educators to invite valuable feedback and collaboration.

Project Activities

A strong collaborative team has been formed among the three participating institutions. The project team meets bi-weekly virtually to share research and educational progress across the three proposed thrust areas: semiconductor materials, integrated circuit (IC) design, and chip tapeout with validation.

Activities by Institution

First of all, each institution has their own project group contributed individually to the project with their various strengths under the three thrusts.

1. Central State University:

Central State University spear heads online undergraduate certificate and summer internship programs through ASEED grant.

a) Online Certificate in Semiconductor Processing: Central State University has developed a 30-credit, fully online certificate in semiconductor processing, in collaboration with Intel subject matter experts. The program includes 3 mandatory courses (Semiconductor Device Physics, Statistical Process Control, Robotics and Automation) and 21 credits of electives (ranging from Data Structures to VLSI Design and Fabrication). To encourage enrollment and train more students, ASEED offered 22 scholarships ($5,000 each) to students who complete the certificate. As of the second year, over 90 applications for these scholarships have already been received. Central State University has created promotional materials and an application process and is coordinating with campus offices to facilitate scholarship distribution in the coming year.

b) Summer Internship Program: The summer internship program hosted by Central State University is an 8-week, hands-on program that joined with Intel funding summer program. The program received 309 applications and selected 46 participants. ASEED funding supported the stipends of 18 of these students. All interns received a $5,000 stipend along with two months of housing, offering meaningful support and valuable hands-on experience in the following five semiconductor and microelectronics topics: i). Introduction to Microelectronics Design (2 weeks) ii). Introduction to Microelectronics Security (2 weeks) iii). Introduction to Printed Circuit Board Fabrication and Design (2 weeks) iv). Introduction to Microelectronics Fabrication (1 week) v). Additive Microfabrication of Electronics (1 week).

2. Prairie View A&M University:

Prairie View A&M University is recently classified as a Carnegie Category 2 institution. The ECE department offers both MS and PhD degrees. ASEED program accelerates the graduate program with courses development and new graduate certificate.

a) Graduate courses development: A new graduate course “ELEG 6341: Advanced FPGA Design and Applications” was developed. The course was officially offered in the Spring 2025 semester, with PI as the instructor. Thirteen students enrolled in the class. The course utilized the Xilinx FPGA platform[26,27,28]. It included a total of nine hands-on labs, covering fundamental Digital Signal Processing concepts and machine learning applications[29], particularly focusing on Convolutional Neural Network (CNN) hardware implementation[30].

b) New graduate certificate program established: The proposed "Computer Hardware and VLSI Design" graduate certificate has been approved and the certificate courses are listed in Table 1. An official announcement has been sent out to the students and gather their feedback. The first 10 students obtained the certificates will be awarded with $2,000 scholarships. A good number of students have expressed interest, and two students have already obtained the certificates and scholarships. This early interest highlights the strong potential of the new certificate program.

Table 1: Courses Support Computer Hardware and VLSI Design Certificate

Course Prefix and Number	**Course Title**	**SCH**
Required courses (9 hours)		
ELEG 6342	VLSI and ULSI Design	3
ELEG 6341	Advanced FPGA Design and Applications	3
ELEG 6310	Advanced Computer Systems Design	3
Elective courses (9 hours)		
ELEG 6343	Advanced VLSI Design Test and Characterization	3
ELEG 6314	Fault Tolerant Computing	3
ELEG 6329	Hardware Security	3
ELEG 6351	Advanced Quantum Devices	3
ELEG 6354	Advanced Solid State	3
ELEG 6365	Intro to High Performance Computing	3
ELEG 6311	Computer Architecture & Advanced Logic Design	3

3. Alabama A&M University:

The ASEED project supported Alabama A&M University's course revamping and further enhanced the concentration and minor programs.

a) A sequence of Micro-electronics/VLSI and Computer Engineering courses were updated in the Fall of 2024 and Spring of 2025. The courses are: EE201L Linear Circuit Analysis Lab; E203L Analog Circuit Design and Analysis Lab; E305 Semiconductor Engineering I; EE 333 Analog Circuit Design and Analysis II; EE350 VLSI Design and Test; EE451 Integrated Circuit Fabrication; E451L IC Fabrication Lab; and S381

Figure 1: Students operated instruments in the clean room.

Computer Architectures. The fabricated chips in clean room by PI were brought to the classroom to make them understand how chips were fabricated with the suitable visual sources shown in the classroom, the clean room was introduced and given an explanation about the process starting from wafer fabrication to chip fabrication. Figure 1 illustrates students work in the clean room.

b) Concentrations and minors are different education models compare to certificates. They are only for enrolled students of certain programs. Alabama A&M University already offered Microelectronics (VLSI) concentration among their four concentration areas for BSEE degree. Students who complete 18 credit hours from the list shown in Table 2 can claim their concentration in Microelectronics (VLSI) where highlighted with bold are the courses contribute to the minor in VLSI. All the courses are improved by ASEED.

Table 2: Microelectronics Concentration & VLSI Minor Option Courses

Course Prefix and Number	**Course Title**	**SCH**
EE 201L	Linear Circuit Analysis I Lab	1
EE 203L	Analog Circuit Design and Analysis I Lab	1
EE 305	**Semiconductor Engineering I**	**3**
EE 333	Analog Circuit Design and Analysis II	3
EE 350	**VLSI Design and Testing**	**3**
EE 451	**Integrated Circuit Fabrication**	**3**
EE 451L	**Integrated Circuit Fabrication Laboratory**	**1**
CS 381	Computer Architecture	1

In summary, the educational opportunities the team provided are: online undergraduate certificate and summer internships; in-person graduate certificate, concentration and minor programs. All the above training opportunities almost cover the whole spectrum of current effective methods for higher education on a specific skill.

Joint Activities

Major joint activities include a seminar series and presentations at the HBCU Chips Annual Workshop.

1. The project team co-hosted virtual seminar series on Advancing Semiconductor Education. Researchers from each institution shared their research and educational accomplishments supported by this project. The three seminars were held on November 18, 2024, March 3, 2025, and November 14, 2025, respectively. Research presentations were highlighted in the seminars:

a) PI at Central State University presented “Quantum Few-body Systems in Two Dimensions,” covering advanced theoretical and computational techniques relevant to 2D materials in semiconductor research.

b) Prairie View A&M University team presented the following topics to showcase recent hardware projects: i). VLSI Chip Design and Fabrication for Solar Panel Diagnosis

System; ii). Design and Implementation of Hardware Accelerators; iii). Hardware Implementation of Image Restoration.

c) Alabama A&M University team gave presentations on: i). Ultra-Wide Band Gap (UWBG) Semiconductor Materials and Devices; ii). Nanostructured Thin-Film Thermoelectric Materials and Devices; iii). Big Data Analytics for Digital Twinning in Semiconductor Manufacturing; iv). Design, simulation, and test of microwave subsystems which cover a broad range of semiconductor-related materials science and fabrication development.

2. The collaborative team also actively contributed to the 2nd HBCU Chips Annual Workshop, hosted at Howard University in April 2025. The team co-presented this ASEED project with an oral presentation entitled "Advancing Semiconductor Education Through NSF-Funded Collaborative Research." In addition to presenting the collaboration work, partners from high schools and community colleges were invited to join the conversation. This effort helps broaden the foundation for workforce development beyond traditional four-year institutions.

Summary and Future Work

The project team has actively engaged in and advocated for semiconductor workforce development. Each institution has piloted research projects aligned with the three proposed primary research thrusts, forming an exemplary educational model. This collaborative approach enables small institutions to complement each other in addressing complex challenges. Central State University has led the effort in introducing current advancements in semiconductor materials through a variety of certificate and internship programs. Remote access to training packages has served as a model for workforce development aligned with modern technological progress. At Prairie View A&M University, the foundation of VLSI design has been expanded across undergraduate and graduate courses by integrating industry-standard tools including be not limited to Verilog and Cadence[31,32,33]. Alabame A&M University has achieved the update and improvement of the eight courses made better training and preparation in semiconductor microelectronics/VLSI and computer engineering[26,34,35,36]. The chip design and tapeout class attracted more students in the class and students became more interested in the chip design.

The project team will keep the seminar series to introduce the research and education findings to peer researchers and educators. An in-person workshop is being planned near the end of the second project year to broadly share project outcomes. Ongoing collaboration among the three institutions will be supported through monthly meetings, campus visits, and joint publications. A systematic study will be conducted to evaluate the effectiveness of different educational models, and the feasibility of establishing a workforce development center will be explored.

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