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**RPPR Final Report**  
as of 30-Apr-2019

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**Final Report** for Period Beginning 11-Sep-2017 and Ending 10-Dec-2018

**Title:** Acquisition of a Multifunctional PicoIndenter System for in situ Correlative Materials Characterization of Small-Scaled Structures

**Begin Performance Period:** 11-Sep-2017

**End Performance Period:** 10-Dec-2018

**Report Term:** 0-Other

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**Distribution Statement:** 1-Approved for public release; distribution is unlimited.

# RPPR Final Report

## as of 30-Apr-2019

**STEM Degrees:** 0

**STEM Participants:** 4

**Major Goals:** The major goals of this project were:

1. Acquire the PicoIndenter System to strengthen our research infrastructure in the field of materials science and nanotechnology (MSN).
2. Work with the manufacturer to provide basic trainings to users who are interested in using the System, and initiate new research projects.
3. Provide new educational resources to undergraduate and graduate students who take the core and advanced level courses in the field of MSN.
4. Provide new outreach resources to inspire more high school students and teachers to further their career in the fields of science, technology, engineering and mathematics (STEM).
5. Attract more industrial partners to use our existing electron microscopy facility, and develop new collaborative projects.

**Accomplishments:** The accomplishments corresponding to the above five goals are:

1. Both PI 88 SEM PicoIndenter and PI 95 TEM PicoIndenter were successfully acquired.
2. Basic trainings were provided to potential users during the installation of the two PicoIndenters. The manufacturer is aware that we will request additional advanced trainings in 2019 after users prepare their own samples.
3. The availability of the PicoIndenter System has been disseminated to students who took the courses in the field of MSN. We are implementing new labs for students who will take the "Introduction of Transmission Electron Microscopy" and "Materials Characterization and Analysis" courses in AY 19/20 to provide direct hand-on experience of using the PicoIndenter System.
4. While recruiting the HSAP participant in summer 2018, flyers were sent to several high schools and organizations to increase the public awareness of the PicoIndenter System. After the participant: Jackson Harwood finished his HSAP experience with us, he gave a presentation to his peers at Lake Norman Charters (LNC) high school. Jackson also brought a group of LNC students and teacher (Mr. Kevin Patterson, physics teacher) to our lab and did a lab demonstration. Jackson has applied for college admission in the STEM field. We will continue our collaboration with LNC for more outreach activities in 2019.
5. We have been actively in contact with local industrial partners, such as Sealed Air and Nanodiagnostic Technology LLC. One SBIR proposal (led by Nanodiagnostic LLC) has been submitted. We are looking forward to developing more collaborative projects with industrial partners in the future.

**Training Opportunities:** This project has provided unique training opportunities to one URAP (Jackson Harwood) and one HSAP (Douglas Lawrence) in summer 2018. At that time, Jackson was a rising senior at LNC high school, and Douglas was a rising senior in the Department of Mechanical Engineering at UNC Charlotte. Their work "In Situ Testing of Nanostructures with Scanning Electron Microscope" was presented in Charlotte Research Scholar (CRS) Summer Symposium. After the summer program, both students set clearer career goals in the STEM field. Jackson has applied for college admission in the field of engineering. Douglas had applied for early entry master program at UNC Charlotte and was admitted.

The project has also provided training opportunities to three female PhD students whose dissertation projects will rely on the PicoIndenter System. All students have received basic training on how to operate the System.

## RPPR Final Report as of 30-Apr-2019

**Results Dissemination:** The results (i.e., the availability of the PicoIndenter System at UNC Charlotte and its functions) have been disseminated to (1) undergraduate students (juniors and seniors) who took the "Introduction to Materials Science" and "Materials and Mechanics Lab" courses, (2) graduate students who took the "Materials Characterization and Analysis" and "Nanoscale Science Seminar" courses, (3) URAP/HSAP/NSF REU participants in the period between summer 2018 and spring 2019, (4) industrial partners such as Sealed Air and Nanodiagnostic Technology LLC via phone communication, and (5) external researchers during personal communication at professional conferences such as TMS, MS&T and MRS.

In the future, the research results produced by the PicoIndenter System will be disseminated by journal publications and conference presentation.

**Honors and Awards:** Nothing to Report

**Protocol Activity Status:**

**Technology Transfer:** Nothing to Report

### **PARTICIPANTS:**

**Participant Type:** High School Student

**Participant:** Jackson Harwood

**Person Months Worked:** 2.00

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

**Funding Support:**

**Participant Type:** Undergraduate Student

**Participant:** Douglas Lawrence

**Person Months Worked:** 2.00

Project Contribution:

International Collaboration:

International Travel:

National Academy Member: N

Other Collaborators:

**Funding Support:**

This project started in September 2017. In the last quarter of 2017, all internal paperwork was done and the purchase orders were sent to the manufacturer: Hysitron (now is part of Bruker).

- The PI 88 SEM PicoIndenter was installed in March 2018. During the installation, one transducer was found malfunction. The repaired transducer was delivered to us in June 2018.
- The PI 95 TEM PicoIndenter was installed in the middle of August 2018. During the installation, we found the geometry of one testing probe suggested by the manufacturer would not satisfy our research needs (particularly for in-situ testing of thin films). We then ordered a new probe with the wedge-shape during the no-cost extension period. The probe was delivered in February 2019.

Although both PicoIndenters were successfully acquired and installed within the project period, they have not been fully used in research projects discussed in our original proposal. The main reason is due to the departure of our old electron microscopist: Dr. Yinggang Lu. (Dr. Lu resigned from UNC Charlotte due to health issue.) In spring/summer 2018, we interviewed several candidates and decided to hire Dr. Youxing Chen as our new electron microscopist. Dr. Chen had extensive experience on using PicoIndenters during his PhD study at TAMU, post-doctoral work at Sandia National Lab, and research associate working experience at U of Minnesota (while at that time his project was in collaboration with Hysitron). Dr. Chen participated the installation of PI 95 TEM PicoIndenter in August 2018. He has officially joined UNC Charlotte in January 2019. He is currently training users to use the two PicoIndenters. We expect exciting results will be produced soon which can lead to new research proposals to be submitted to DoD.