Nanotechnology Workforce and Curriculum Development

CNF Project Number: CNF Summer Internship
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Primary CNF Tools Used: Unaxis 770 Deep Silicon Etcher, ABM Contact Aligner, Hammatech Wafer Developer, Anatech Plasma Asher

Abstract:

Nanotechnology, and all of the promises and penitential that it holds, is becoming increasingly important from an economic, workforce. Microprocessors, computer memory, and other technologies that make modern life possible all depend on research and development at the nanoscale. It is therefore critical that more people are exposed to possible careers and ideas surrounding this concept. While it is important to ensure that current employment needs in this field are met, it's critical that we look toward the future of the industry. This requires students in K-12 educational programs to be well-versed in these concepts and ideas. I worked to make sure that teachers, students, and industry partners are working together to achieve these goals.

Summary of Research:

Curriculum Development:

The New York State Science Learning Standards (NYSSLS) are being rolled out progressively, with 2026 as the target date for a complete transition away from the previous standards, which have been in place since 1996.1 In the intervening thirty years, there have been new discoveries from animals to elements that have reshaped how humans interact with their world. Chief among these is an explosion in the possibilities that nanotechnology can offer.

The new standards, while commendable, do not explicitly call out nanoscale concepts. For example, while there are performance expectations at all grade levels around engineering design, none of them are specifically relevant to solving problems at the nanoscale. There are also expectations at all grade levels for students to build devices that transform one type of energy into another, but again, nothing is mentioned about the scale. This presents an opportunity to include nanoscale examples where older, macroscale examples might have been previously used.

Dr. Tamer Uyar in the fiber science department studies a process called electrospinning, whereby a polymer is extruded from a needle via an electric field. Varying the voltage, humidity, or a number of other factors can change the size of the nanofibers that are produced. I worked with Dr. Uyar this summer to develop ways that this technology can be demonstrated in the classroom, and will continue to do so over the course of this academic year.

Because nanotechnology is inherently cross-curricular, it's also the ideal vehicle to deliver instruction that highlights the crosscutting concepts that the NYSSLS emphasize at every level. Most practicing scientists realize that a working knowledge of chemistry, physics, math, and myriad other subjects is necessary to grow our collective understanding and make progress in any field. To that end, I worked with and presented to in-service teachers through the United Federation of Teachers and the American Federation of Teachers to show them how nanoscale concepts can fit into their curricula.

I also presented at the Northeast Regional Defense Technology meeting at Rensselaer Polytechnic Institute on the value of creating and maintaining industry-education partnerships.

Education and Outreach:

The goals of developing a competent and dynamic workforce for the burgeoning US semiconductor industry depend on students being knowledgeable of and interested in the field. To that end, I worked with students at several outreach events, including a Micron chip camp and two visits from students from New York City. These students came away with an appreciation for the complexity of the devices that are around them every day, as well as the possibilities for future education and employment in the field. I also gave tours to incoming first-year Cornell undergraduate students and to first-year graduate students. These tours gave a comprehensive perspective on what the CNF can offer in terms of research possibilities.

Because not all students or workers have access to a facility like CNF or the programs that it offers, I worked to help develop virtual reality (VR) modules that teach about important concepts in nanoscale manufacturing.

Workforce Development:

A shifting economy requires a nimble workforce in order to be sustainable. The United States has invested in this ideal through initiatives like the CHIPS act, which, among other things, aims to bring more semiconductor manufacturing and job force training back to the country. In service of this, workforce development needs to happen on two main fronts: retraining of people already in the workforce, and preparation of students who will be entering it in the future.

I worked with the New York State Department of Labor to show them the mismatch between current educational programs and the needs of the semiconductor workforce, and will continue to work with them as one of many options to disseminate our virtual reality content.

Microfluidic Device Fabrication:

While students can understand commercial microprocessors and the tools and methods used to produce them, their small size, immense complexity, and sensitivity to contaminants makes them difficult to work with the K-12 setting. Microfluidic devices are fabricated with identical techniques on identical substrates, but are much more forgiving. It's also possible to interact with them outside a cleanroom and on a scale that is smaller, but familiar, to most students. They therefore provide an ideal method to engage students with nanofabrication techniques in a way that allows for easy measurement and interaction with equipment already present in most science labs.

I have prepared several microfluidic devices that students can use to explore concepts related to the NYSSLS, and also use as jumping-off points for other concepts in a wide variety of STEM courses.

References:

[1] https://www.nysed.gov/curriculum-instruction/science-implementation-roadmap-and-timeline.

PROCESS & CHARACTERIZATION