SUSTAINABLE EDUCATION IN THE AGE OF THE SECOND QUANTUM REVOLUTION: Fifteen Years of the University of Rochester NSF Supported Efforts

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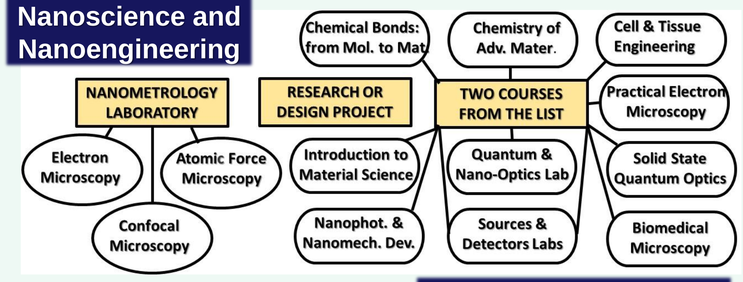
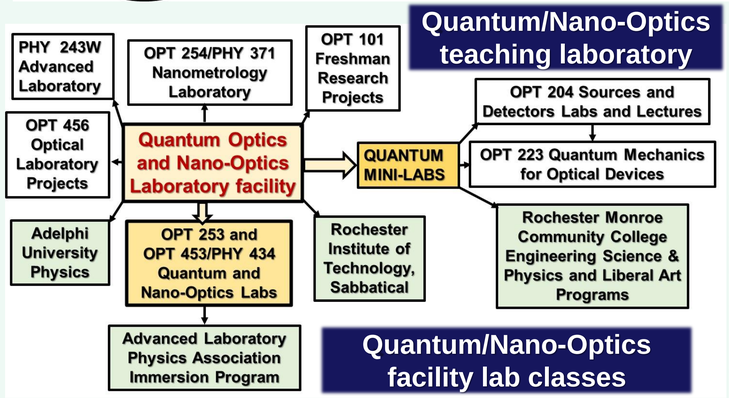
PROJECT OVERVIEW

Integrated Nanosystems Center (URNano): interdisciplinary nanoscience research

Certificate in Nanoscience and Nanoengineering

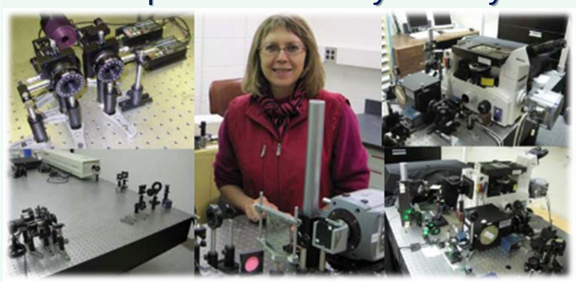


Quantum/Nano-Optics teaching laboratory



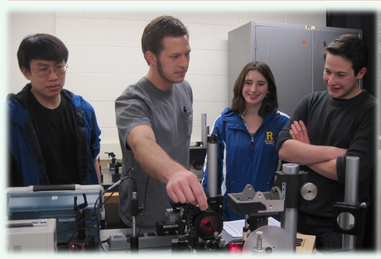
Quantum/Nano-Optics facility lab classes

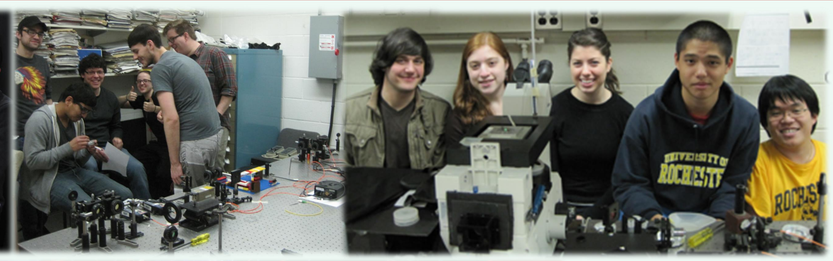
The goal of this poster is sharing 15 years of experience at the University of Rochester (UR) in preparing students from freshman to senior and graduate level as well as community college students to a second quantum revolution that promises extraordinary advances to pharmacology, material science, renewable energy, climate change, sustainable agriculture, absolutely secure communication, and more. Two UR facilities played a key role in these efforts: Integrated Nanosystems Center (URNano) and the NSF-funded Quantum and Nano-Optics Laboratory Facility.



IMPORTANT ACHIEVEMENTS (see details in Refs. [1,2]):

- from 2006 to spring 2022, a total of ~850 students have utilized quantum/nano labs (including 144 MCC students) and more than 250 students have used them for lab demonstrations.
- initially supported by NSF, the program on the Certificate in Nanoscience and Nanoengineering issued certificates to 45 students (by May 2022).
- **creating a *reproducible* model of collaboration** in quantum and nanotechnology between a university with state-of-the-art, expensive experimental facilities, and a nearby, two-year community college with participation of the local MCC. 52 MCC students carried out two labs at the UR on the AFM and a photolithography in a clean room; and 92 MCC students – two "quantum" labs using state-of-the-art photon counting instrumentation.
- developing *reproducible* hands-on experiments on quantum and nanophotonics ("MINI-LABS"), learning materials and pedagogical methods to educate students with *diverse* backgrounds, **including freshmen and non-STEM-major CC students**. These minilabs were also introduced in some Institute of Optics required classes.





TRAINING FUTURE TECHNICIANS: MONROE COMMUNITY COLLEGE

LEFT: MCC students in cleanroom garments before their photolithography lab in URNano. RIGHT: MCC and UR logos prepared by MCC students.

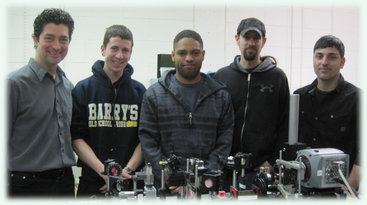
Three NSF educational grants supported training of 144 students from the local Monroe Community College (MCC) at the UR. Each group of 5-6 MCC students carried out two 3-h labs at the UR with a preliminary lectures of Prof. P. D'Alessandris (MCC) and UR pre-lab quizzes.

MCC students at the UR laboratory on entanglement and Bell's inequalities answering pre-lab quiz questions.

Two directions of MCC students' training:

(1) single-photon counting instrumentation;

(2) atomic force microscopy (AFM) of nanoparticles and photolithography in a clean room.



Prof. P. d'Alessandris and his MCC students in a single-photon interference lab with a modern electron multiplying EM-CCD, low-light level imaging camera.

Symposium: How to Teach "Quantum" in the Age of the Second Quantum Revolution

UR organizes this symposium during the Conference on Education and Training in Optics and Photonics ETOP 2023 (Cocoa Beach, Florida, May 15-18, 2023): https://etop.creol.ucf.edu/quantum/ .

WEBSITE:

http://www2.optics.rochester.edu/workgroups/lukishova/QuantumOpticsLab/ .

KEY REFERENCES:

1. S.G. Lukishova, "Fifteen years of quantum optics, quantum information and nanooptics educational facility at the Institute of Optics, University of Rochester", *Special issue of Optical Engineering* "Education and Training in Quantum Science and Technologies", Vol. 61 (8) 081811 (2022).
2. S.G. Lukishova and N.P. Bigelow, "Undergraduate program in nanoscience and nanoengineering: five years after the National Science Foundation grant including two pandemic years", *Special issue of Optical Engineering* "Education and Training in Quantum Science and Technologies", Vol. 61 (8) 081810 (2022).

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