*Description of the Research Facility and Needs*

The existing research facility consists of three separate laboratories in a former junior high school building that was acquired from Keystone Central School District and refurbished in 2004-2005 and two other basement areas. Total space of the laboratories is 3000 square feet. At the time the University acquired the high school building and outfitted it for classroom use (2002) the nanoscience programs did not exist. Since then we've had 30 students graduate from these programs.

All of the nanotechnology research instrumentation were acquired since 2005 and set up in existing space. Three laboratories are located on the third floor of the building and contain less sensitive instruments. The other two laboratories are much smaller (10% of the existing space) and are located in basements in two buildings that provide good, though not ideal, vibrational and acoustic isolation. To observe and manipulate matter at the atomic or molecular level such isolation is essential. One of these laboratories contains the Atomic Force Microscope / Scanning Tunneling Microscope while the other lab, which is 10 minutes from this building, contains the Scanning Electron Microscope. In addition to acoustic and vibrational isolation issues, the existing laboratories are poorly ventilated. As a consequence of the age of the facility dust control is an ongoing problem that is detrimental for the experiments and device fabrication that we conduct.

None of the laboratories were specifically designed or modified for nanotech research. They contain very limited areas under chemical hoods and no wet lab facilities. The overarching problem is the physical separation of these spaces and maintaining the level of cleanliness (Class 100,000 classification) required at a minimum for fabricating and analyzing nanoscale structures. This physical separation requires transfer (via the hallway and steps) of samples from one room to another for treatment and characterization. For the same reason, we had to develop storage areas for chemicals in each room, which further impedes the work. The consolidation of all nanotechnology instrumentation in a single, accessible location that meets environmental requirements for nanoscale work will enable more researchers to work simultaneously, and permit a wider range of experimentation and better utilization of the available space.

The planned renovation of another former high school building on campus will transform it to a modern science center that will also house all science classrooms and laboratories and the Nanotechnology Laboratories and address many of the afore mentioned problems, notably the consolidation of nanotech laboratories and instruments in one area and addressing the vibrational and acoustic isolation, proper ventilation, and dust management issues. Funds for the basic renovation have already been allocated by the Commonwealth of Pennsylvania. A sketch is included in the Supplementary Documents. We are now in the design phase; construction bids will begin next year and the renovated facility will be online in Fall 2012. Not included in the planned renovation is a Class 100,000 clean room within the Nanotechnology Laboratories.

ARI funding will allow the nanotechnology programs to incorporate a class 100,000 clean room modeled after the class 100,000 clean room of Penn State University's Center for Nanotechnology Education and Utilization (CNEU) into the new facility. It will also allow us to consolidate these spaces into a single, highly functional laboratory that will support the wide range of research that faculty members from all disciplines are undertaking. In addition, undergraduates will be able to conduct nanoscale research in a relatively clean environment and they will learn clean room protocols. This experience is essential if they are to continue in research or industrial careers involving nanotech.

All of our Nanotechnology students attend the eighteen-credit Nanofabrication Manufacturing Technology (NMT) semester at Penn State University's NSF-sponsored Advanced Technology Education (ATE) Center, part of the National Nanotechnology Infrastructure Network (NNIN)[76] at the end of their sophomore year, supported by a Pennsylvania Department of Economic Development grant. This experience gives them technical skills and introduces them to working in a cleanroom environment. When the students return to Lock Haven University they apply technical skills to work on research projects with our faculty in the sciences[11,12,15,22,23,62,63,73-75,77-108].

This proposal requests $333,286 to incorporate a clean room into the renovated nanotechnology laboratories. Given the timing of the science center renovation and the Commonwealth investment in the overall project, this upgrade – which will bring our level of research and research training to a new level - can be achieved quickly and economically.

The total cost of the basic nanotechnology laboratories will be about $1.2 million and is included within the $28 million Science Center renovation project. (As described in the project management plan and timeline, the contract with the architectural firm was just signed and the preliminary plans will be finalized). If this proposal requesting $333,286 is funded, about 2500 sq. ft. within the laboratories will be upgraded to a Class 100,000 clean room with the associated fixed equipment. The clean room will be located inside the 3500 sq. ft. facility, accessible to all nanotech instrumentation. Since this area is within the planned renovation, the clean room can be installed at a reasonable cost of about $133,735 modeled after CNEU's facility. The cost is also low because we will use fan filter modules on the clean room since the overall air quality in the area will be addressed as part of the larger project. Finally the major cost of HV/AC requirements are also included in the bigger renovation. The fixed equipment that is included in this proposal to be installed inside the clean room are 12 ft of wet benches, 24 ft of fume hoods, Toxic gas monitors, a gas cabinet, a glove box, a eye wash station, and a deionized water system, all at a total cost of $155,877. This clean room facility will be used 80% of the time for research. Some of the research projects by undergraduates are program requirements of their major. The clean room will be used 20% of the time to teach one 4 credit hour laboratory course on Thin Film Science and Technology. The 80-20 % was arrived at by considering the lab time required for this course and the amount of time students will spend on individual research projects. University's contribution to this nanotechnology lab project ($1.2 million) far exceeds the 20% of the

time the Clean room will be used for teaching. The remainder of the 18 credits of laboratory teaching required for the Nanotechnology program will be done outside the renovated facility, at Penn State University's NMT summer semester. The Clean room will be maintained by the university and supported by the Nanotechnology budget line that sustains our nanotechnology programs.

The proposed facility will allow reliable fabrication of optoelectronic devices (solar cells, light emitting devices) ensuring higher standards for cleaning, particulate management, and eventually work under oxygen free atmosphere in a glove box. Many of the device failures we now experience are likely due to one or more of the above factors. The proper ventilation will allow us to establish enough space covered with wet benches and fume hoods so that the device fabrication can be done in a reliable and reproducible continuous sequence.

Proper ventilation will enable the use of gases different than noble gases, oxygen, and nitrogen. Currently no other gases are used in our laboratories because of safety concerns. The installation of a gas cabinet is also not possible in the current labs, because the ventilation system cannot accept additional load. Overcoming these obstacles will allow us to introduce Reactive Ion Etching (RIE) for material processing and additional deposition processes based on Chemical Vapor Deposition (CVD). These are fundamental tools for creation of functional submicron structures.