INSTITUTIOANL CAPABILITIES STATEMENT

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Background of Institution

NCCU is the nations's first state-supported public liberal arts college founded for African Americans, it is part of the University of North Carolina (UNC) system. Through its long history, dating from 1910, its mission has been to offer a strong and challenging educational environment that prepares students to "advance the consciousness of social responsibility in a diverse, global society". The university continues to demonstrate a "strong commitment to academic excellence in a diverse educational and cultural environment" by prioritizing the development of innovative, high quality academic and research programs across the sciences, including such recent, large-scale initiatives as the creation of the Biomedical/Biotechnology Research Institute (BBRI) and the Biomanufacturing Research Institute & Technology Enterprise (BRITE) Center of Excellence, which serve to address the research and training needs of underserved minority groups in the health science and biotechnology industries, respectively. Also indicative of the NCCU vision for research infrastructure improvement is the creation of the $40M Townes Science Complex, completed in 2005 as a home for the multiple disciplines represented by the NCCU College of Arts and Science. This complex has already begun to promote a new level of excellence in education and research at NCCU by providing students and faculty immediate access to colleagues across the disciplines, as well as to world-class equipment and state-of-the art research and education laboratories, making it an ideal home for the highly technical and interdisciplinary work of NSF Center of Research Excellence in Science and Technology (CREST), NASA University Research Center, and NSF Partnership in Research in Engineering and Material Science (NSF-PREM) Centers.

The current NCCU student enrolment is 8,604 students (77% black, 11% Caucasians, 2% Hispanic, 1% Asian, 1% American Indian, 1% international, 4% unknown and 2% multiracial, 90% in-state residents, 67% female), providing a valuable opportunity for recruiting students of traditionally underrepresented race and/or gender to the sciences. NCCU has capitalized on this opportunity, establishing itself as a top institution of baccalaureate origin for science doctorate recipients who are African-American U.S. citizens. (NSF/SRS Survey of Earned Doctorates,1991-95). Over the last 9 years, NCCU has graduated on average 70 undergraduate and 15 graduate students per year in the fields of Biology, Computer Science, Chemistry, Earth Science, Mathematics, and Physics; 30% of the undergraduates are admitted to graduate school. Students represent the backbone of the research enterprise at NCCU. During the last 10 years, enormous experimental infrastructure that facilitates research has been built. Around the state of art research laboratories strong and productive research programs are established in material science, nanotechnology, renewable energies, low and medium energy nuclear and hypernuclear physics, astrophysics, geophysics, earth and environmental sciences, robotics, computer sciences, genomics, chemistry, and biology.

Characterization facilities

1. Time resolved optical spectroscopy: The output of a Spectra – Physics Spitfire regeneratively amplified laser system (800 nm, 2 mJ, 40 fs) is used for transient absorption and transient Rayleigh scattering measurements. This ultrafast spectroscopy is complemented by time-resolved photoluminescence using the same excitation and signal collection paths. These measurements are performed with nanosecond time resolution using time correlated single photon counting. Static photoluminescence and Raman mapping can be performed using the same optical system and a CW Argon ion laser.
2. Scanning probe / Optical microscopy system: This system, which integrates an AIST scanning probe microscope and a Horiba micro-Raman system, is capable of simultaneous scanning probe and optical microscopic characterization of samples. Available scanning probe imaging modes include: Contact, Semi-Contact, Non-Contact, Lateral Force Microscopy (LFM), Piezo Force Microscopy (PFM), Phase contrast, Magnetic Force Microscopy (MFM), Single-Pass MFM, Electrostatic Force Microscopy (EFM), Single-Pass EFM, Scanning Kelvin Probe Microscopy (SKM), Scanning Capacitance Microscopy, Scanning Tunneling Microscopy (STM), conductive AFM and near field optical microscopy using apertured fiber probes. The system is also capable of tip enhanced Raman scattering through a side mounted microscope objective.
3. Scanning electron microscope / microbeam analysis: FEI NanoSEM 630 thermal field emission scanning electron microscope with low vacuum (up to 1.2 torr) and beam deceleration capabilities, backscattered electron detectors for high / low vacuum operation, and a transmitted electron detector. Energy dispersive x-ray spectroscopy (EDX) can be performed an Oxford X-Max 50 silicon drift detector, and a Channel 5 HKL system is available for transmitted and backscattered Kikuchi diffraction measurement to correlate local crystal structure / composition with optical properties in samples with alignment marks.
4. Time resolved mm wave conductivity: Time dependent transmission or reflection of an mm-wave beam (tunable from 110 – 170 GHz) generated by an ELVA-1 backward wave oscillator is measured using a Keysight KT-DSO90604A 6 GHz bandwidth, 20 GSa/s oscilloscope. Excitation pulses are supplied by either a Coherent Helios 532-1-50 laser (532 nm, up to 70 kHz repetition rate, pulse width < 700 psec), or the Spitfire ultrafast laser system described above. This system is capable of contact-free measurement of entire time dependent photoconductivity decay curves resulting from a single laser shot over time scales of up to milliseconds with sub – nanosecond time resolution, and is currently used to study carrier dynamics in organic photovoltaics.
5. Electrical Characterization - A Deep Level Transient Spectroscopy system can be used for conventional DLTS and thermally stimulated current to measure energies and concentration of trap levels in semiconductors. A Hall Effect system is also available to determine carrier densities and mobilities. All measurements can be performed from 4.2K to 300K.
6. Photoemission electron microscopy – The UV-PEEM system is connected via a UHV

sample transfer system to the custom gas source molecular beam epitaxy system, enabling in situ studies of nanostructure growth. The system has a demonstrated resolution of ~10 nm. UV photons are provided either by a 100W Hg lamp, or the Duke Free Electron Laser.

7. Cyclic voltammetry system for electrochemical characterization of nanostructured carbon electrodes and graphene-metal oxide composites.

Growth Facilities

1. Gas source molecular beam epitaxy growth system – This custom built system designed for epitaxial growth of III – Nitride materials has a base pressure below 2 x 10-10torr, and contains three EPI Knudsen cells for gallium, aluminum and indium solid sources. The nitrogen source is ammonia gas. Reflection high energy electron diffraction (RHEED) and Auger electron systems attached to the growth chamber are available to monitor the growth process.

2. CVD systems for graphene and inorganic semiconductor nanowire growth – Two systems are available, one dedicated to graphene growth, and one dedicated to inorganic semiconductor nanostructure growth. These systems are built around tube furnaces capable of reaching 1100ºC with base pressures of 1 x 10^{-3} torr. Gas flow in each system is controlled by mass flow controllers, and pressure is automatically controlled by a downstream throttle valve. Substrates and materials for thermal evaporation in both systems can be transported into and out of the heated zone while the system is under vacuum using magnetically coupled carriers.

3. UHV pulsed laser / electron beam deposition chamber - This load locked chamber is used for growth of nanostructures by pulsed laser ablation contains a six target carousel and a heatable, rotating substrate holder. The system also has a low power electron beam deposition system used to deposit metal (Au, Al, Ag) and dielectric (SiO2, MgO) thin films.