A. NCMN ELECTRON MICROSCOPY CORE FACILITY

1. Research Services and Fee Structure

To grow UNL and NU research competitiveness, materials and nanoscience researchers must increasingly analyze the structure, composition and properties inside nano-volumes of materials with near-atomic resolution in all directions. The new instruments in the NCMN Core Facility for Electron Microscopy (CFEM) – the FEI Nova NanoSEM 450 field emission scanning electron microscope (SEM), installed January 2012, and the FEI Tecnai Osiris transmission / scanning transmission electron microscope (TEM/STEM), installed in March / April 2012 greatly enhances UNL research capabilities and potential. These instruments are located in the new, custom-designed space in the basement of Jorgensen physics building on 16th Street, and will be a key user-access asset in NSF, DOD and other major research centers and programs, as well as individual programs including those of the 80 plus faculty members of NCMN. Moving and re-installation of the existing JEOL JEM2010 TEM transmission electron microscope and JEOL JSM840A SEM scanning electron microscope in the new Facility space began in November 2011 and was completed in January 2012.

The NCMN Core Facility for Electron Microscopy is a user facility providing state-of-the-art tools dedicated to materials and nanoscience research for structural characterization at an atomic/nano/microscale. The Facility includes specialized sample preparation tools, along with electron microscopy image, diffraction and spectral data analysis and processing software and hardware. Staff support is available for training, consultation on application and related theories, and research monitoring and assistance. The mission of the Facility is to help researchers use the instruments, data processing and sample preparation capabilities of the Facility for themselves, with full training, guidance and support, resulting in researchers being able to attain research results and understanding that would not otherwise be possible.

With its field emission source, even more than the existing JEM2010, the new Tecnai Osiris instrument can focus enough electrons into sub-nanometer (few atom diameter) probes to obtain detailed, statistically significant information from regions containing only a few tens of atoms. With this instrument, for the first time in Nebraska and in the surrounding states, all NCMN facility research users will obtain such comprehensive data from key interfaces in advanced materials and from single-nanometer (six atom wide) particles at chosen locations with near single-atom resolution. In addition, the tomography capability (an electron equivalent of medical CT scans) will make it possible for the first time in Nebraska to obtain full 3-D images and characterization, not just 2-D images or surface analysis, with sub-nm resolution.

The current $1.3M funding of a Major Research Instrumentation proposal to the National Science Foundation has resulted in the installation of the FEI Tecnai Osiris instrument that will allow researchers to map elemental concentrations, atomic bonding and dielectric characteristics, magnetic and electric domains, and crystallinity quantitatively and in detail at the scale of 1 nm to single atom sizes. This instrument incorporates a combination of many characterization tools that is unique amongst all surrounding states. Such research capabilities enable NU researchers to compete nationally and internationally and are essential to UNL's becoming a very highly respected institution in the CIC and Big 10 through the quality of the research and the associated quality of education and training of undergraduate and graduate students.

The new Tecnai Osiris STEM is equipped with: (1) bi-prism for holography, (2) electron energy loss spectroscopy, (3) x-ray analysis, and (4) tomography of particles embedded in low atomic number media. Capabilities (1), (3) and (4) do not exist at NU. The Osiris STEM will provide all this at levels competitive with UNL's target research university peers.

In concert with the other CFEM instruments, the Osiris STEM will enable a wide range of new and more-productive research and education activities; examples of the range of activities include:

(1) Evaluation and detailed characterization of nanowires, nanofibers, nanoparticles, and nanodevices unobtainable by any other methods at NU or in the region.

(2) Advanced materials and devices for spintronics, advanced energy technologies, and nanodevices, including those for biomedical fields. The new CFEM instruments will allow Nebraskan researchers to explore these aspects as they need, for the first time.

(3) Images and measurements will be attainable at the standard now expected nationally and internationally in papers in Science, Nature and top journals and in the most competitive proposals to federal funding agencies.

(4) Ph.D. and faculty recruitment in materials and nanoscience and nanoengineering at nationally and internationally competitive levels will be enhanced greatly by research characterization that the new SEM and STEM instruments will enable.

The FETEM has major potential impacts in all "nano" research and training, in related science and engineering, and in research and global recruiting

The function of the Central Facility for Electron Microscopy is to provide hands-on access to electron microscopes, sample preparation equipment plus data collection and data reduction instrumentation, along with advice, training and research collaboration. The scope of the Facility is materials characterization of the topography, morphology, elemental composition, crystalline microstructure, crystal defects, and atomic arrangements of materials, largely on a scale from 10 micrometers down to the near-atomic level.

Main equipment:

Calendar schedule for FEI NanoSEM, JEOL JEM2010, JEOL JSM840A and FEI Osiris.

(1) **JEOL JEM 2010 TEM**
200kV, analytical/high-resolution mode, LaB6 filament, single-tilting and double-tilting sample holders. (Oxford EDS system, Gatan dual-view CCD camera, TSL texture analysis system, Digi-TEM beam control system).

(2) **JEOL JSM 840A SEM**
LaB6 filament, second electron and backscattered electron detectors, Kevex Quantum x-ray microanalyzer, Digital imaging system.

(3) **VG Microscopes HB501 STEM**
Field emission scanning transmission electron microscope, now including:
Windowless x-ray microanalysis (Oxford/ 4pi), Digital image acquisition (4pi), Parallel-acquisition ELLS, Energy-filtered electron diffraction, Differential phase contrast detector, Electron beam induced nanofabrication facility.

Specimen preparation devices:

- Emscope SC500 Au sputter coater
- Diamond blade slow speed saw
- SBT Model 910 lapping and polishing machine
- Branson 2200 ultrasonic cleaner
- VCR Group Inc. Dimpler D500i
- Gatan Inc. Model 691 PIPS
- Leica stereo microscope ZOOM 2000
- Intek optical microscope

Users of the facility:

The Facility is accessible to all qualified researchers at UNL, at other universities and in industrial and other laboratories on payment of the appropriate charges.

Under normal circumstance, these researchers will be expected to have the requisite background knowledge for electron characterization of materials before some training will be given for a particular instrument.

In some cases, research collaboration is possible for common research interests and/or if researchers need the capabilities of the equipment and experienced examination of samples but are unable to use the facilities for themselves. Limited full service handling and examination of materials is available for these researchers according to availability of the facility specialist.