Introduction of Transmission Electron Microscopy (TEM) and Sample Preparation Laboratory in Harry Reid Center, UNLV

UNLV’s TRP (Transmutation Research Program) has been responsible for establishing the electron microscopy facilities to assist UNLV multi-discipline research. Through almost two years’ efforts, the TEM and its sample preparation lab are ready for serving the research activities from various academic departments of UNLV. The capability and functionality of the two labs are introduced below.

1. TEM Lab

A 300 KV field emission TECNAI-F30-Super-twin TEM is located in room 145, HRC. As high as 300 KV acceleration voltages allow the Tecani F30 to reach a point resolution of 0.2 nm, line resolution of 0.10nm, and information limit of 0.14nm. The high resolution capabilities will obtain the information about atomic structure of the specimen. This TEM system is fully loaded including HAADF (high angle annular dark field) detector, EDX (X-ray energy disperse spectrometry), and GIF (Gatan Image Filter).

Integration microscope with HAADF detector allows TEM to perform STEM (scanning transmission electron microscopy) mode. Since the defects of image lens such as chromatic aberration is absent during STEM imaging, STEM mode is used for high resolution image, microanalysis, and micro-diffraction at the atomic level.

EDX system attached on TEM is able to detect the characteristic X-ray and produce spectra, and then separate them into a spectrum according to their energy, when the electron beam interacts with a TEM specimen. Through the rapid signal processing, the system is able to identify all the elements above Li in the periodic table present in the specimen.

GIF system is a powerful technique that can drastically enhance image contrast and resolution in TEM, as well as quickly obtain highly sensitive elemental maps with a large number of pixels. GIF also allows the TEM system to perform EFTEM (energy-filter transmission microscope) mode, which can remove the inelastically scattered electrons resulting in remarkable contrast enhancement and resolution improvement of even very thick TEM specimens. The EFTEM mode can acquire several images of different energy ranges and combines them to form a quantitative element map. Another powerful technique of GIF is EELS (electron energy-loss spectrometry), which can be employed to analyze the energy distribution of electrons that have interacted inelastically with the specimen. These inelastic collisions include a number of information about the electronic structure of the specimen atoms, which in turn reveals details of the nature of these atoms, their bonding, nearest-neighbor distributions, and their dielectric response.

The whole TECNAI-F30 system is full computer control under Windows NT operating system. The remote control function allows the instrument to be operated outside the TEM room. The microscope control software package, TIA (TECNAI image analysis) system, includes various optional functions to meet the particular requirements from various disciplines such as life science, biology, and materials science. Currently, we only purchased the low dose function applicable for biology research. Other function can be added in the system at any time if needing.

2. Sample Preparation Lab
Specimen preparation is very important for TEM or SEM observation and analysis. There are many ways available for preparing TEM sample. Minimum of artifacts during preparing sample is the first consideration, when choosing the sample preparation technique. Combining with the existing SEM / Micro-prob sample preparation facilities, the facilities of TEM sample preparation has been established for preparing TEM or SEM sample, focusing on metallic materials, semiconductors, ceramics, and geo-science samples. The lab is located in Technology Building, TEC 121, and the available facilities for TEM sample preparation and their capabilities are listed below:

1. **Buehler Isomet Low Speed Diamond Saw**
   The Isomet low speed saw is a precision sectioning saw designed for cutting all types of materials, including metallic materials, composites, cermets, plastics, laminates, and electronic devices, with little or no deformation.

2. **Buehler Tech-Met Grinder/Polisher**
   The Tech-Met Grinder/Polisher has variable speeds from 50-500 rpm and 8-inch platen, allowing the TEM specimen or optical microstructure sample to be ground or polished.

3. **Allied High Tech. Inc MultiPrep™ System**
   The MultiPrep™ System enables precise semiautomatic sample preparation of a wide range of materials for microscopic (optical, SEM, TEM, AFM, etc.) evaluation. Capabilities include parallel polishing, precise angle polishing, site-specific polishing or any combination thereof.

4. **Southbay Technology Inc. D500i Dimpler system**
   Dimpling is an indispensable procedure during preparing TEM sample, especially for semiconductor and cross-section sample. Before sample is finally by ion mill, sample need dimpling to reduce the following ion milling time. D500i Dimpler is a precision electro-mechanical metallographic lapping instrument. It continuously monitors and controls dimpling parameters and accurately terminates at preset specimen thickness. D500i is applicable for ceramics, brittle metals, and silicon, etc.

5. **Fischione Instruments Inc. Model 1010 LAMP (low angle milling and polishing) system**
   The Model 1010 Ion Mill is an advanced, compact, table-top, precision ion milling/polishing system, which consistently produces high-quality TEM specimens with large electron transparent areas. The uniqueness of this system is low angle and low energy ion beam, and LN2 cold stage, which enable the system to eliminate the shadowing effects of the sample holder, radiation damage, and specimen heating. These features allow Model 1010 LAMP to be applicable for polymer, layered or composite materials, and thin film in cross-section, in addition to general materials.

6. **Struers TenuPol-5 Electrolytic Polishing System**
   Electropolishing technique has been primarily employed to prepare TEM specimens of metallic materials. Recently, this technique is also applicable for superconductors such as YBa$_2$Cu$_3$O$_7$. In electropolishing, two acid electrolyte flows are pumped by a jet to simultaneously impact on the both side of a specimen disc, forming an anodic film of electrolyte on the specimen surface. Through an electro-chemical reaction, this film removes material from the specimen surface. Finally, an electron transparent thin area is obtained.
7. Zess Stemi DV-4 Stereomicroscope

This microscope has a high-intensity halogen illuminator with three illumination modes: bright-field reflected light, bright-field transmitted light, and mixed lighted. This microscope with x8-32 zoom stereo is able to utilize to examine electron devices, TEM or SEM sample surface, etc.