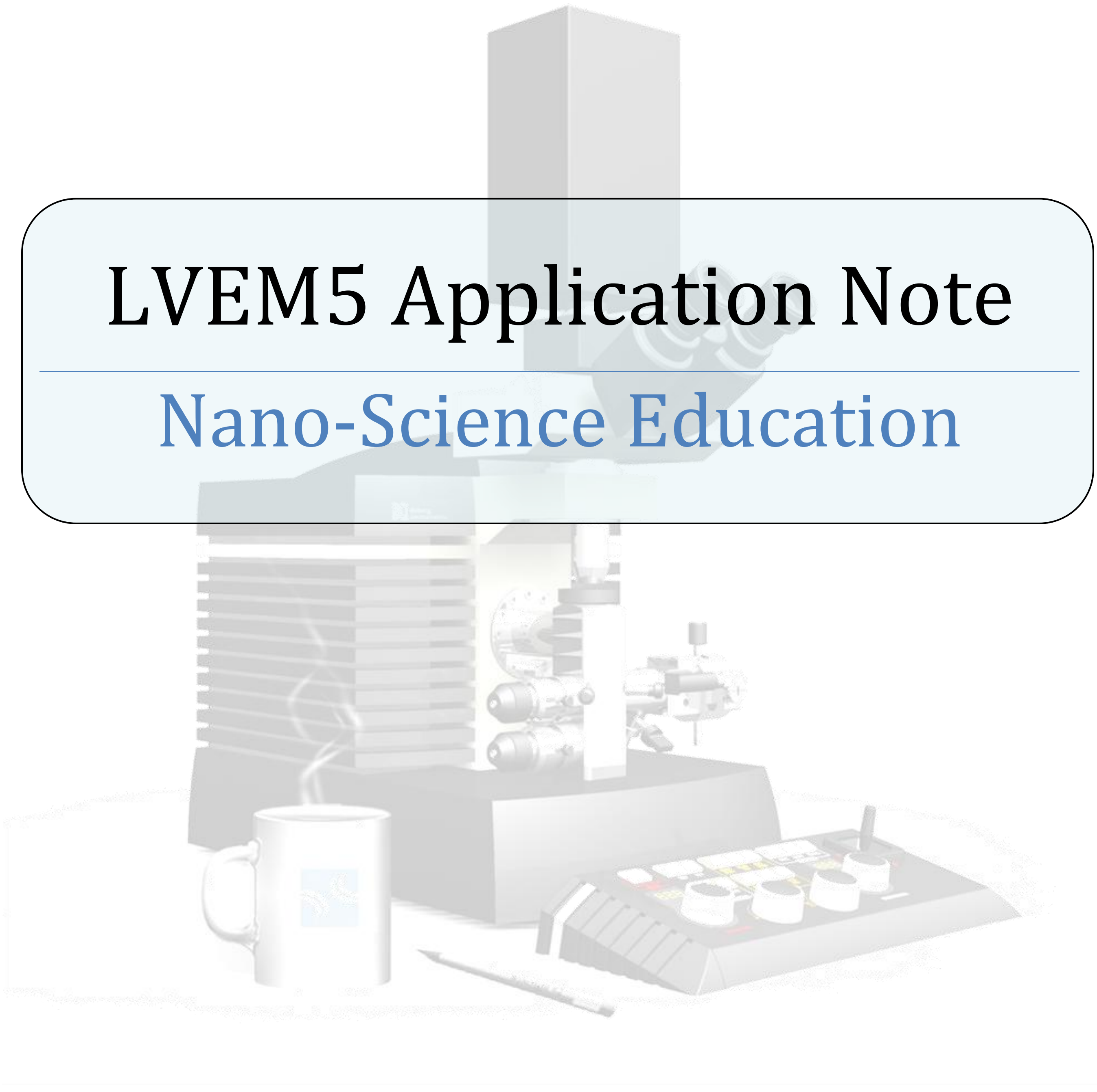
LVEM5 Application Note

Nano-Science Education



Delong America
LVEM5 Benchtop TEM
TEM · SEM · STEM · ED

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LVEM5 in Nano-Science Education

Introduction

We are in the infancy of a technological revolution promising to have the power to change the world. Recent advances in the field of nanotechnology have initiated a global paradigm shift which is positioning nano-science as one of the largest multidisciplinary technologies to date. It seems as though almost every area of the material and life-sciences has benefitted from going beyond the micro-scale and into the nano-scale. The National Science Foundation (NSF) has estimated that we would need up to two million trained nanotechnologists worldwide by 2015. Currently, there are only approximately 20,000. (National Nanotechnology Initative, NNI, 2009).

By implementing nanotechnology into the undergraduate education program at the early stage, an engaging environment is created; in which students broaden their horizons for science, math, engineering, and technology, while preparing them for their places in the future nano-driven employment. (Dudas & Tsung-chow, 2004)

The LVEM5 is a multimodal electro-optical imaging tool designed to be used in the lab or classroom. It is currently in use in institutional and private research labs around the world in many exciting disciplines of nano-science. The LVEM5 is well positioned as an educational tool to give students at the high school and college level an early introduction to nano-science. The LVEM5 will introduce students to three different imaging techniques that are together the fundamental backbone of the nano-sciences; Transmission Electron microscopy (TEM), Scanning Electron Microscopy (SEM), and Scanning Transmission Electron Microscopy (STEM). Whether it is developing more efficient solar cells or finding a new cancer treatment, the LVEM5 is well suited to prepare students for entry into many areas of the materials or life-sciences.

The LVEM5 can be used in the introduction of students to these and many other 'nano' disciplines

- Antibody Development
- Cancer Research
- Carbon Nanotubes
- Cell Biology
- Drug Discovery
- Histology
- Materials Science
- Micro-electronics
- Nanoparticle Synthesis
- Pathology
- Polymer Sciences
- Protein Research
- Tissue Samples
- Virology
- Toxicology

LVEM5 in Nano-Science Education

The LVEM5

Accessible

The LVEM5 is so remarkably simple that anyone can use it. No longer will only highly trained technicians be able to take meaningful electron micrographs. The controls are intuitively configured on an ergonomically designed remote control panel that can be positioned as required. Feedback is provided directly on the control panel as well as through the LVME5's comprehensive software. Every installation of a LVEM5 includes personalized on-site training for your course technicians. Students will be able to operate the instrument after a brief introduction and minimal supervision. If support or assistance is ever needed, the LVEM5 technical staff is readily available by phone or email.

Versatile

The LVEM5 is already an ideal addition to many laboratories doing research in nano-sciences. Its multimodal imaging capabilities makes it a comprehensive imaging tool. The LVEM5 is truly a 3-in-1 electron microscope. Not only is it a Transmission Electron Microscope (TEM), but it can be configured with up to two different scanning modes for use as a Scanning Election Microscope (SEM) and a Scanning Transmission Electron Microscope (STEM). With the LVEM5 you can switch between imaging modes without moving your sample. This way you can capture both surface and transmission images from the same area of interest. With only one tool you can significantly improve the understanding of your nano materials.

Miniature Form Factor

The LVEM5 is the only multi-modal electron microscope available in a benchtop configuration. You will no longer need to coordinate a field trip to your institutions core facility as the laboratory portion of your nanotech courses. The LVEM5's miniature size means that it can be installed in your teaching laboratory, right where you need it, so that your students will earn real hands on experience. The LVEM5 does not require a dedicated facility for installation. No special power or cooling requirements are needed and vibration isolation is generally not a concern.

Resolution & Contrast

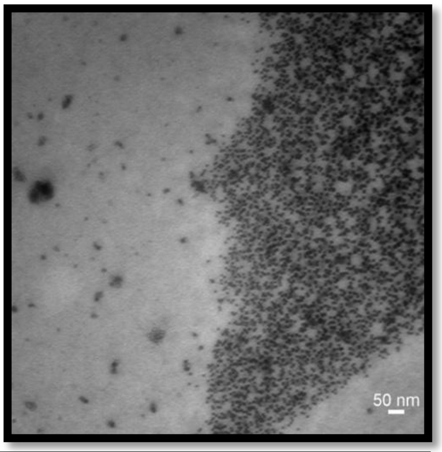
Don't let the small size of the LVEM5 mislead you. It may be miniature in size but it's a giant advantage in the lab. The LVEM5 is capable of resolving objects as small as 2 nanometers in transmission and scanning modes. Additionally, the LVEM5 is capable of producing higher contrast images than a conventional transmission electron microscope without the need for stain. In no way are you sacrificing imaging quality or obtainable resolution with a benchtop configuration. The LVEM5 easily produces high quality images suitable for presentations or publications.

LVEM5 in Nano-Science Education

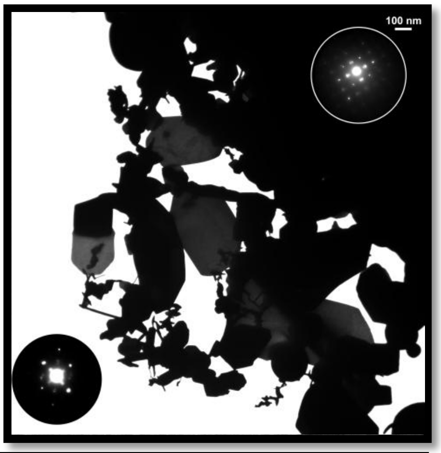
What this all means for your curriculum

The LVEM5 tool will allow you to introduce students to all areas of nanoscale. Real hands-on experience with three different types of Nano-imaging techniques commonly used in industry will certainly give your students a competitive edge upon entry into the workforce.

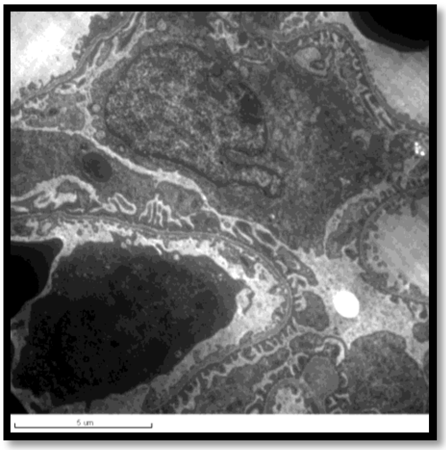
Selected Images



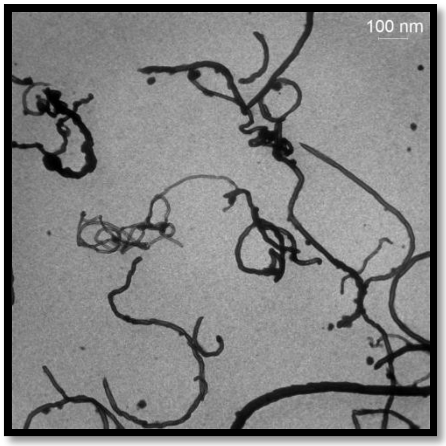
Nanoparticles
TEM Mode



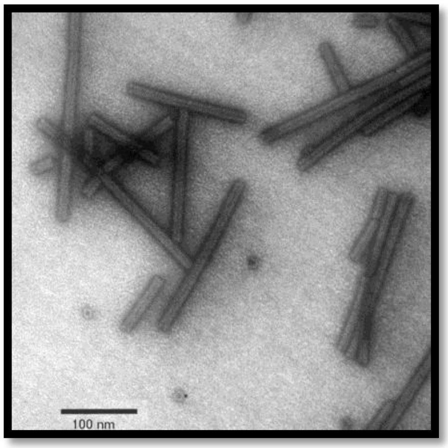
Molybdenum Oxide
TEM Mode
(With diffraction patterns)



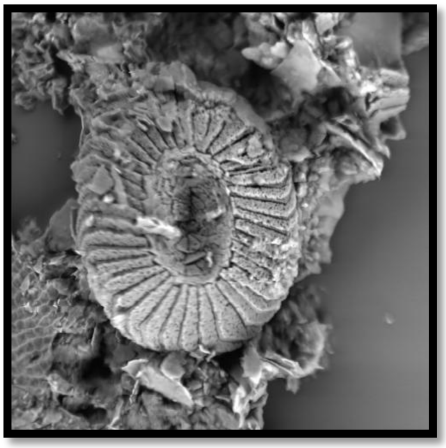
Kidney Tissue
TEM Mode



Multi-Wall Carbon Nanotubes
TEM Mode



Tobacco Mosaic Virus
TEM Mode



Fossilized Shell
SEM Mode

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Specifications

Operation

Nominal accelerating voltage	5 Kv
Specimen Size	Standard ϕ 3.05 mm grids
Time for sample exchange	Approx 3 min.

Electron Optics

Condenser lens	**Permanent magnet**
Focal length*	4.30 nm
The smallest illuminated area	100 nm
Condenser aperture	Φ 50, 30 µm
**calculated for 5 Kv*	
Objective lens	**Permanent magnet**
Focal length*	1.26 mm
C_s (spherical aberration coefficient)	0.64 mm
C_c (chromatic aberration coefficient)	0.89 mm
δ_{theor} (theoretical resolution)	1.12 nm
α_{theor} (theoretical aperture angle)	10^{-2} rad
Objective aperture	Φ 50, 30 µm
**calculated for 5 Kv*	
Projection Lens	**electrostatic**
Magnification on the YAG screen	36-470x
Electron Gun	**SE Cathode ZrO/W[100]**
Current density	0.2mA sr^{-1}
Lifetime	> 2,000 hours

Light Optics

Objective Olympus M 40x	NA 0.90
Objective Olympus M 4x	NA 0.13
Binocular M 10x	
Olympus U-TR30-2 widefield trinocular observation tube	
TEM image capture	
Camera	Retiga 400R CCD
Pixel size	2048 x 2048 pixels
Digitalization	12 bits
Pixel size	7.4 x 7.4 µm
Cooling	Optional Peltier cooling available
Scan image capture	
monitor	512 x 512 pixels
Saving image	Up to 2048 x 2048 pixels
digitalization	8 bits

Imaging Modes

TEM	
Resolving power	2.5 nm
Total magnification	2,500 – 202,0000x
ED	
Minimum probe size	100 nm
Diffraction lens	Magnification 3.5
STEM	
Resolving power	2.0 nm
Minimum magnification	(25 x 25 µm) 6,000x
SEM (BSE detector)	
Resolving power	4 nm
Minimum magnification	(200 x 200 µm) 800x

Vacuum

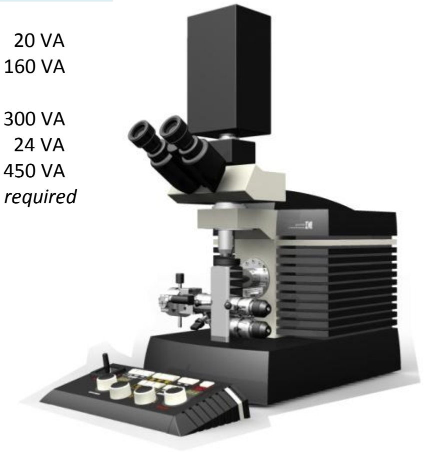
Airlock System	
Diaphragm and turbomolecular pump	10^{-5} mbar
Object space	
Ion getter pump (10 l sec^{-1})	10^{-8} mbar
Electron Gun	
Ion getter pump (7 l sec^{-1})	10^{-9} mbar

Consumption

Control electronics in standby (ion getter pumps only)	20 VA
Control electronics	160 VA
Including airlock pumping system	300 VA
Camera	24 VA
PC and monitor	450 VA
No cooling water for the microscope is required	

Weights and Dimensions

Electron and light optics	
Weight	25 kg
Dimensions (w/o camera)	29 x 45 x 43 cm
Airlock pumping system	
Weight	15 kg
Dimensions	30 x 30 x 34 cm
Control Electronics	
Weight	19 kg
Dimensions	47 x 27 x 27 cm



Works Cited

Dudas, M., & Tsung-chow, J. S. (2004). An Easy Way to Introducing Nanotechnology for Undergraduate Education. *Challenges and Opportunities for Engineering Education, Research and Development.* Miami, Florida.

National Nanotechnology Initative, NNI. (2009). USA.