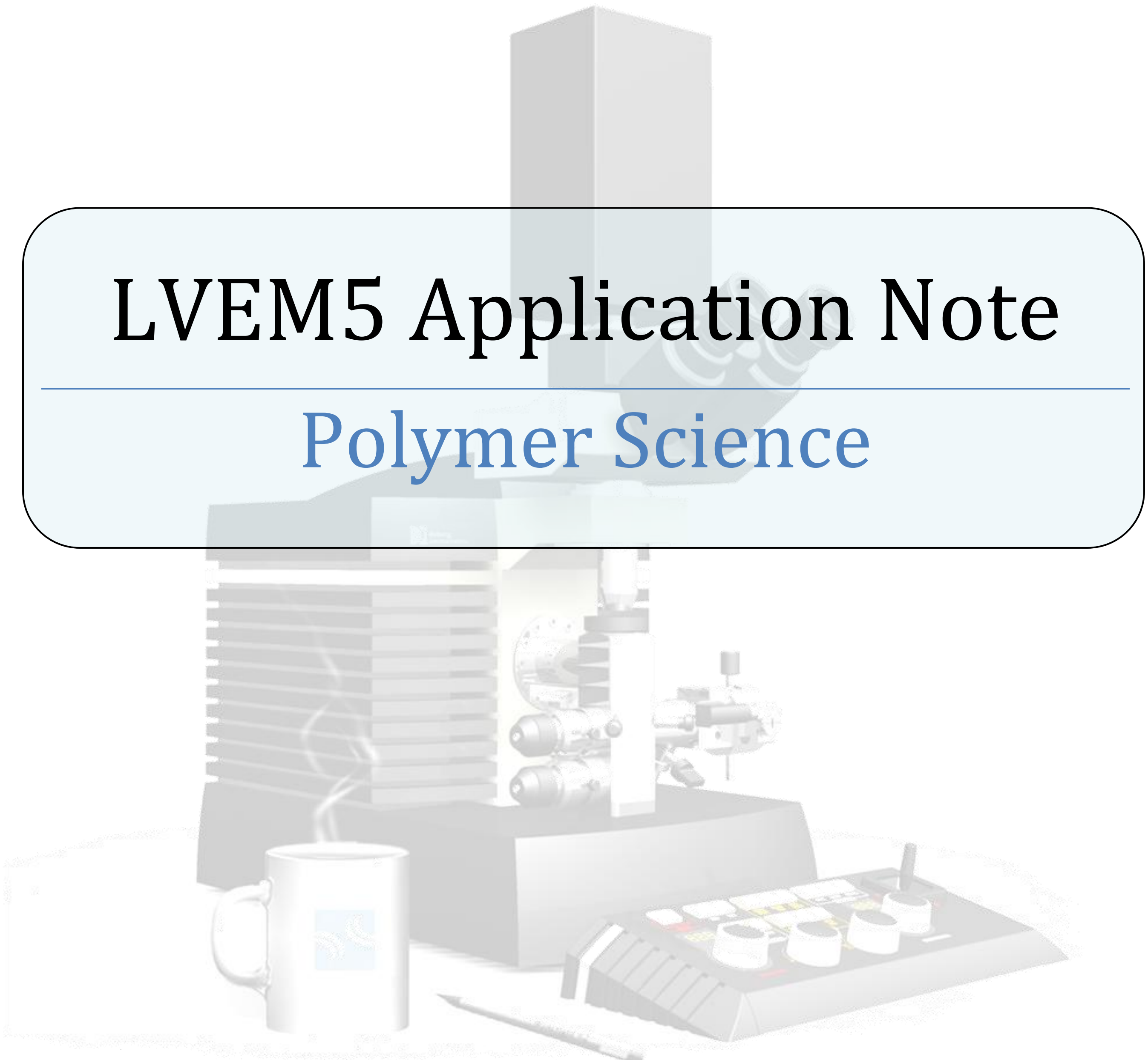
LVEM5 Application Note

Polymer Science



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

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Polymer Science

Introduction

"The LVEM has proven to be particularly useful for the high contrast imaging of a wide variety of polymers, organic molecular thin films, and biological materials. We have obtained images on a variety of systems including polyethylene single crystals, pentacene and TIPS-pentacene thin films, block copolymers, and poly(3,4-ethylene dioxythiophene). We have also found it useful for imaging single dendrimer molecules, as well as a variety of inorganic nanoparticles.

The 5 kV operating voltage significantly increases the TEM image contrast, making it possible to minimize or avoid altogether the use of heavy metal stains that are usually a necessary evil in polymer transmission electron microscopy. These metals, including osmium, ruthenium, tungsten, and uranium, are difficult to work with in the laboratory, can present safety hazards, and may interact with the sample in a way that obscures its native structure.

Another significant advantage of the LVEM is the small chamber size, making it possible to rapidly change samples. Its small footprint makes it possible to locate directly in the lab, providing nearly immediate feedback about sample nanostructure."

- Dr. David C. Martin

Karl W. and Renate Böer Professor
and Chair of Materials Science and Engineering

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David C. Martin Ph. D.

Dr. David C. Martin's research addresses a number of areas in polymer science, with a particular focus on the design and development of materials at the interface between prosthetic devices and living tissue. His work has been supported by the National Science Foundation, the National Institutes of Health, the Army Research Office, NASA, and industry.

Dr. Martin is a fellow of the American Institute of Medical and Biological Engineering and an honorary professor at the Nanjing University of Science and Technology. In the past, he was an Alexander von Humboldt Fellow at the Max Planck Institute for Polymer Research and a Visiting Research Scientist at DuPont.

Dr. Martin earned his Ph.D. in polymer science and engineering from the University of Massachusetts at Amherst.

How the LVEM5 helps

Versatile

The LVEM5 is the ideal addition to any laboratory doing research in Polymer 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 materials.

Miniature Form Factor

The LVEM5 is the only multi-modal electron microscope available in a benchtop configuration. No longer will you need to send batches of samples to a core-imaging facility, wasting time and resources. The LVEM5's miniature size means that it can be installed in your workspace, right where you need it. 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.

Accessible

The LVEM5 is so remarkably simple that anyone can use it. No longer will you need highly trained technicians to take 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. By the end of training, users are capturing meaningful images. If support or assistance is ever needed, the LVEM5 technical staff is readily available by phone or email.

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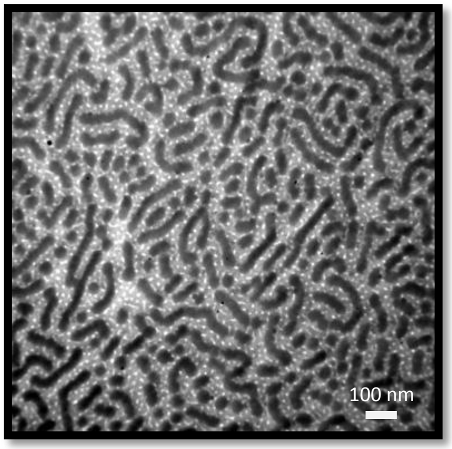
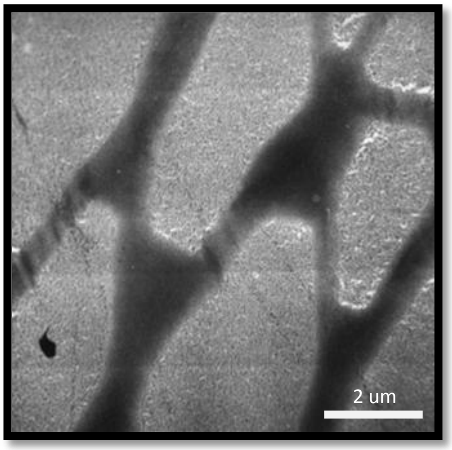
What this all means for you

With the LVEM5 you will be able to resolve the different phases in your polymer sections, filaments, and thin films without the need for stain. Visualizing Polymer nano-structure, its morphology and its defects can be done with ease, all while the material is in its unstained natural state. This can all be easily accomplished in minutes on the LVEM5, right in your own lab. You get all this for a fraction of the price of a conventional electron microscope.

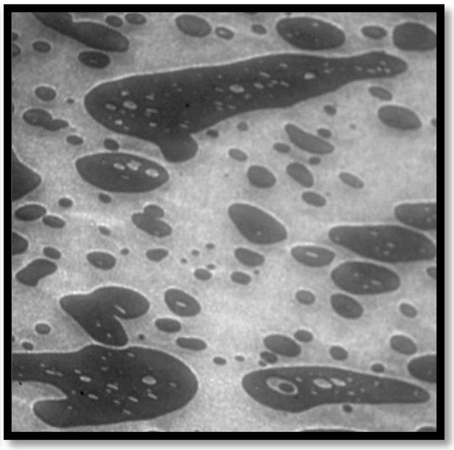
Selected Images



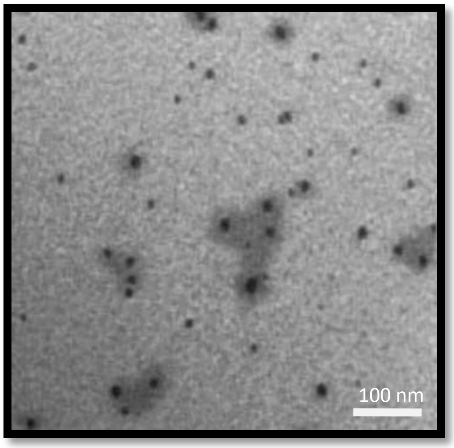
Polystyrene Poly(Methyl Methacrylate) (PS PMMA) Block Copolymer
TEM - *Stained*



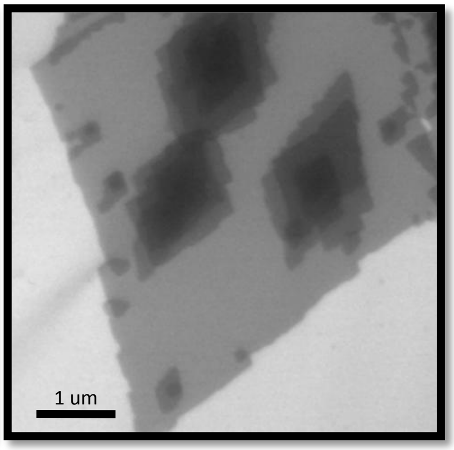
Silk-like Protein with Fibronectin Functionality (SLPF) Electrospun Filaments
TEM - *Unstained*



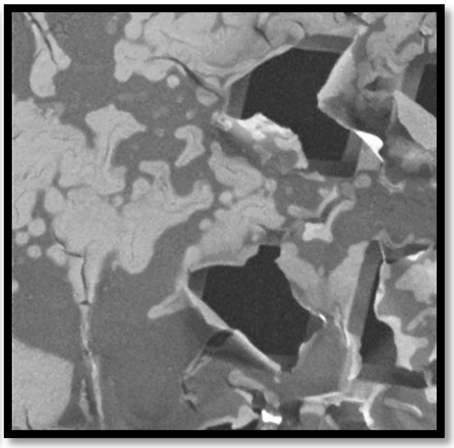
Polycarbonate Poly(Styrene-co-Acrylonitrile) (PC SAN) 50/50 Blend
TEM - *Unstained*



Poly(Amidoamine) (PAMAM) Dendrimers
TEM - *Unstained*



Lamellar Polyethylene (PE) Single Crystals
STEM - *Unstained*



Delaminated Electropolymerized PEDOT\PSS\GOD Film
SEM

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**
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	Peltier cooling
Scan image capture	
monitor	512 x 512 pixels
Saving image	Up to 2048 x 2048 pixels
digitalization	8 bits

Imaging Modes

TEM	
Resolving power	
TEM BOOST	1.2 nm
Basic System	2.0 nm
Total magnification	
TEM BOOST	1,400 – 700,0000x
Basic System	5,000 – 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	3 nm
Minimum magnification	(200 x 200 µm) 640x

Vacuum

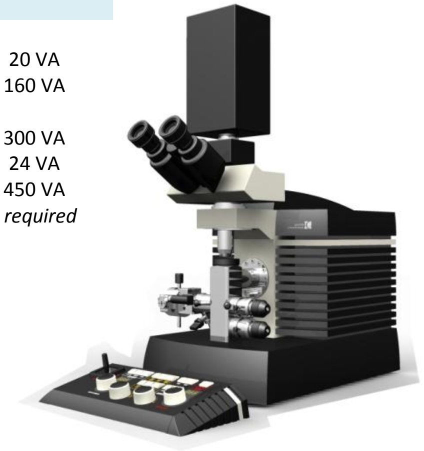
Airlock System	
Diaphragm and turbomolecular pump	10^{-5} mbar
Object space	
Ion getter pump (10 l sec^{-1})	10^{-8} mbar
Electron Gun	
Ion getter pump (7 l sec^{-1})	10^{-9} mbar

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



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