relationships between various features of the specimen. For ease of interpretation, it is desirable that this mapping be simple - we want the image to look like the specimen. Even if no measurements are intended, distortion of the relative distances between various portions of the image conveys a false impression of the specimen under examination. This reduces the ability of the image to impart meaningful information to the microscopist.

Image magnification is obviously related to the linearity of the image, since changes in magnification across an image create distortion. However, a linear image does not guarantee correct magnification, nor does calibrated magnification at one point guarantee that it is calibrated at another point. If the image has the same magnification at every point, the scale is also linear at every point. This argument can also be reversed - if the scale is linear at every point then the magnification is the same at every point - but, in either case, the magnification is unknown until properly calibrated.

The only way to guarantee an accurate image is to check the image field at every point using a known reference. Some calibration specimens require significant labor by the operator to perform this analysis. An easy-to-use calibration specimen will provide markers across the entire image. Diffraction grating replicas, for sample, provide a specimen with this characteristic, as do the MOXTEK calibration specimens. In addition to covering the entire image area, it is important to have easily interpreted calibration markers. This is the weakness with microspheres, for example. Their random distribution in both size and position make it difficult to analyze the image linearity or magnification easily and rapidly.

The proper procedure is to image an appropriate calibration specimen under the operating conditions to be used with your experimental sample. A regular grid or periodic straight lines provide an image which your eye can easily analyze for most distortions. With a little practice, the healthy eye can detect a distortion of down to one or two percent. This provides a quick analysis of the image linearity, either identifying problems which need to be addressed or providing assurance that the image is linear. Once image linearity is established, a quick measurement of the calibrated markings at any point on the image will determine the magnification accuracy for the entire image. The magnification can then be adjusted appropriately.

This is a quick, simple procedure which can be performed in under ten minutes and may save you hours of grief. In addition, when your images are published, you will know they are accurate representations of your sample and that your experimental technique is above reproach. ■

NEW PRODUCT NEWS

Denton Vacuum, Inc. introduced the newest in their series of table top chromium coating units, the Desk II Turbo Sputter Coater, recently at the MSA/MAS/MSC Conference. The Desk II TSC is a totally self-contained turbo molecular pumped sputter/etch unit. Its integral mechanical pump with on-board 80 l/s turbo pump assures faster and safer operation and takes up less space than systems with awkward floor-mounted pumps. The Desk II TSC comes ready-to-operate with all the required pumps and a starter gold target. The Desk II TSC's unique design is the most advanced in the industry. Lighted push buttons arranged logically by function provide sure, easily reproducible films. To monitor gas pressure and electrical current, the Desk II TSC uses reliable solid state electronic bar graphs instead of analog meters. One of the more advanced features of the Desk II TSC is the ability to etch clean surface contamination from non-delicate samples. This allows the imaging of many samples without the need for coating in today's FESEM's. The Denton Desk II TSC also sputters the typical gold, gold-palladium and platinum films in common use today as well as the newer high resolution materials such as chromium and tungsten for use with today's FESEM. Denton Vacuum, Inc.: (609)439-9100, Fax: (609)439-9111, dMail: j_campbell@dentonvacuum.com or http://www.dentonvacuum.com **Circle Reader Inquiry #40**

New Vertical Engage Scanner for MultiMode™ Spumes

Digital Instruments announces a new scanner for its leading line of MultiMode Scanning Probe Microscope (SPM), Atomic Force Microscope (AFM) and Lateral Force Microscope (LFM) systems. The new scanner replaces and improves upon the original "J" scanner by providing direct vertical motion and eliminating lateral movement of the cantilever during engage. The new "JV" scanner greatly simplifies the process of engaging on small features such as optical fibers, specific grain or defect structures, or targeted features of an IC device. It has a nominal scan range of 100-125 µm and is full motorized and computer controlled, with no manual adjustments. Digital Instruments: (800)873-9750, Fax: (805)899-3392. **Circle Reader Inquiry #42**

Easy-to-operate EM 208S Transmission Electron Microscope Offers High-Quality Imaging to Life Science Microscopy

The new EM208S transmission electron microscope from Philips Electron Optics offers microscopists in the life sciences excellent imaging capabilities with a user interface that is clear and easy to use. The instrument has been designed for routine image analysis in life sciences, including pathology, anatomy, histology and virology. It is also ideally suited to many industrial applications, e.g., as an instrument for routine quality control of polymers, photographic emulsions, pigments, paints and cosmetics.

The EM2085 is the successor to the field proven EM208. The instrument now incorporates a number of additional features requested by customers, such as the inclusion of a motorized stage and a color monitor.

To facilitate navigation around the sample, the instrument has a computer-controlled, full motorized specimen stage with a reposition accuracy of better than 2 microns (guaranteed, after changing specimen tip). The specimen stage control software stores the XY positions, allowing automatic exposure sequences. By pressing the exposure button, the microscope will move the motor state to the correct position, change the magnification, illumination and focus condition to user selected values and then make the exposure. This sequence will be repeated automatically until all selected positions have been photographed. In addition, the electric motors are coupled to the manual specimen rods. The mechanism blocks the stage when it would be moved out of the grid, protecting it against undesired forces that might otherwise cause mechanical distortion. Philips Electron Instruments: (201)529-6168, Fax: (201)529-2252. **Circle Reader Inquiry #41.**

USED EQUIPMENT FOR SALE

☎ ***Cambridge Stereoscan 100 SEM with Backscattered Electron Detector.*** In excellent condition, newer turbo-molecular pump, limited usage, under service contract. Call John at (802)656-4504.

☎ **NEWPORT CONFOCAL ATTACHMENT,** VX-100 Spinning Disk Confocal adapter, complete for upright microscope. Dealer's demo unit, like-new condition. When new, was $25,000, asking $15,000. Call Hitech Instruments, Inc.: (800)-4-HITECH(444-8324) or fax: ((610)353-3317.

☎ **MILITARY RESEARCH LAB IS CLOSING.** Military contractor is selling **at drastically reduced prices** its Sorvall ultramicotome, refrigerated and benchtop microtomes, sliding microtome, Tissue Tech embedding center, stereo microscopes, Joyce Loebl microdensitometer and LECO sulfur analyzer. For specification sheets, call: (202)544-0836.

Downloading ImageTool

UTHSCSA ImageTool (IT) is a free image processing and analysis program for Microsoft Windows 95 or Windows NT. IT can acquire, display, edit, analyze, process, compress, save and print gray scale and color images. IT can read and write over 22 common file formats including BMP, PCX, TIF, GIF and JPEG. Image analysis functions include dimensional (distance, angle, perimeter, area) and gray scale measurements (point, line and area histogram with statistics). ImageTool supports standard image processing functions such as contrast manipulation, sharpening, smoothing, edge detection, median filtering and spatial convolutions with user-defined convolution masks. IT also has built-in macro capabilities that allow the user to record repetitive tasks and playback saved macros to automate image analysis.

ImageTool was designed with an open architecture that provides extensibility via a variety of plug-ins. Support for image acquisition using either Adobe Photoshop plug-ins or Twain scanners is built-in. Custom analysis and processing plug-ins can be developed using the software development kit (SDK) provided (with source code). This approach makes it possible to solve almost any data acquisition or analysis problem with IT

ImageTool provides for geometric transformations such as rotate, flip vertical, flip horizontal and magnification up to four levels. All analysis and processing functions are available at any magnification factor. The program is a multiple document interface (MDI) application supporting any number of windows (images) simultaneously.

Spatial calibration is available to indicate real world dimensional measurements such as millimeters, microns, feet, miles, etc. for linear and area. Density or gray scale calibration can be done relative to radiation or optical density (OD) standards.

IT version 1.1 now provides for object analysis and classification with over 20 morphological descriptors such as: area/perimeter, roundness, ferret diameter, compactness, major/minor axis length, centroid and many others. Any of these factors can be used automatically categorized and count objects within the image.

ImageTool ver. 1.1 supports the Data Translation DT3155 frame grabber for Windows NT. Other frame grabber boards will be added in the coming months.

UTHSCSA ImageTool is available via anonymous ftp at ftp://maxrad6.uthscsa.edu:

A CORRECTION:

In "Resolutions Considerationss for Photomacrography and Photomicroscopy", page 10 iin our May 1996 issue, the equation in 4) should read: $(2\ \text{Print Resolution})^2 = (2\ \text{Max Print Resolution})^2 + C^2$. The area of the blurr circle from the combined diffraction and geometric blurr's is equal to the sum of the blurr circle areas. Table 1 is based upon this correct relationship.

A Few Remarkable TEM Facts

Phil Fraundorf, University of Missouri

What follows is a list of some physical perspectives on the electrons used routinely for transmission electron microscopy. Without knowing it, you may on a daily basis be putting to practical use things, like the wave nature of electrons, that were inconceivable in the early part of this century. In fact, some of the properties of these electrons may be only marginally conceivable today!

Fast Electrons: A back of the envelope calculation for 300 keV electrons gives gamma = (300=511)/511 = 1.587, so that they travel at $w = c^2[1-(1\text{-gamma})^2] = 0.777\ c$ or (lightyears per inertial year) of elapsed time. However, if we consider traveler (i.e., electron or proper) time for such a speeding electron, this would give that the travel u = gamma*w = 1.232 lightyears per traveler year of elapsed time! With this spatial 4-vector velocity well over c, we're dealing with relativity in action! I wonder how many g's of acceleration they experience in the electron gun in order to get up to speed? For more on this subject, you might want to check our browser-interactive relativistic Accel-One problem solver, and the theory pages attached, at http://newton.umsl.edu/-run/index.html

Lonely Electrons: I think that it was John Armstrong at Caltech who once pointed out to me that the number of microscope beam electrons in your TEM specimen at any one time is so small that the odds of such electrons interfering with each other to form diffraction patterns is quite small. The vertical separation between electrons in the column is *well*, where I is the specimen current, w is the electron inertial velocity, and e is the charge per electron. For an nanoamp of 300 kV electrons, this is $(0.777 \times 3\times10^8\ m/s) \times (1.6 \times 10^{-19}\ C/e) / (10^{-9}\ C/s) = 0.037\ m/e$. Under some illumination conditions there may be no more than 1 beam electron in the column at a time! Hence diffraction patterns in the TEM are basically formed by individual elections interfering with themselves! As you know, such interference will occur only if we don't take steps to determine the path of individual electrons through the specimen! If we look too closely at these paths, the diffraction patterns would disappear (cf. Englert et al., *Scientific American*, Dec. 1994, 86-92 on quantum erasure).

Fat Electrons: The transverse coherence widths of electrons which make possible electron phase contrast (HREM) lattice imaging and probably electron holography might also be seen as lateral broadening of individual electron wave-packets via the uncertainty principle, which results because we know too much about their transverse momentum! My intuition tells me that we're talking about lateral wave-function spreads of, say, 15 Angstroms in a LaB_6 HREM to more than 100 Angstroms in field emission gun systems. Are these numbers reasonable? By increasing the spread of electron angles in the incident beam, this transverse coherence width can presumably be decreased (e.g., you want it small for Z-contrast imaging (I think), or varied as in the variable coherence-width strategies of Murray Gibson at U. of I.

Long Electrons: The tight tolerances on high voltage stability and the emitted spread in electron energies means that our uncertainty in the longitudinal momentum of TEM electrons is quite small, and hence again by the uncertainty principle that the wave-packet spread in the direction of motion for TEM electron can be quite large. Distances of, say, 1000 Angstroms come to mind! The associated tight distribution of incident electron energies decreases chromatic and instability damping of fine details in CTEM and HREM images, so that for most applications you may want your electrons "as long as possible". An exception might be in variable-coherence strategies (mentioned above), where shorter electrons might provide sensitivity to shorter-range vertical correletions.

The foregoing thoughts on fast, lonely, fat, and long electrons are not really things I've had time to think much about, but they are interesting, and hence I would enjoy other perspectives on them, as well as suggestions for other "remarkable TEM facts" to add to the list! A "live" draft of this list will be accessible through our scanned Tip & Electron Image Lab page at: http://newton.umsl.edu/stei-lab/