Proceedings of the Iowa Academy of Science

Volume 76 | Annual Issue Article 45

1969

Closed-Circuit Television in Electron Microscopy

Elmer A. Rosauer
Iowa State University

Closed-Circuit Television in Electron Microscopy

ELMER A. ROSAUER[1]

Abstract. Closed-circuit television adapts well to the educational aspects of electron microscopy in terms of extending immediate student participation. The advantages and some examples of the dual role in education and research of such a system are presented.

A research electron microscope is invariably called upon to flex its educational muscles. One which does so regularly is operated by the Iowa State University Engineering Research Institute. Undergraduate and graduate courses in electron microscopy of inorganic materials are offered on a regular basis by the Department of Ceramic Engineering at Iowa State University. An electron microscope suffers from the same educational drawback as its light counterpart; namely, direct viewing of the electron image on the fluorescent screen is limited to a few observers. This situation ideally lends itself to the use of closed-circuit television. Experience has shown that research dividends are also realized.

The microscope at Iowa State, a Siemens ELMISKOP I, was purchased in 1962 and has been updated with accessories from time to time. A part of the electron microscope fluorescent screen is imaged through suitable light optics onto the target of a Vidicon. This image is converted into an electrical signal, amplified, and reconstructed into an optical image on a television screen.

The light optics consist of a tandem lens, which includes a 70 mm f 1.4 Heligon and a 140 mm f 2.8 Lumar. The Heligon f stop is variable from 1.4 to 8.0. Tandem optics are preferable to single optics since the light intensity falling on the Vidicon plate is increased by a factor of 2.25. The Vidicon camera tube, also known in Europe as a Resistron, is extremely sensitive to light and can pick up objects under conditions where a luxmeter held facing the object would register about 30 lux. In low light applications the Vidicon can have a better signal-to-noise ratio than an Orthicon. A tremendous advantage of the Vidicon is that it does not retain the optical image even after the object has been removed. The tandem lens and Vidicon tube are housed in a conveniently small unit which also contains the associated deflection circuit, the video preamplifier and a transistorized combined protection and blanking circuit. The complete camera circuitry is transistorized except the amplifier input.

A separate control unit generates and shapes the required waveforms, amplifies the video signal from the camera, and mixes it

[1] Department of Ceramic Engineering and Engineering Research Institute, Iowa State University, Ames, Iowa.

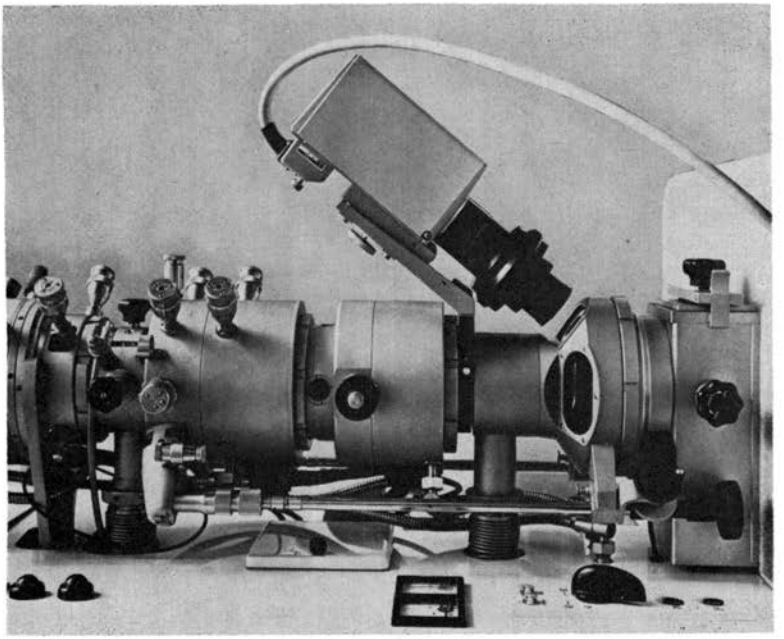

Fig. 1. TV camera with tandem lens is aimed at fluorescent screen through one of three available viewing ports.

with the required synchronizing pulses to generate a composite video signal of 1.5 V peak-to-peak white positive into 60 ohms. The control unit also houses a light sensitivity control which automatically varies the camera tube target voltage to regulate its sensitivity to ambient illumination, thus providing the best possible picture. A frequency divider in the control unit produces a two-to-one odd-line interlaced scanning mode with 525 lines/frame and 60 fields/sec.

The first transmitted image is displayed on a 17 cm control monitor which has its own controls for brightness and contrast. The audience display monitor is 36 cm in diameter and normally has its own image controls. However, since the display monitor is some distance from the microscope operator, these image controls have been rewired into a small control panel beside the first control monitor. A position switch was incorporated to permit filament preheating, thereby extending useful tube life. The entire television system is powered through a regulated microscope outlet of 220 V, 60 Hz.

In practice, the camera replaces the binoculars on a swivel mount and is aimed at the fluorescent screen. The optic axis of the camera or binoculars is positioned at an angle of 36° with the

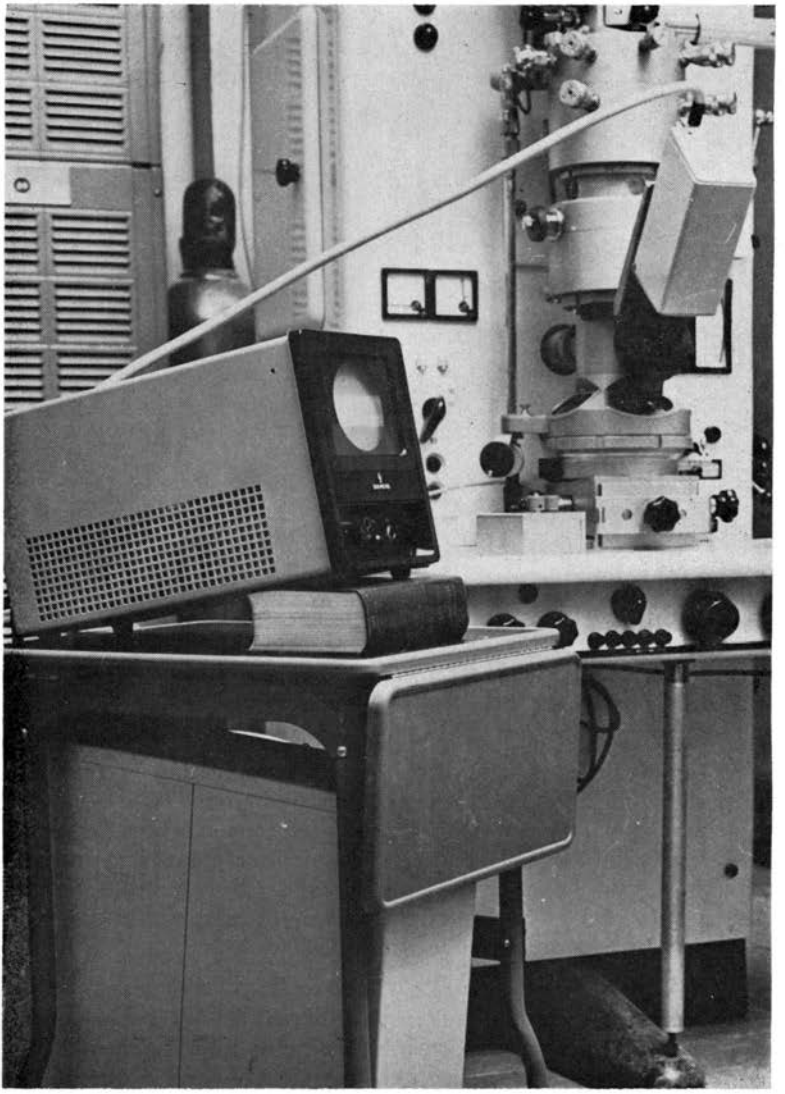

Fig. 2. Small box on microscope table has intensity and contrast controls for the wall-mounted monitor. Control monitor in foreground has its own controls. Control unit is visible under the monitor.

electron-optic axis of the microscope. When the electron image is viewed with the camera or binoculars, the fluorescent screen is positioned normal to their common axis. The entire camera may be translated normal to the fluorescent screen to obtain best focus. It is convenient to mount the control unit in the lower part of a secretarial typewriter stand with the control monitor on the stand

top. Then the control monitor may be conveniently rolled in place beside the microscope so the operator may observe what the camera is imaging. The area of the fluorescent screen imaged by the camera is 25 mm in diameter. The control monitor displays this image with a 4x magnification. An image is produced on the display monitor with a 14x magnification. Brightness and contrast controls are all within easy reach of the operator. The display monitor is wall-mounted about 8 ft. from the floor to provide unobstructed viewing for a large group of seated or standing observers. The microscope room was planned large enough to accommodate accessory microscope instrumentation as well as about one dozen seated students.

The graduate-level course is designed to present sufficient theory on electron optics and microscope operation so each student can work at the microscope independently. Normally such instruction would involve a tremendous amount of time in personal demonstration for each student. With the television system, demonstrations of microscope operation can be performed for the entire group of students while the instructor is able to maintain personal contact with each student.

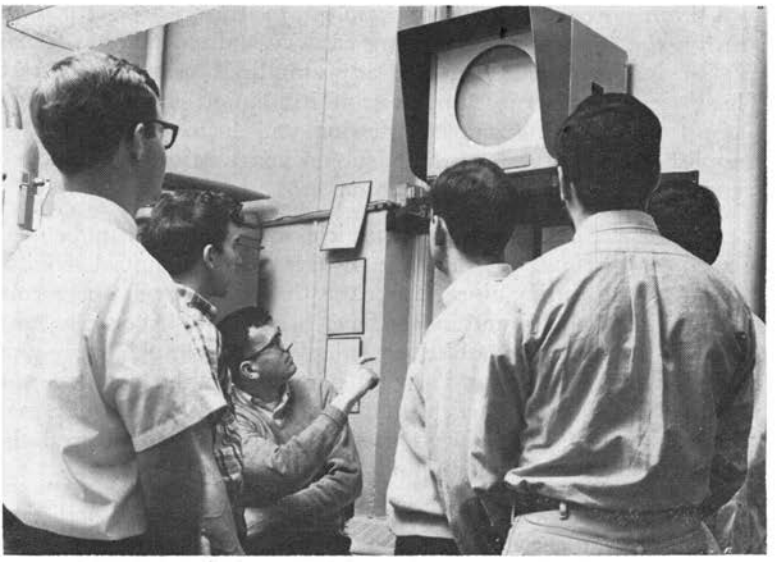

Fig. 3. Students discuss the electron microscope image on the display monitor.

As the instructor discusses different microscope operations in terms of what is being televised, the students may view the operation being performed at the miscroscope or view the image change

on the display monitor. For example, the paraxial and corresponding diffraction images of a crystal may be displayed in the normal bright field manner. Insertion of a suitable objective aperture removes the diffraction images and enhances contrast. Shifting the objective aperture off axis results in a dark field image. By removing the objective aperture and inserting a suitable aperture in the intermediate lens and focusing this lens on the back focal plane of the objective lens, a selected diffraction image is displayed. If one of the diffraction spots is selected with an objective aperture and the selector aperture in the intermediate lens is removed while the strength of the intermediate lens is increased, the diffraction spot will appear bright in a dark field. Simple focusing and compensation of objective lens astigmatism on the basis of Fresnel fringes are easily observable. Thus, within a short time, the instructor may effectively demonstrate electromagnetic lens focusing action and the mechanism of image formation.

The television system requires very little adjustment in brightness or contrast due to the automatic light sensitivity control in the control unit. Unusually bright electron images can be accommodated by stopping the Heligon lens from f 1.4 down to f 8.0. The direct beam in selected diffraction images may be removed by a beam stop above the fluorescent screen. Images too faint to be seen on the fluorescent screen are easily visualized on the display monitor by opening the lens and adjusting brightness and contrast. Thus, specimens subject to electron irradiation damage can be successfully viewed. Complete viewing and focusing may be accomplished on the basis of the television image prior to permanent recording on a photographic emulsion.

Experience has shown that particle size analyses can be performed rapidly on a routine basis. In this case the control monitor is used for measuring since it is close to the specimen stage controls. Both graticules and rulers have been used successfully, and measurements may be tabled or entered on a simple paper-tape adding machine. As many as 500 particles can be counted and measured in 30 min. Particle shape and surface morphology may be noted as well. It is always possible to permanently record the electron image by conventional photography.

Work is underway to reduce the time necessary for statistical particle size measurements as well as to make the measurements more quantitative in terms of particle morphology. This involves computerizing digital information obtained from video-taped scans.

Closed-circuit television offers particularly satisfying educational advantages in electron microscopy. Research advantages, in terms of minimizing electron beam damage and obtaining quantitative image information, can also be realized.

ACKNOWLEDGMENTS

The television system described was purchased with funds made available by the Engineering Research Institute. Appreciation is expressed for the encouragement and support for work in this area freely given by Dr. D. R. Boylan, Director of the Engineering Research Institute, and Dr. D. R. Wilder, Head of the Department of Ceramic Engineering.