CONF-790813--4 PREPRINT UCRL- 82408

Lawrence Livermore Laboratory

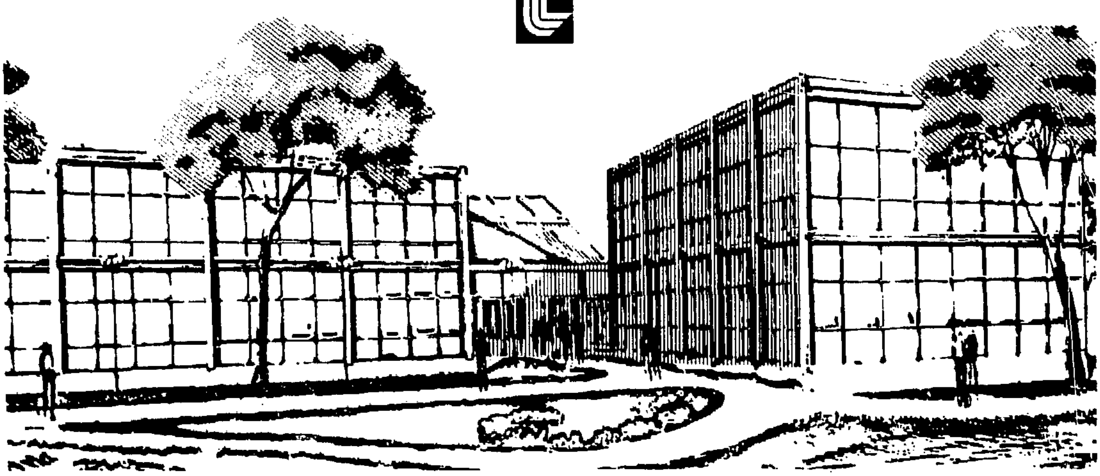
FULL SURFACE EXAMINATION OF SMALL SPHERES WITH A COMPUTER CONTROLLED SCANNING ELECTRON MICROSCOPE

C. M. Ward, D. L. Willenborg and K. L. Montgomery

February 28, 1979

This paper was prepared for submission to the
14th Annual Meeting of the Microbeam Analysis Society
San Antonio, Texas, August 13-17, 1979

MASTER



FULL SURFACE EXAMINATION OF SMALL SPHERES WITH A COMPUTER CONTROLLED SCANNING ELECTRON MICROSCOPE*

C. M. Ward, D. L. Willenborg, K. L. Montgomery

Lawrence Livermore Laboratory
Post Office Box 5508
Livermore, California 94550

-----

*This work was performed under the auspices of the U.S. Department of Energy at Lawrence Livermore Laboratory under contract number W-7405-Eng-48.

Targets for inertial confinement laser fusion experiments require 70-300 μm diameter glass spheres which meet precise dimensional requirements including surface finishes better than a few thousand angstroms. Interferometry is effective in detecting defects down to a spatial width of a micron and is routinely used in target selection.[1] Submicron wide defects are observed using Scanning Electron Microscopy (SEM) where the high resolution and easy image interpretation is effective. The main disadvantage of SEM examination has been the necessity to permanently attach a sample to a mount preventing an acceptable sphere from being used as a target. A manual rotation SEM stage demonstrated that it is possible to manipulate spheres and examine them through 4π steradians.[2] Application of this stage to target selection showed that many apparently good spheres contained unacceptable submicron defects which were not being picked up in other inspections. Consequently, a computer automated stage and SEM system for spheres as shown in Figure 1 has been developed permitting candidate spheres examination prior to inclusion in targets.

The stage in Figure 2 is composed of two groups of slides each having independent Y and Z stepper motor driven motions. On each slide group is mounted a glass capillary having a plane surface formed on the end in conductively coated silicone rubber. A sphere is lightly contained between the rubber tips such that when counter Y and Z motions are applied the sample rotates in place. Using the resultant Z and Y motions, a sphere is scanned from pole to pole along lines of longitude. Under computer control, microspheres are sequentially rotated and a picture is recorded at preset points. A simple inspection requires around 150 pictures at 1000x while careful evaluations may require more than 1000 pictures at magnifications up to 10,000x. During the analysis, the sphere remains in focus and in the field of view.

Primary image recording is made on a raster scanning video disc which is arranged to synchronize with the SEM. In normal operation a SEM picture is recorded on photographic sheet film. This is unacceptable for automatic operation and insufficient to provide rapid feedback as to system operation. A video disc can store up to 300 images with almost instant retrieval and at an acceptable contrast range, however standard units operate at TV sweep rate which is too fast to obtain adequate signal to noise ratio in SEM pictures. We employ a microprocessor based system developed in conjunction with Information Processing Systems of Belmont, California, which has a full line buffer on the input permitting 400 line by 500 point SEM recording at 30 sec to 250 sec frame rates with TV playback. An up to 70 times improvement in signal to noise ratio is achieved. Synchronization of the disc to the SEM permits the computer to tell the disc to step and take a picture with the disc in turn initiating the SEM scan. If the examination requires more than 300 pictures, the system will stop at track 299 and wait for the operator to record the stored images onto video tape prior to continuing.

Operation of the SEM is basically unchanged for 4π steradian examination except that since some scans of over 1000 pictures are necessary, total continuous recording time may exceed 36 hours. This requires that the instrument have sufficient stability to not need readjustment during this time. Achieving this goal has been a matter of electronics adjustment, attention to contamination control and using a stable electron emitter. We use a Broers style electron bombardment heated lantanum hexaboride emitter (LaB_6)[3] which gives high brightness and stable emission for over 100 hours. Experience to date has indicated no problems with SEM stability through even the longest scans.

Figure 3 is a portion of an automated 3000x scan on a 140 μm glass sphere with a ∿ 100 Å carbon coating. Each image from upper left to lower right shows the surface of the sphere rotated by 24° along one longitudinal scan. Initial 4π scans were made viewing normal to the surface. While allowing photo mosaics to be made, these were difficult to use for height measurements. By recording the examination looking over the horizon it is easier to detect significant items and a scan can always be found with the object in profile for a height measurement. The larger defects in these pictures would be detected on an interferometer however many small defects at or below the interferometer resolution can also be seen. The broad light and dark areas on the images are due to charging effects from the thinly coated sphere. An analogue homomorphic processor is used to suppress this where objectionable levels are encountered. Software additionally allows a point on the sphere to be rotated to a position where a side looking Si(Li) x-ray detector can be inserted in front of the secondary detector permitting analysis of defect compositions.

This system is proving to be relatively simple to operate and quite versatile. Its primary application is currently in the understanding of submicron defects on target spheres, and ensuring that spheres used in critical laser fusion experiments meet all surface requirements.

Figure Captions

Figure 1. Full surface examination system layout.

Figure 2. Stepper stage for sphere manipulation

Figure 3. Computerized 4π steradian SEM scan of a carbon coated 140 μm glass sphere at 3000x magnification. Steps are 24° along a line of longitude starting from the upper left.

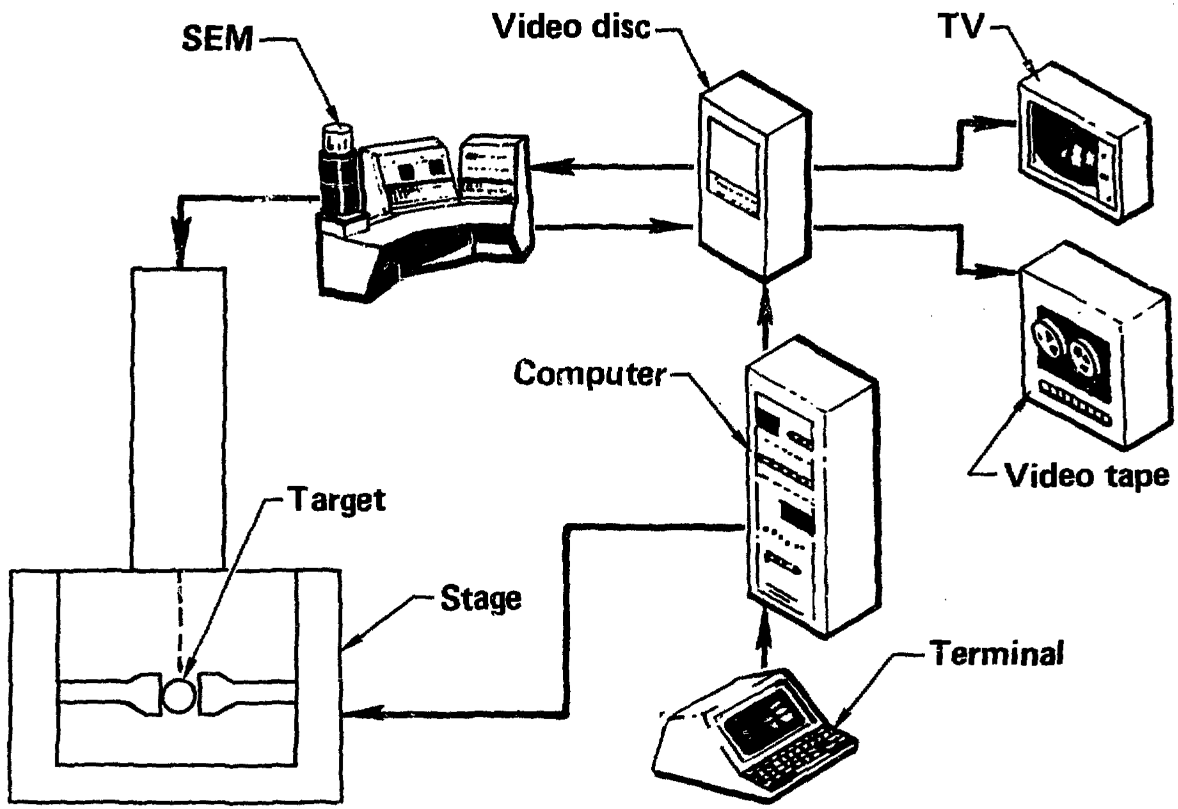
References

1. B. W. Weinstein, C. D. Hendricks, "Interferometric measurement of laser fusion targets", Applied Optics, Vol. 17, 3641, November 15, 1978.

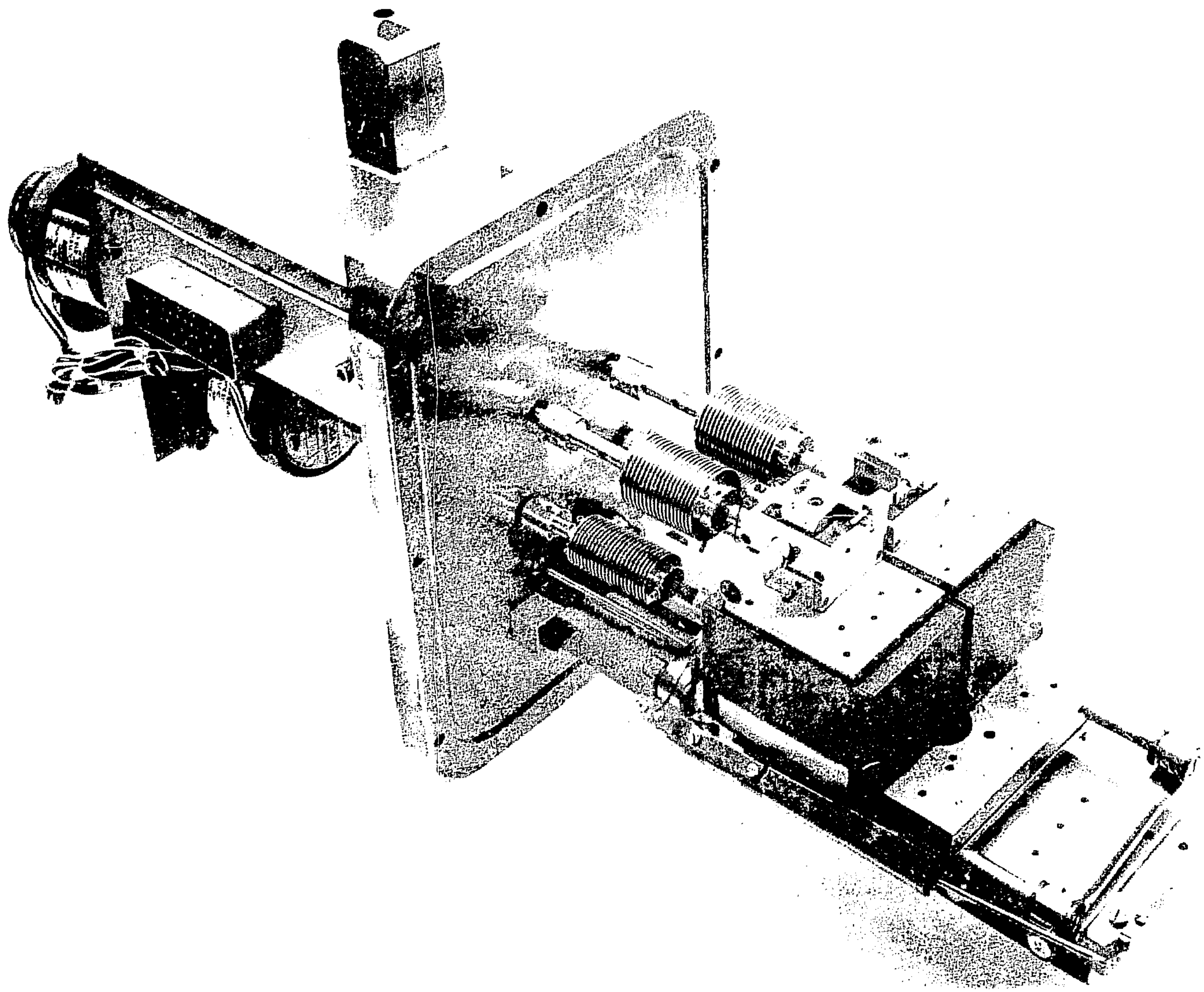
2. C. M. Ward, C. D. Hendricks, B. W. Weinstein, "A technique for full surface examination of small spheres in the scanning electron microscope", Scanning Electron Microscopy, Vol. 1, 783-788, 1978.

3. A. N. Broers, "Recent advances in scanning electron microscopy with LaB_6 cathodes", Scanning Electron Microscopy, 12-18, 1974.

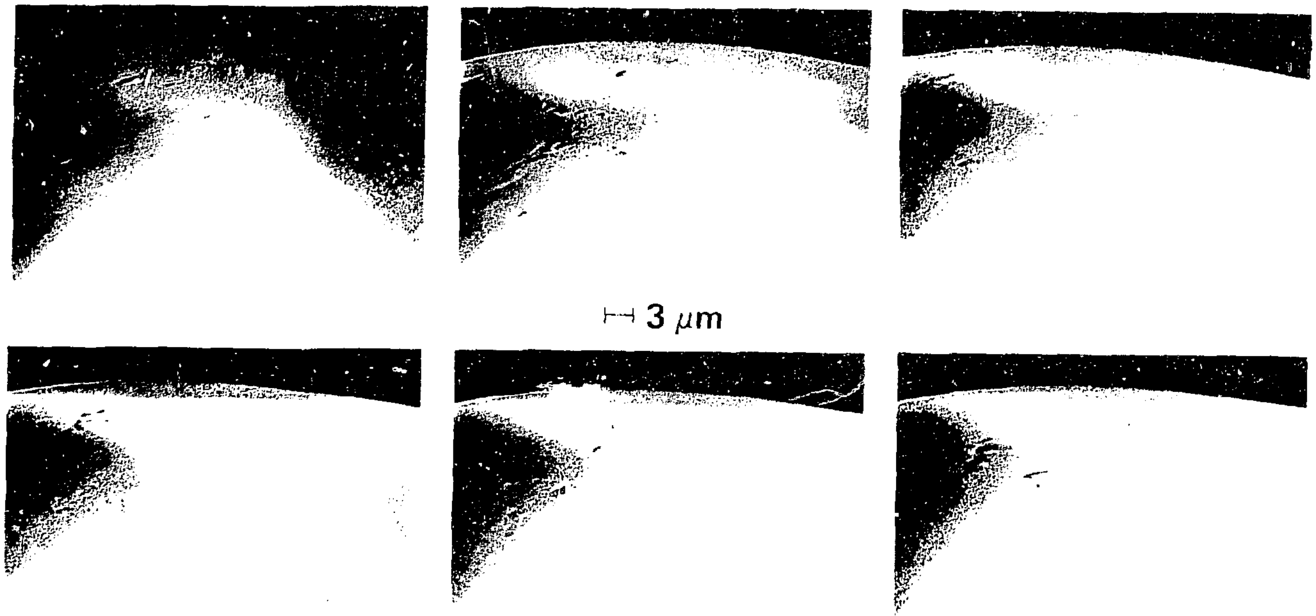
4π SEM EXAMINATION SYSTEM



10-30-1278-4507



COMPUTERIZED 4 Pi SEM SCAN



140 μm Glass sphere carbon coated

24° Per step

3000x magnification

10-30-1278-4605