Argonne National Laboratory

Scanning Confocal Electron Microscope (SCEM): Nanoscale Quality Control in Semiconductor Manufacturing and R&D

In today's technologically driven society, many important electronic/photonic devices are being manufactured at a continuously decreasing scale. To maximize component density and further decrease size, such devices also are being fabricated as multi-layered structures. A well known example is the semiconductor microprocessor, which can have from one to five or more layers in a structure that may be only 2-10 microns thick. Within the individual layers of this device, important features can range in size from about 100 micrometers to 10 nanometers.

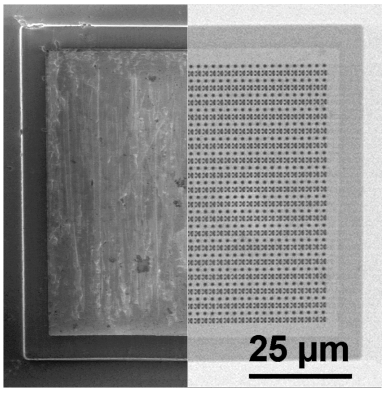
At all levels of today's manufacturing, microscopy plays a key role in the fabrication, analysis—including failure analysis--of this nanoscale technology.

The Challenge

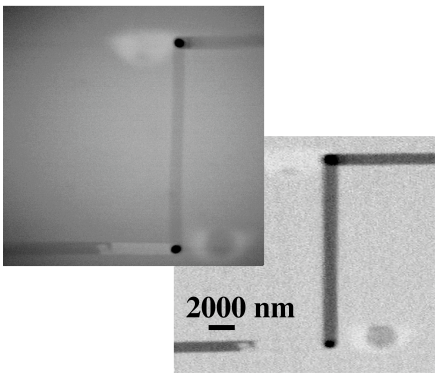
Imaging of sub-micron subsurface features of optically dense materials at high resolution has always been a difficult and/or time-consuming task. This role has been largely relegated to technologically complex and expensive instrumentation having highly penetrating radiation, such as the synchrotron-based Transmission X-ray Microscope (STXM) , or it has involved the time-consuming and expensive preparation of very thin cross-section slices for study using the Transmission Electron Microscope.

Argonne's Solution

Argonne National Laboratory has invented an electron optical device, the scanning confocal electron microscope (SCEM), that overcomes a number of the limitations of both traditional approaches.

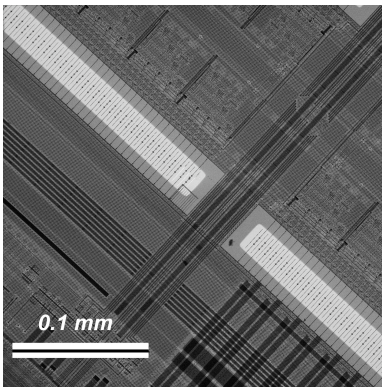


The figure above shows two views of the same area of interest in a 10-micrometer-thick semiconductor bond pad. At left is a conventional SEM image. At right is an SCEM image of the same area, showing details of the internal microstructure that are hidden from view in the SEM image.



This figure compares images obtained from the same area of an electromigration void at an interconnect using SCEM (left) and STXM (right). This result illustrates that the resolution of the SCEM rivals that of the STXM in a device that can be procured and operated at a fraction of the cost.

Typical Application of the SCEM



The cost-effective SCEM merges the concept of confocal imaging with the ease of use of an SEM, the resolution of a Transmission Electron Microscope, and the penetration of the X-ray Microscope. Argonne's SCEM has resolutions of <100 nanometers in semiconductor samples 8 microns thick and, under appropriate conditions, has demonstrated spatial resolutions ≤20 nanometers. The resolution of the SCEM is currently equal to or better than typical X-ray microscopes, permitting large fields of view (see low magnification image at left), yet it functions as much as 100 times faster, can be located in a conventional laboratory space and operated by a single trained researcher as standalone instrumentation.

Benefits of Argonne's Scanning Confocal Electron Microscope

- Cost-effective
  - The cost of a complete system is less than current x-ray microscopy based systems
  - The SCEM can be retrofitted into some advanced technology electron microscope systems
  - Nondestructive analysis means semiconductor devices can be studied under dynamic conditions or applied loads and subsequently put into service
- Compact
  - Can be located within a conventional size laboratory or inside a clean room
- Simple to operate
  - Requires only one trained technician
- Unparalleled observation and study capabilities
  - Images subsurface/buried structures in semiconductors up to ~10 micron thick
  - Huge field of view--up to ~0.5 square millimeters in ~1 minute, with real-time navigation and magnification adjustment
  - Spatial resolution equal to or better than current X-ray microscopes
  - Imaging mode operates up to 100 times faster than STXMs
- Compatible with operation via TelePresence Microscopy (TPM) , which allows remote viewing and operation using Network protocols. TPM is another methodology developed by Argonne National Laboratory advanced microscopy research program.

For More Information

Argonne seeks inspection-equipment makers, electron-column manufacturers and electronic/photonic device makers and integrators for collaboration to fully develop commercial applications. Inventions and operating protocols may be made available as part of a licensing agreement. Patent pending. Prior to initiating technical discussions with the inventor, Nestor Zaluzec, please contact Jim Gleeson to arrange execution of a nondisclosure agreement.

Licensing Inquiries

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