MODEL 3000

Annular Dark Field (ADF) Detector

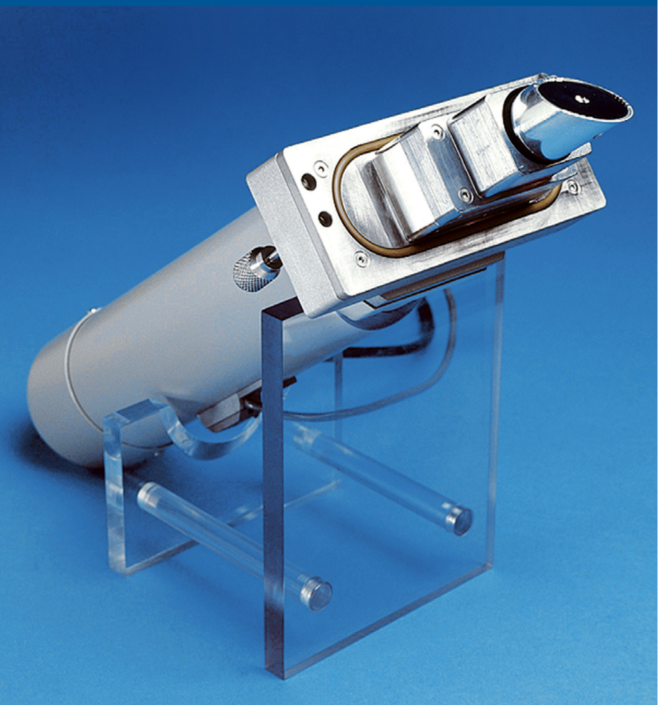
High-angle annular dark-field STEM imaging

FISCHIONE INSTRUMENTS

MODEL **3000**

Annular Dark Field Detector

Captures images formed by collecting electrons that have been forward scattered through high angles using high angle annular dark field (HAADF) scanning transmission electron microscopy (STEM).



- **High resolution STEM imaging**
- **Yields Z-contrast information**
- **Simultaneous high angle annular dark field imaging and electron energy less spectroscopy (EELS)**
- **Single electron detection capability**
- **High quantum efficiency**
- **For TEMs with active STEM coils**
- **Fully retractable from the beam path**
- **Highly accurate and repeatable positioning**

HIGHLY EFFICIENT DETECTION

The Fischione Model 3000 Annular Dark Field (ADF) Detector incorporates a single crystal yttrium aluminum perovskite (YAP) scintillator optically coupled to a photomultiplier tube. Its unique design requires very few optical junctions and yields high quantum efficiency.

In addition, the detector accommodates simultaneous high angle annular dark field imaging and electron energy loss spectroscopy (EELS).

HAADF STEM imaging

Images are formed by collecting electrons that have been forward scattered through high angles, typically a few degrees or more, using HAADF STEM. Unlike normal dark-field imaging where the signal comes from elastic (Bragg) scattering of electrons, typically to smaller angles, the HAADF STEM signal is the result of inelastic scattering of electrons to larger angles.

For high angles, elastic and inelastic interactions between the incident electrons and the columns of atoms within the specimen produce image contrast. Because inelastic scattering depends on the number of electrons in an atom, the strength of scattering varies with atomic number.

The Model 3000 Annular Dark Field (ADF) Detector was specifically developed to capture these highly scattered electrons. Spatial resolution is determined by the size of the focused incident electron probe. Atomic resolution is possible with electron beam sizes of less than 3 Å. The signal is typically collected, amplified, and converted to gray levels. Certain atoms within the electron transparent region of the specimen will appear brighter than others.

As a result, it is possible to distinguish between atomic columns made up of different elements. Brighter spots represent the higher atomic columns while the less intense spots indicate the lower atomic columns.

Precise construction

The ADF detector, which was developed in collaboration with Cornell University researchers, is pneumatically inserted and fully retracted from the beam path.

Precision mechanical parts mean that positioning is accurate and repeatable and operation is extremely reliable. A key component of the reciprocating mechanism is its metal bellows, which ensures the vacuum integrity of the microscope.

The detector is fully self-contained and incorporates effective X and Y adjustments for easy alignment to the optical axis. If the microscope column contains a port opposite the ADF detector, other types of detectors or CCD cameras may also be inserted into the beam path.

SPECIMEN PREPARATION

A key characteristic for high-resolution STEM imaging is the quality of the specimen. For the best results from either ADF or high-resolution electron microscopy (HREM) imaging, the specimen should be thinner than 40 nm. Thicker materials may limit spatial resolution by broadening the incident electron probe as it passes through the transparent region. Nevertheless, a few nanometer spatial resolution is still possible in micron-thick samples.

Specimens are prepared using traditional TEM specimen preparation techniques such as electropolishing, ion beam milling, or focused ion beam (FIB). However, the presence of thick amorphous layers on the entrance surface of the sample can severely degrade the quality of lattice images. Furthermore, the specimen must be free from any type of organic contamination, which precludes effective imaging and analysis.

Fischione offers a complete product line for the conventional preparation of high-quality TEM specimens, including the Model 1020 Plasma Cleaner and the Model 1070 NanoClean that yield atomically clean specimens.

Image interpretation

HAADF is more strongly dependent on specimen thickness than backscattered electron imaging. Specimens possessing significant variations in thickness may show high intensity in the thicker areas. In these cases, the HAADF signal does not necessarily indicate a high atomic number.

In addition, de-channeling of the electron beam can also produce contrast variations from local strain fields, vacancies, dislocations, and changes in crystal tilt. In many cases, these effects can be distinguished from atomic number contrast by comparing a medium-angle ADF (MAADF) image (30 mrad inner angle) with a high-angle ADF image (greater than 50 mrad inner angle). Strain contrast is greater in the MAADF image and lesser in the HAADF image while mass-density contrast is similar in both images.

STEM image resolution depends on the size and shape of the electron beam and the current in the spot. In principle, these two parameters are directly related. Smaller spot sizes possess lower beam currents. An important characteristic in determining the spot size is the stability of the electron probe. Combining a small spot size with a high stability beam yields better STEM image resolution. Modern microscopes possess stable spots down to a few Angstroms, with high beam current density, allowing atomic resolution STEM imaging.

Applications

- Quantitative mapping of elemental chemistries
- Imaging of semiconductors, multi-layered structures, interfaces, and quantum wells
- Grain boundaries, dislocations, and precipitate investigations
- Catalyst characterization
- Analysis of superconductors and geological materials

FISCHIONE INSTRUMENTS

E.A. Fischione Instruments, Inc.
9003 Corporate Circle
Export, PA 15632 USA
Tel: +1 724.325.5444
Fax: +1 724.325.5443
info@fischione.com
www.fischione.com

Document Number PB3000 Revision 01 09/2013