Model 806 HAADF STEM Detector

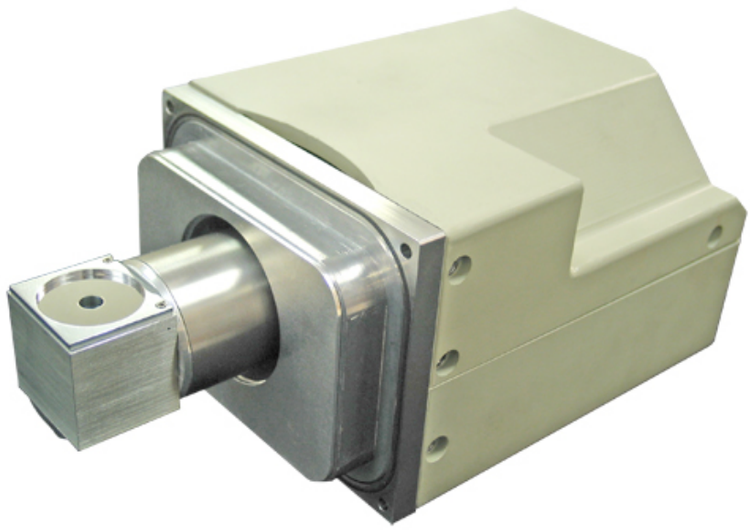


Figure 1 New Gatan 806 HAADF STEM detector head.

Specification

Scintillator material	YAP
Analog Output	
Equivalent input charge noise	0.5 e- RMS
Level	0 to 4 V pp nominal (Hi Z load)
	0 to 2 V pp nominal (50 Ohm load)
DC Offset	Adjustable bipolar offset +/- 0.5 V
DQE	> 95%
Pulse Output	
Level	Standard TTL level
Counting losses	10% at 20 MHz average event rate, using Digiscan II
Mechanical	
Interface	Gatan UltraScan Housing
Detector insertion/retraction	Pneumatic mechanism, Computer software controlled
Collection angles	50 to 180 mrad at 4 cm Camera Length
Interlock	Software and Hardware interlock for opposing detector on Ultra Scan housing
X-ray radiation safety	up to 300 keV
Regulatory compliance	CE
Software control	All detector system settings. Scriptable.
	Automatic detector gain setting and calibrated pixel intensity (e-/pixel)
Computer interface	USB, RS232

Key Benefits

1. Optimized Geometry

For EELS analysis, the correct choice of camera length and EELS collection angles is critical. The same is true for Z-contrast (also referred as high angle angular dark field – HAADF) STEM imaging. The Gatan model 806 HAADF STEM detector is specifically designed to capture the optimum range of scattering angles for Z-contrast STEM at camera lengths optimally suited to simultaneous EELS acquisition with any Gatan EELS system (GIF2000, Tridiem or Enfina). The model 806 mounts to a Gatan UltraScan camera housing and is compatible with any 100-300 kV TEM/STEM that can accommodate this housing. Model 806 can be mounted together with the model 894/895 UltraScan or model 832 ORIUS CCD cameras. The detector geometry and mounting position are compatible with concurrent deployment of Gatan's model 805 BF/DF STEM detector, thus enabling simultaneous and optimized EELS, Z-contrast and diffraction-contrast STEM imaging when combined with Gatan model 777 STEMPack.

2. Single electron detection

The 806 detector and its electronics have been optimized for the low to moderate count rates typically encountered in HAADF STEM work. The system has very low noise and is capable of detecting single electron events, both in analog and pulse-counting modes.

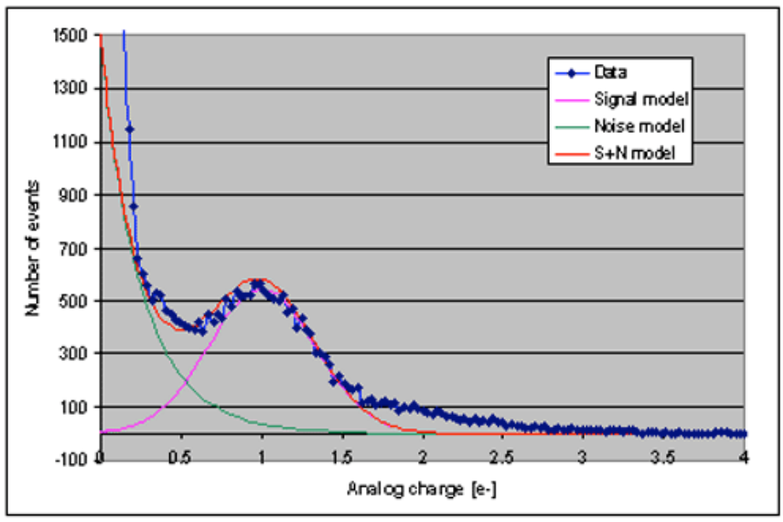


Figure 2 Histogram of analog mode pixel charges.

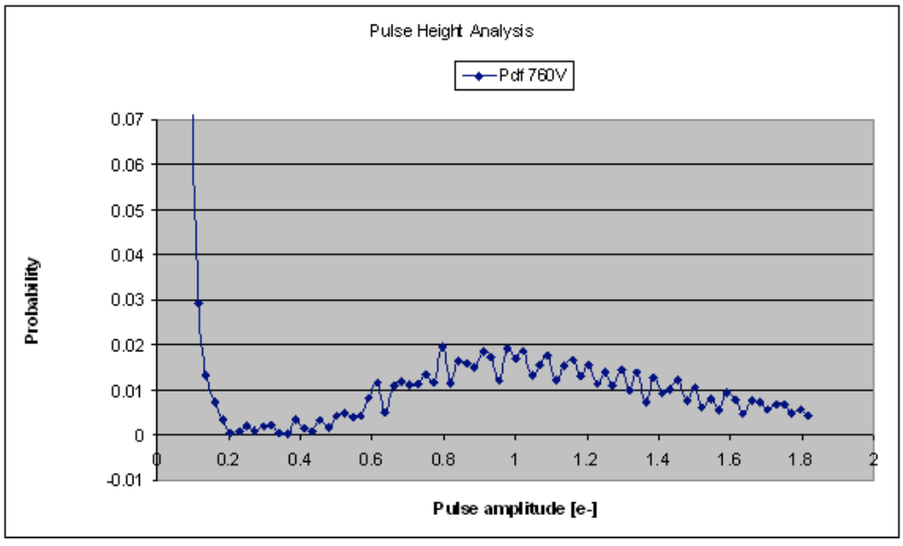


Figure 3 Pulse Height Analysis using the 806 HAADF Detector, showing the single electron detection capabilities of the system.

The data were gathered using a 200 KeV STEM, biasing the Photomultiplier tube at -760 V. The discriminator threshold was swept from pulse amplitudes of zero to 1.8 electron charges. The noise distribution has a Standard Deviation of 0.06 e- , and the gain distribution has a Standard Deviation of 0.25 e-.

3. Calibrated output

When integrated as part of a complete STEMPack configuration (with DigiScan II), the model 806 HAADF detector is automatically calibrated in units of primary electrons detected. This enables true quantitative interpretation of Z-contrast STEM images and the counting statistics of the signal. Installation with Gatan's original 688 DigiScan or a 3rd party digital STEM system yields the same outstanding low-noise, computer controlled operation but with the output in arbitrary digitizer units.

4. Ease of use

The calibration of the detector greatly simplifies its operation since the zero-count baseline (black level) is always known and fixed, thereby requiring only the adjustment of the detector gain as the beam intensity varies. The detector gain (PMT voltage) is automatically and quickly optimized with a single mouse click. For operators who prefer manual control, direct digital gain control is also provided. The detector output remains calibrated in true electron counts over the entire range of practical gain and dwell time settings.

5. Hardware configuration

The electronics of the system have been unified into a single, 19" chassis that is a standard part of the product package. Detector insertion and operation settings are all software controlled within DigitalMicrograph, the primary acquisition, control, and data handling application in the Gatan Microscopy Suite (GMS) software system. There is no need for manual access to the detector electronics, which can thus be mounted in a remote rack well away from the TEM column. While the 806 HAADF detector in principle can be installed as a stand-alone STEM detector, it is strongly recommended that the system be installed together with STEMPack or, at minimum, a DigiScan II to realize the full capabilities and ease of use of the system.

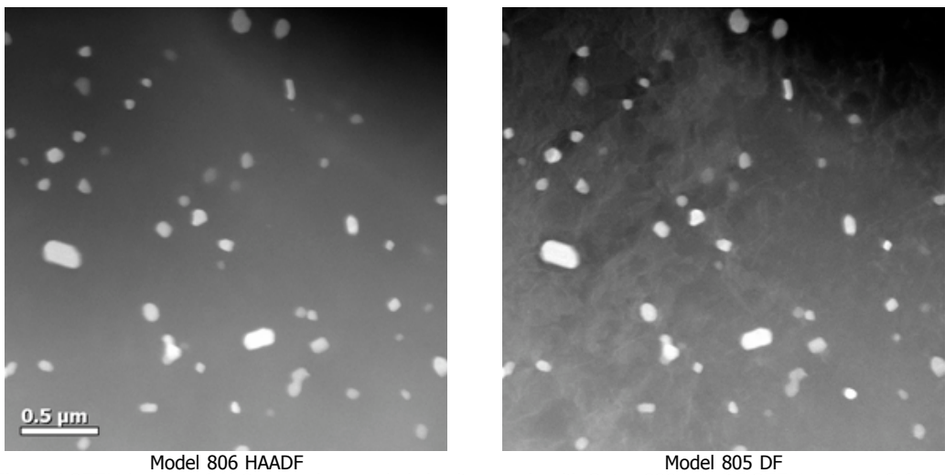
Application examples

1. Z-contrast vs. diffraction contrast in STEM imaging

Z-contrast STEM images are formed by collecting electrons scattered to high angles (~50 to 200mrad) where the scattering is predominately incoherent and roughly proportional to the square of the atomic number, Z, of the scattering atom. This contrast mechanism can yield images where even small changes in average number are easily discriminated. Moreover, the incoherent nature of the scattering eliminates the contrast reversals that can dominate coherent scattering images and can provide a 1.5x increase in spatial resolution over coherent imaging.

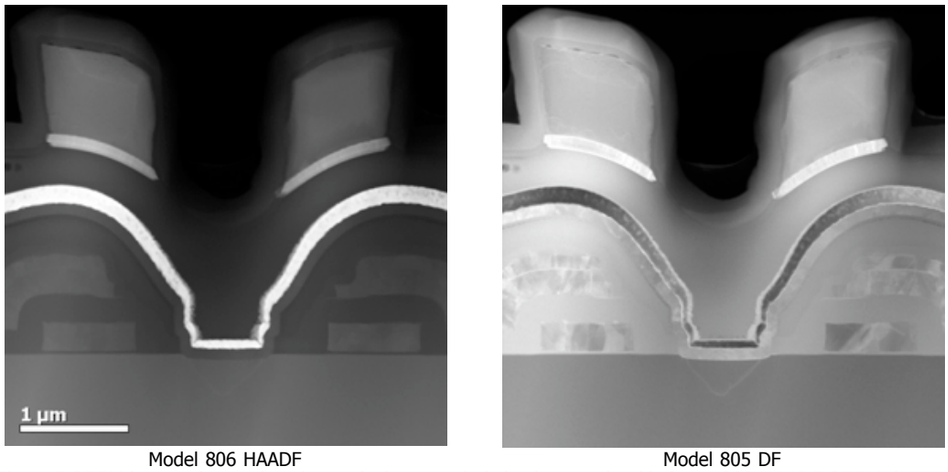
On the other hand, conventional angular dark-field (ADF) images formed using electrons scattered low to medium angles (~10 to 50mrad) show strong diffraction contrast. Diffraction contrast is useful in studying the crystalline nature of the specimen, for example grain size, defects, strain fields, etc.

The 806 HAADF and 805 BF/DF detectors are designed to complement each other, and work together with Gatan EELS analysis equipment. The carefully designed placement and size of the two detectors allow the simultaneous and optimized acquisition EELS data together with HAADF and ADF STEM resulting in a complete picture of the sample composition and structure.



Model 806 HAADF Model 805 DF

Figure 4 STEM images of Al-Cu sample recorded simultaneously with Gatan 806 HAADF STEM detector (left) and 805 BF/DF STEM detector (right). The DF image shows strain fields and defects in the sample, but the smallest precipitates are difficult to identify. In the HAADF image, the diffraction contrast is greatly minimized giving a clear accounting of the precipitates.

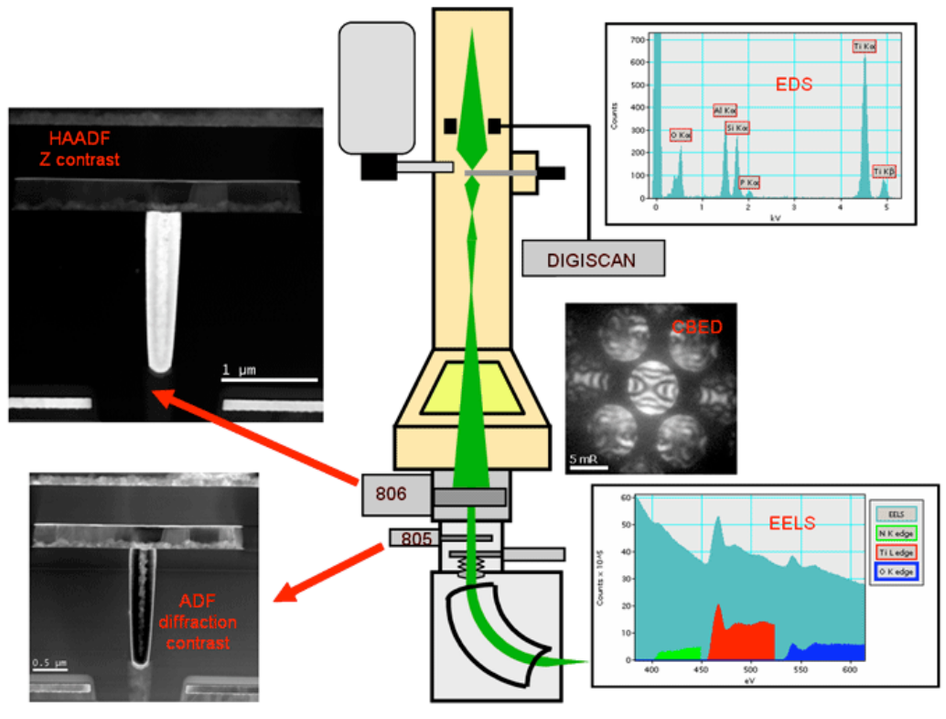


Model 806 HAADF Model 805 DF

Figure 5 STEM image of a semiconductor device recorded simultaneously with Gatan 806 HAADF STEM detector (left) and 805 BF/DF STEM detector (right). The Z-contrast effect in the HAADF image allows unambiguous identification of the material layers, while the low-angle ADF image is difficult to interpret due to strain and contrast reversal effects. However, the low-angle ADF image shows fine structures not evident in the HAADF image.

2. The optimized STEM solution - Putting it all together!

Model 806 HAADF STEM detector is a great addition to STEMPack and EELS analysis. This integrated and optimized system provides efficient access to all possible STEM-mode signals within Gatan's GMS software environment. Hence it allows users to gain a complete understanding of the structure and chemistry of the sample under investigation.



Ordering information

Model No	Description
806	HAADF STEM detector system for up to 300 keV beam energy – includes detector head assembly, controller, and cables as well as GMS software license for detector calibration, detector control, and DigiScan II pulse input option
806.T	Installation and training for Model 806 HAADF STEM detector