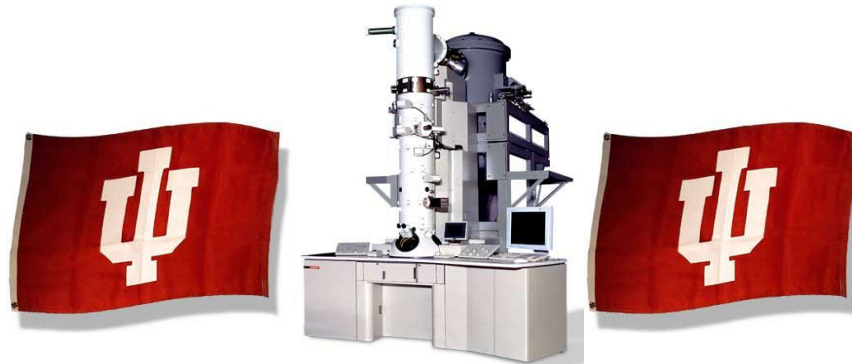


# Indiana University JEM-3200FS



## Installation Specification

**Model:** JEM – 3200FS  
**Serial Number:** EM – 15000013  
**Objective Lens Configuration:** High Resolution Pole Piece (HRP)  
**JEOL Engineer:** Michael P. Van Etten

### Final Test Results:

Test Parameter	Test Result	JEOL Specification
<b>Probe Size</b>		
CBD 1.0nm $\alpha$ 9	0.809nm	$\leq 1.0$ nm
CBD 0.5nm $\alpha$ 9	0.44 nm	$\leq 0.5$ nm
<b>Probe Intensity</b>	62,5pA / cm <sup>2</sup>	$\geq 50$ pA / cm <sup>2</sup>
<b>Probe Stability</b>	0.7nm / min	$\leq 1.0$ nm / min
<b>Stage Stability</b>	0.56nm / min	$\leq 1.0$ nm / min
<b>Diffraction Pattern Roundness</b>	99.2%	$\geq 99\%$
<b>Energy Resolution</b>	0.79eV	0.9eV
<b>TEM Lattice Resolution</b>	0.102nm	0.102nm
<b>TEM Point Resolution</b>	0.19nm	0.19nm
<b>STEM Resolution</b>		
BF STEM	0.136nm	0.2nm
HAADF STEM	0.136nm	0.2nm

Figure 1: Final Test Results



## Field Emission Gun Data:

FEG Component	FEG Data
Dark Current ( $\mu\text{A}$ @ 300kV)	105 $\mu\text{A}$
Anode 1 (kV)	3.05kV
Anode 2 (kV)	7.04kV
Bias (V)	-300V
Filament (A)	2.274A
	(Denka = 2.351A)
Emission Current ( $\mu\text{A}$ )	125 $\mu\text{A}$

Figure 2: Field Emission Gun Data



Figure 3: FEG Emission Pattern

## Probe Intensity Test Result:

Result: 62.5pA/cm<sup>2</sup>

Test Method:

JEOL Current Density meter

TEM Condition:

Specimen: None

Accelerating Voltage: 300kV

Direct Magnification: 100kX

Imaging Mode: CBD 1.0nm  $\alpha$  9

Condenser Lens Aperture: 50 $\mu\text{m}$

Emission Current: 125 $\mu\text{A}$



## Probe Size Test Result (1.0nm):

Result: 0.809nm

Test Method:

Gatan Ultrascan 4000 CCD camera  
Exposure time: 0.03 seconds  
Measure width of probe at half maximum (FWHM)

TEM Condition:

Specimen: None  
Accelerating Voltage: 300kV  
Direct Magnification: 1MX  
Imaging Mode: CBD 1.0nm  $\alpha$  9  
Condenser Lens Aperture: 50 $\mu$ m  
Emission Current: 125 $\mu$ A

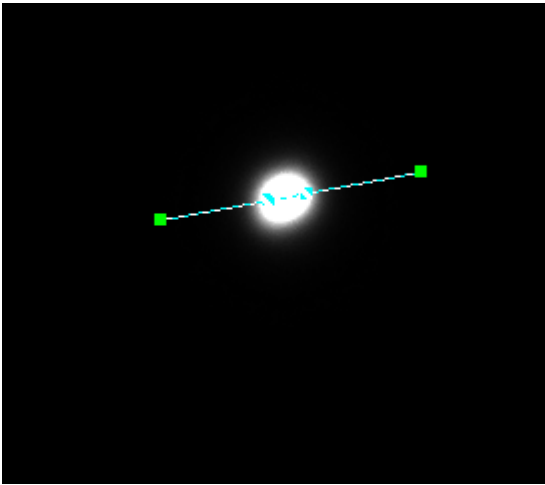


Figure 4: Probe size CBD 1.0nm  $\alpha$  9

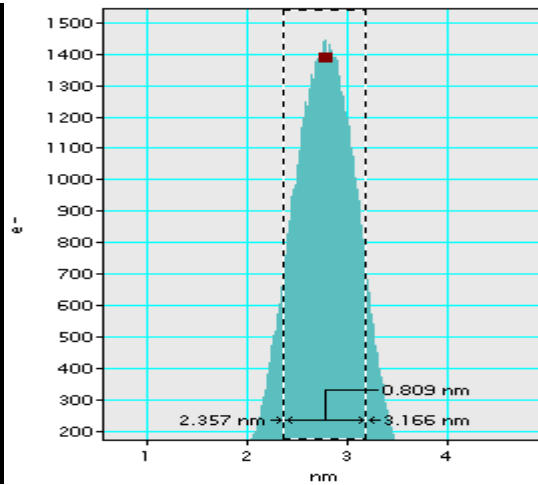


Figure 5: Profile of Figure 4



## Probe Size Test Result (0.5nm):

Result: 0.44nm

### Test Method:

Gatan Ultrascan 4000 CCD camera  
Exposure time: 0.03 seconds  
Measure width of probe at half maximum (FWHM)

### TEM Condition:

Specimen: None  
Accelerating Voltage: 300kV  
Direct Magnification: 1MX  
Imaging Mode: CBD 0.5nm  $\alpha$  9  
Condenser Lens Aperture: 50 $\mu$ m  
Emission Current: 125 $\mu$ A

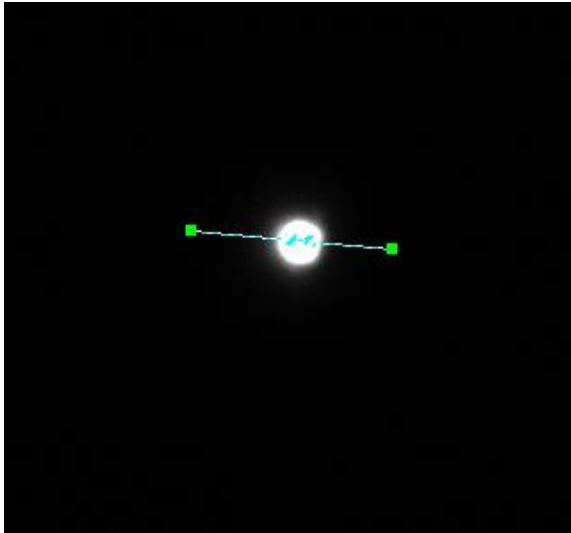


Figure 6: Probe size CBD 0.5nm  $\alpha$  9

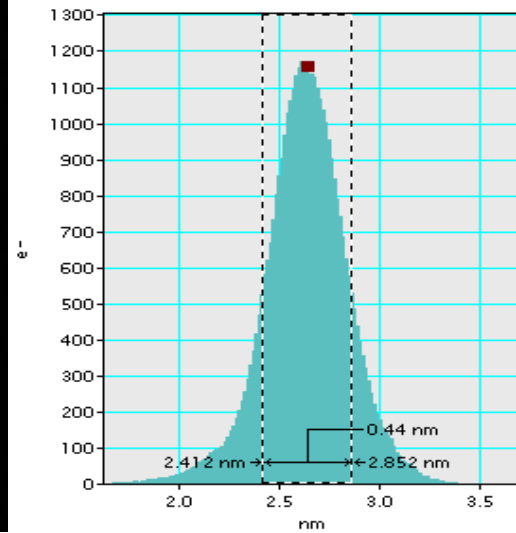


Figure 7: Profile of Figure 6



## Probe Stability Test Result:

Result: 0.7nm / minute

Test Method:

Gatan Ultrascan 4000 CCD camera  
Exposure time: 0.1 seconds  
A: CBD 1.0nm  $\alpha$  9 probe  
B: CBD 1.0nm  $\alpha$  9 probe after 10 minutes  
Gatan DM "simple math" function (A + B)

TEM Condition:

Specimen: None  
Accelerating Voltage: 300kV  
Direct Magnification: 2MX  
Imaging Mode: CBD 1.0nm  $\alpha$  9  
Condenser Lens Aperture: 50 $\mu$ m  
Emission Current: 125 $\mu$ A

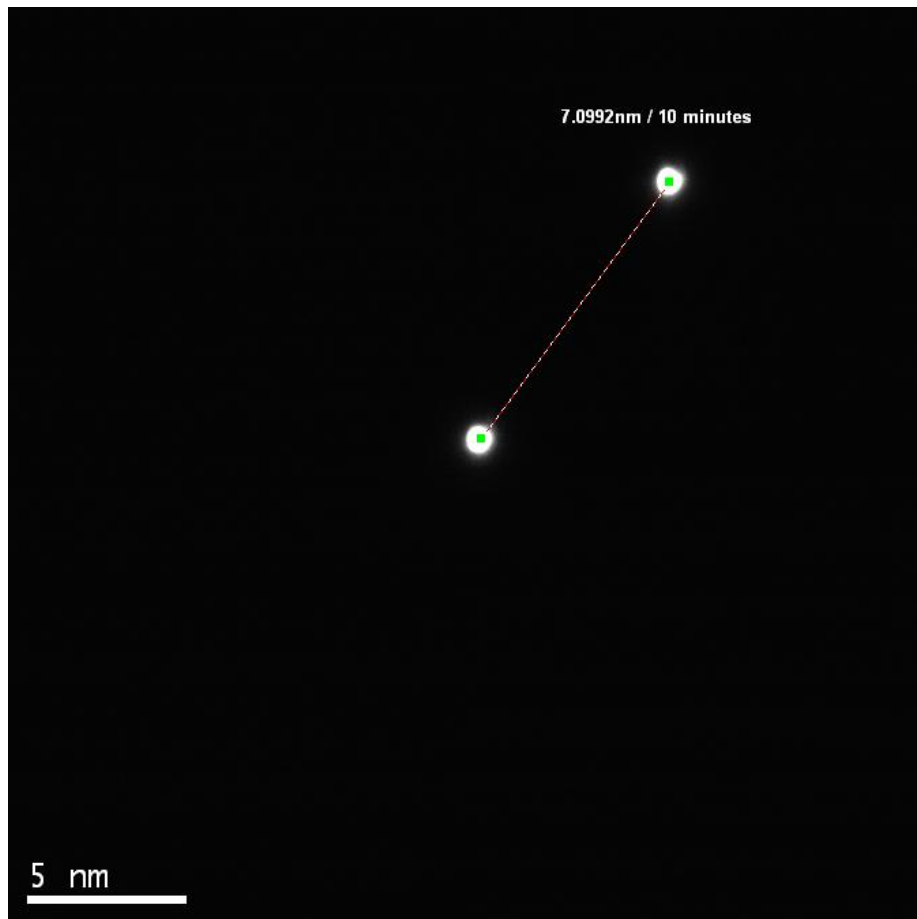


Figure 8: Probe Stability



## Stage Stability Test Result:

Result: 0.56nm / minute

Test Method:

Gatan Ultrascan 4000 CCD camera  
Exposure time: 2.0 seconds  
A: Au particle on amorphous Ge  
B: Au particle on amorphous Ge after 10 minutes  
Gatan DM “simple math” function (A + B)

TEM Condition:

Specimen: Amorphous Ge with Au particles  
Accelerating Voltage: 300kV  
Direct Magnification: 500kX  
Imaging Mode: TEM 1-1  
Condenser Lens Aperture: 70 $\mu$ m  
Emission Current: 125 $\mu$ A

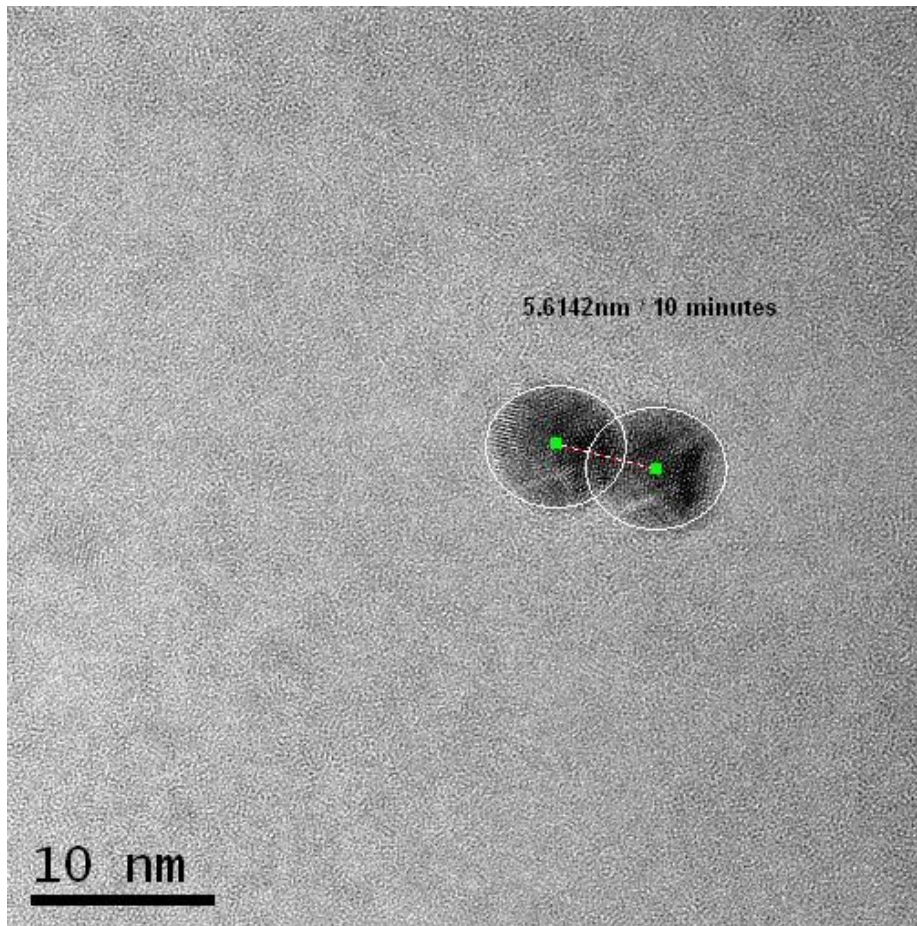


Figure 9: Stage Stability



## Diffraction Pattern Roundness Test Result:

Result: 99.2%

Test Method:

Gatan Ultrascan 4000 CCD camera  
Exposure time: 0.1 seconds  
Measure ratio of X1/Y1 and X2/Y2

TEM Condition:

Specimen: Poly-crystalline Au  
Accelerating Voltage: 300kV  
Imaging Mode: SADIFF  
Camera Length: 100cm  
Condenser Lens Aperture: 70 $\mu$ m  
Selected Area Aperture: 50 $\mu$ m  
Emission Current: 125 $\mu$ A

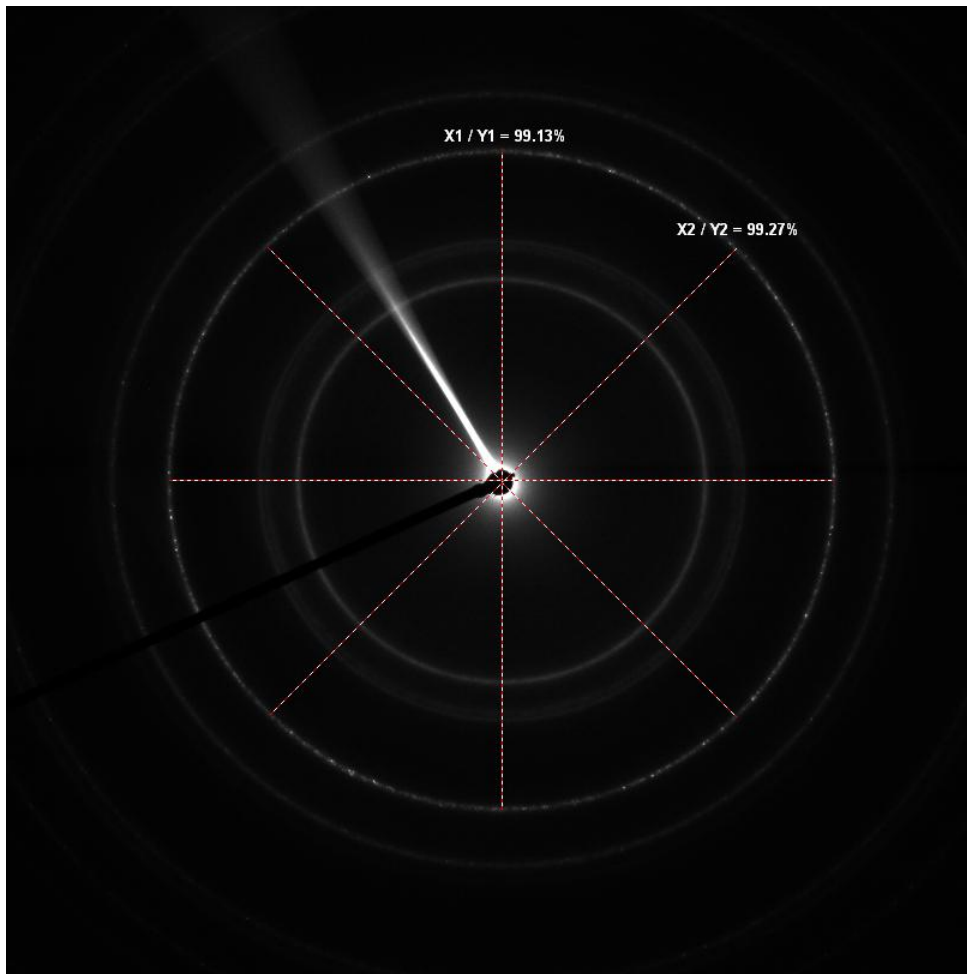


Figure 10: Diffraction Pattern Roundness



## Energy Resolution Test Result:

Result: 0.79eV

### Test Method:

Gatan Ultrascan 4000 CCD  
Exposure time: 0.2 seconds  
Measure width of probe at half maximum (FWHM)  
A: Photo of Zero-loss beam  
B: Photo of beam after 10eV shift via HT  
Use Gatan DM "simple math" function (A + B)  
10eV / pixel width between A and B \* FWHM

### TEM Condition:

Specimen: None  
Accelerating Voltage: 300kV  
Direct Magnification: 50kX  
Imaging Mode: TEM 5-3 / Spectrum Mode 220 $\mu$ m/eV  
Condenser Lens Aperture: 150 $\mu$ m  
Selected Area Aperture: 10 $\mu$ m  
Emission Current: 40 $\mu$ A

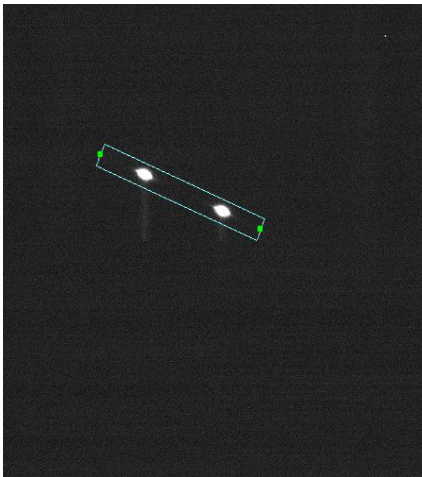


Figure 11: Zero-loss probe (A) with 10eV shift (B)

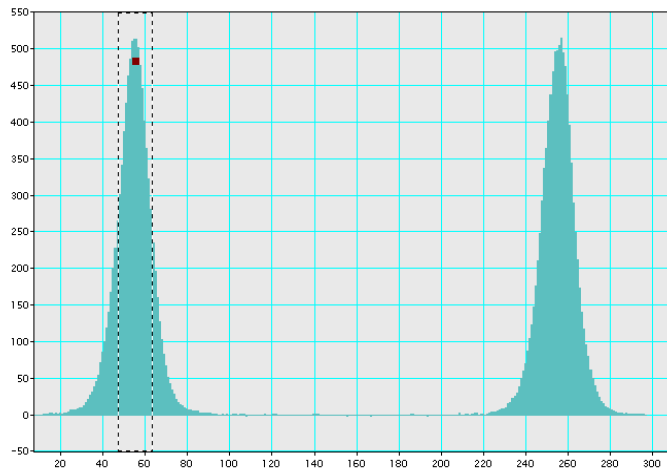


Figure 12: Profile of Figure 11





## TEM Lattice Resolution Test Result:

Result: 0.102nm

Test Method:

Gatan Ultrascan 4000 CCD camera  
Exposure time: 2.0 seconds

TEM Condition:

Specimen: Single Crystal Au  
Accelerating Voltage: 300kV  
Direct Magnification: 1.5MX  
Imaging Mode: TEM 1-1  
Condenser Lens Aperture: 70 $\mu$ m  
Emission Current: 125 $\mu$ A

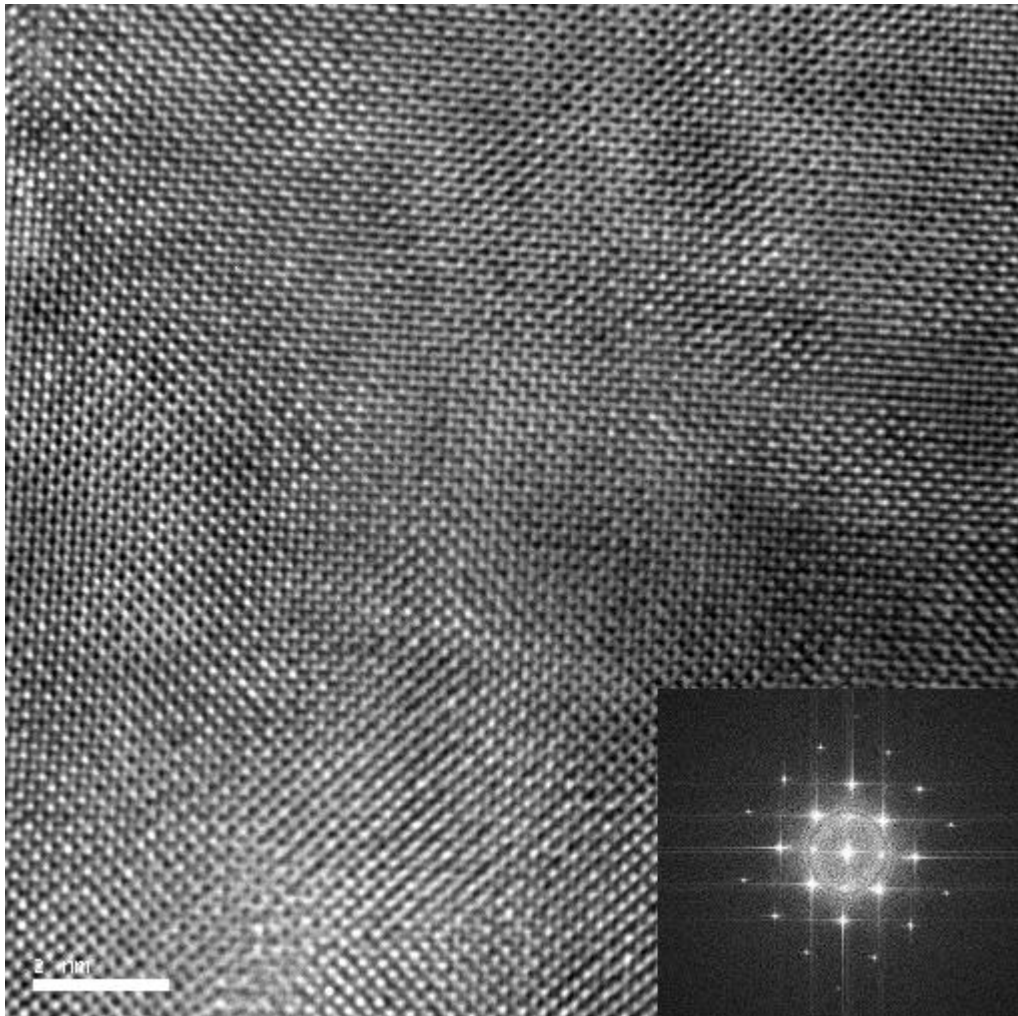


Figure 13: TEM lattice resolution



## TEM Point Resolution Test Result:

Result: 0.19nm

Test Method:

Gatan Ultrascan 4000 CCD camera  
Exposure time: 2.0 seconds

TEM Condition:

Specimen: Amorphous Ge with Au particles  
Accelerating Voltage: 300kV  
Direct Magnification: 500kX  
Imaging Mode: TEM 1-1  
Condenser Lens Aperture: 70 $\mu$ m  
Emission Current: 125 $\mu$ A

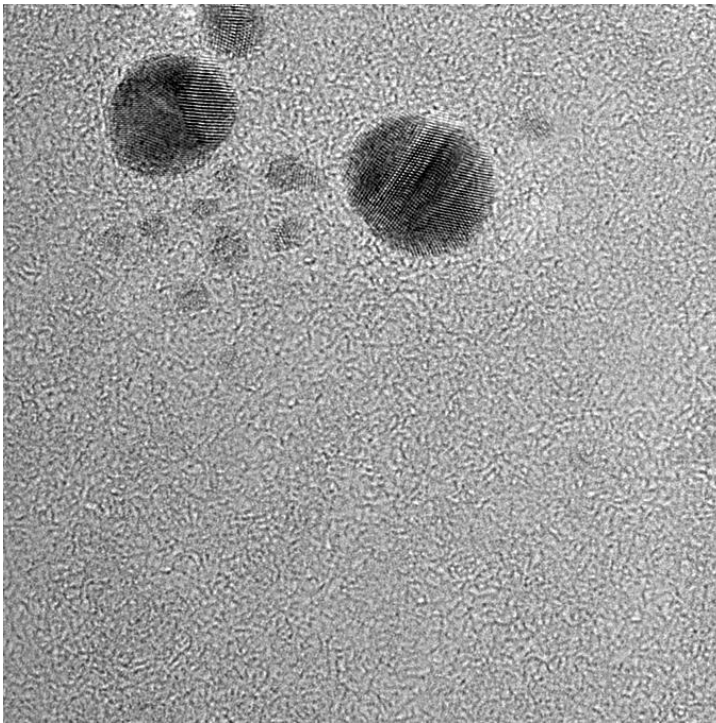


Figure 14: Amorphous Ge with Au particles at Scherzer Focus

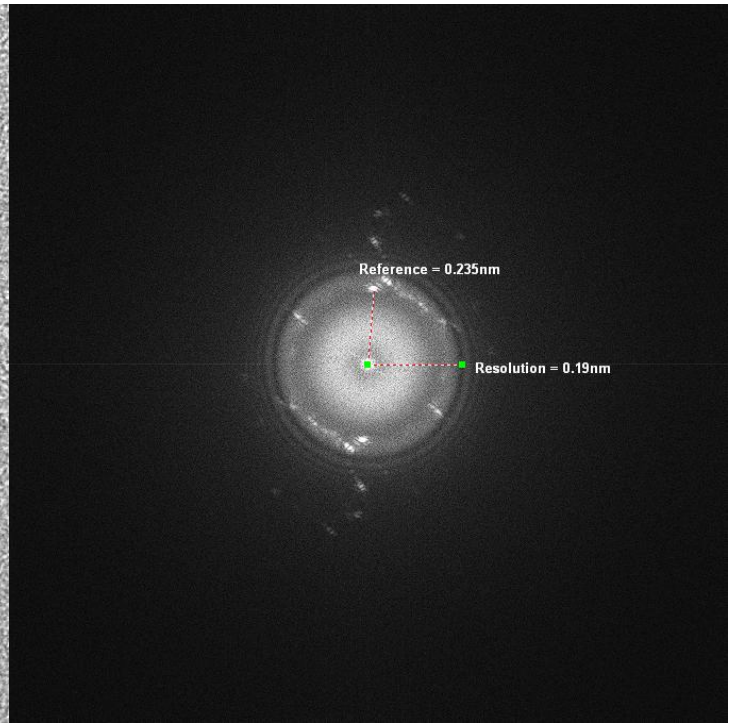


Figure 15: FFT of Figure 14



## Bright Field STEM Resolution Test Result:

Result: 0.136nm

Test Method:

JEOL BF STEM detector via Gatan Digiscan  
Pixel time: 64 $\mu$ s / pixel

TEM Condition:

Specimen: Si 110  
Accelerating Voltage: 300kV  
Direct Magnification: 25MX  
Imaging Mode: STEM / Spot Size "S"  
STEM Camera Length: 60cm  
Condenser Lens Aperture: 50 $\mu$ m  
Emission Current: 125 $\mu$ A

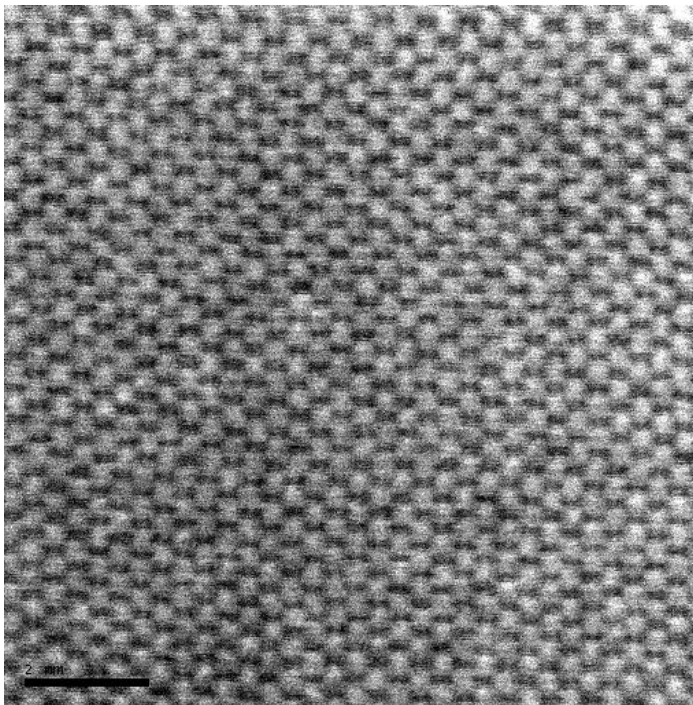


Figure 16: BF STEM Resolution

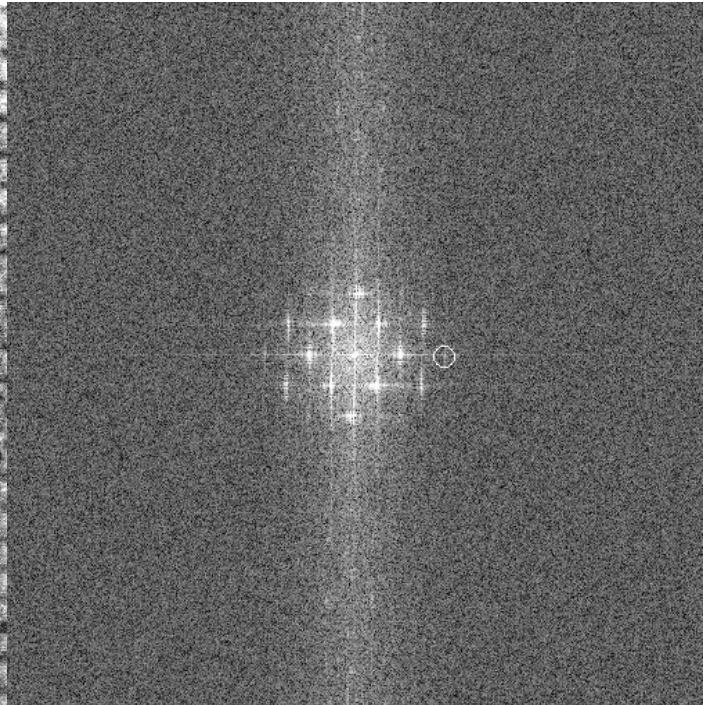


Figure 17: FFT of Figure 16



## HAADF STEM Test Result:

Result: 0.136nm

Test Method:

JEOL UHAADF STEM detector via Gatan Digiscan  
Pixel time: 64 $\mu$ s / pixel

TEM Condition:

Specimen: Si 110  
Accelerating Voltage: 300kV  
Direct Magnification: 25MX  
Imaging Mode: STEM / Spot Size "S"  
STEM Camera Length: 10cm  
Condenser Lens Aperture: 50 $\mu$ m  
Emission Current: 125 $\mu$ A

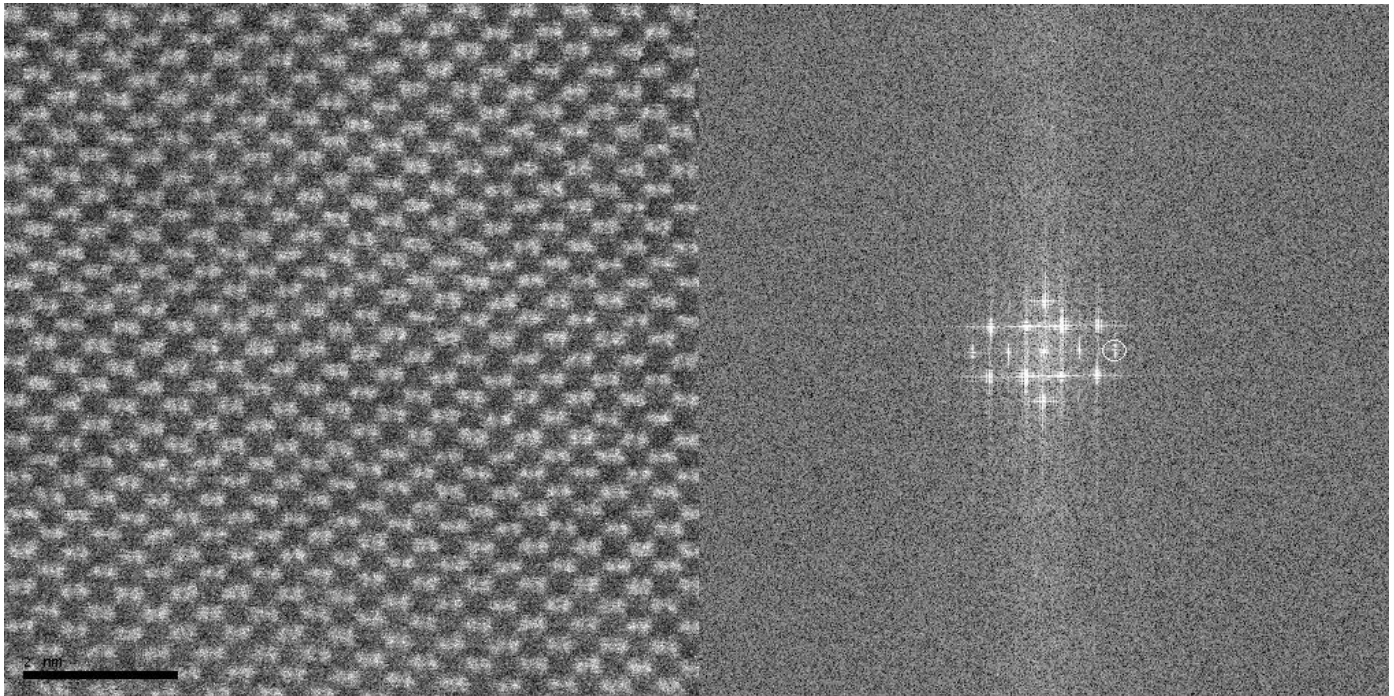


Figure 18: HAADF STEM Resolution

Figure 19: FFT of Figure 18

