

분석지원 장비 상태 보고서

(전자현미경연구부)

대상 장비(기기코드)	공지 성능	공지 주기
초고전압투과전자현미경 (HVEM, AE01)	- Image Resolution : 0.12 nm - Information Limit : 0.12 nm - Energy Resolution : 1.3 eV - HT/OL Stability : ≤ 1.0 ppm / ≤ 0.5 ppm (DC at 1250 kV)	연 2회 (1월, 7월)
바이오 초고전압투과전자현미경 (Bio-HVEM, OC101)	- Image Resolution : 0.1 nm - Information Limit : 0.1 nm - Energy Resolution : 1.3 eV - HT/OL Stability : ≤ 0.75 ppm / ≤ 0.174 ppm (DC at 1000 kV)	연 2회 (1월, 7월)
고분해능 바이오전자현미경 (HR Bio-TEM, OC102)	- Image Resolution : 0.27 nm (300 kV) - Information Limit : 0.14 nm (300 kV) - Specimen drift : 0.43 nm/min	연 2회 (1월, 7월)
전계방출형 투과전자현미경 (FE-TEM, AE02)	- Image Resolution : 0.19 nm - Information Limit : 0.12 nm - Energy Resolution : 1.35 eV (200 kV, 3 mm Aperture) - EDS Resolution : 143 eV	연 2회 (1월, 7월)
수차보정 에너지여과 전자현미경 (UC-EF-TEM, AE12)	- Image Resolution : ≤ 0.11 nm (200 kV) ≤ 0.14 nm (MC, 60 kV) - Information Limit : ≤ 0.11 nm (200 kV) ≤ 0.14 nm (MC, 60 kV) - Energy Resolution : ≤ 0.15 eV (200 kV) ≤ 0.07eV (MC, 60 kV) - EDS Resolution : 124 eV	연 2회 (1월, 7월)
생물전용 투과전자현미경 (Bio-TEM, AE03)	- Image resolution : 0.35 nm - Information limit : 0.20 nm - Specimen drift : 1 nm/min with standard holder	연 2회 (1월, 7월)
초고분석능 주자전자현미경 (UHA FE-SEM, AE14)	- Image Resolution : 0.9 nm (15 kV) - EDS Energy Resolution : 126 eV Mn FWHM	연 2회 (1월, 7월)
집속이온빔시스템 (FIB, NE02)	- Image Resolution of e-beam : 1.2 nm at 30 kV - Image Resolution of Ga-beam : 7 nm at 30 kV - EDS Resolution < 129 eV - Stage Stability < 2 μm	연 2회 (1월, 7월)
500MHz 고체 핵자기공명 분광기 (Solid State NMR, QM07)	- NMR Magnet Field : 11.7 T - NMR Frequency : 500 MHz - Spinning Speed : 20 kHz, 45 kHz	연 2회 (1월, 7월)
Gas Adsorption-Desorption Measurement System (MSB-AD-H, QM05)	- Weigh Resolution : $\geq 10^{-5}$ g - Pressure Limit : ≤ 100 bar - Temperature Limit : ≤ 673 K	연 2회 (1월, 7월)
전자현미분석기 (EPMA, AE11)	- Crystal (RAP) efficiency : 50,948 cps (Mg Kα) - Crysta l(PET) efficiency : 28,061 cps (Ag Lα) - WDS (LIF) Resolution : 0.0066 Å (Fe Kα)	연 2회 (1월, 7월)
다목적 X-선회절분석기 (XRD, NE03)	- Linearity : 0.015° - Reproducibility : 0.000111° - Modulation : 0.084°, 42.142%	연 2회 (1월, 7월)

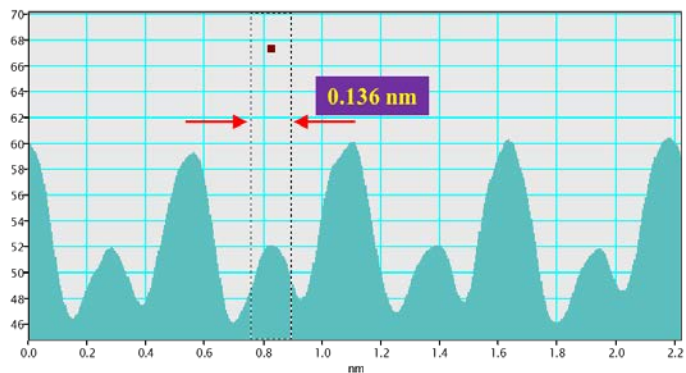
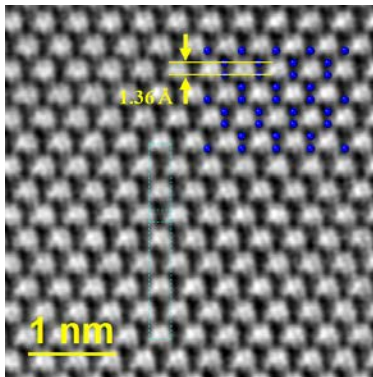
1. Point Resolution

○ 측정 조건

Si single crystal [110], HV-GIF CCD camera, x 40 k, at 1250 kV

○ 측정값

0.136 nm (theoretical resolution: 0.117 nm)



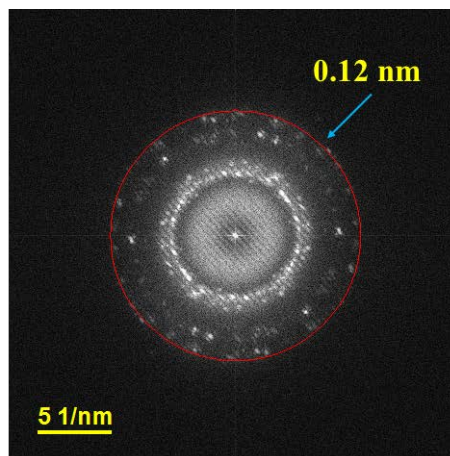
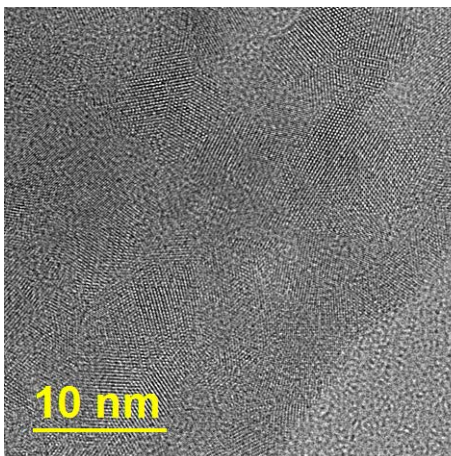
2. Information limit

○ 측정 조건

Au NPs on amorphous carbon film, HV-GIF CCD camera, x 40 k, at 1250 kV

○ 측정값

0.12 nm



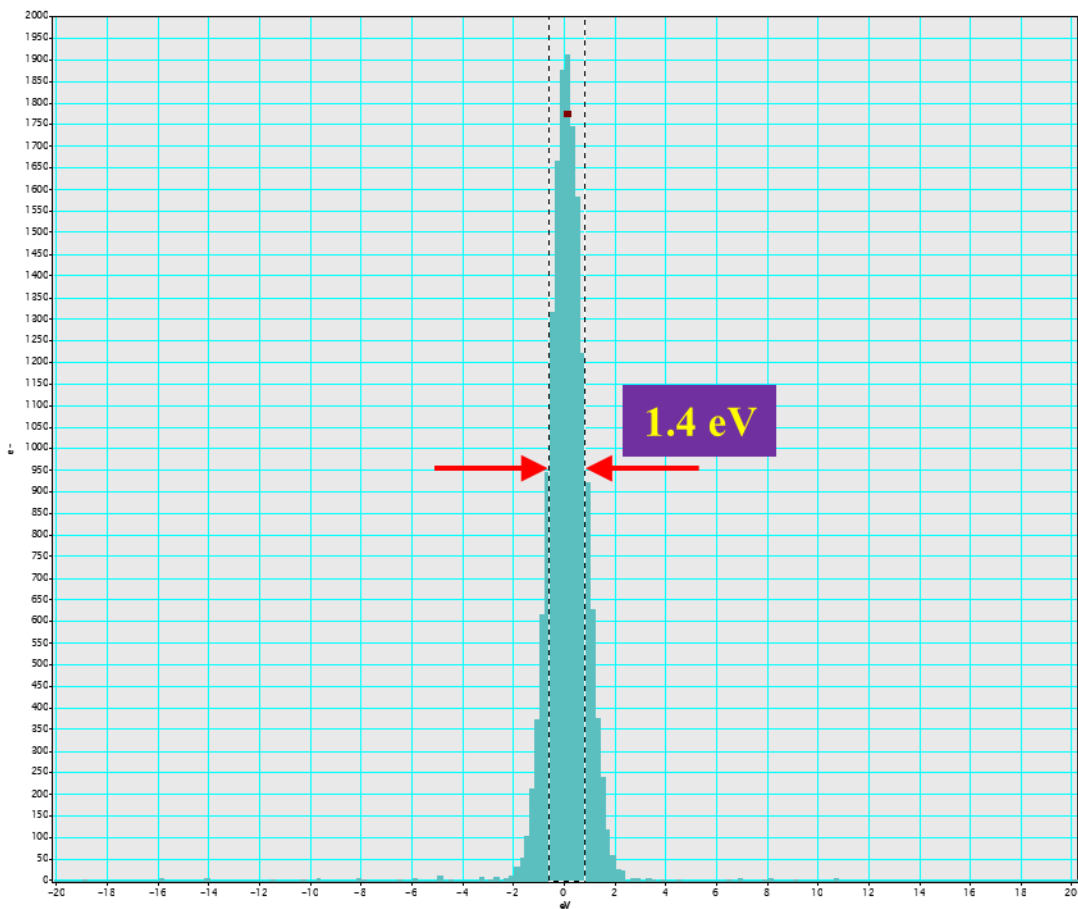
3. Energy resolution at 1250 kV

○ 측정 조건

Filament: under saturated
Specimen: without
Acquisition time: 0.2 s
Aperture size: 2 mm
Dispersion: 0.2 eV/pix
HV-GIF CCD camera, x10 k

○ 측정값

1.4 eV



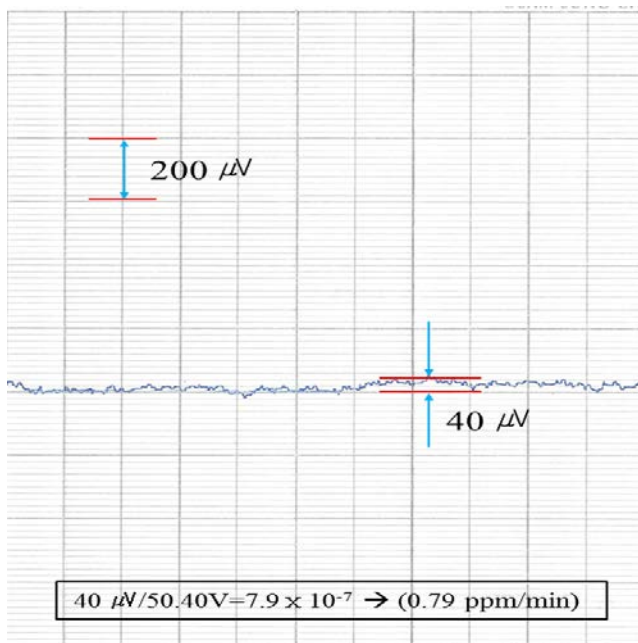
4. HT stability at 1250 kV

○ 측정 조건

Recorder	HIOKI PR8112 Pen Recorder
Recorder Range	± 10 mV
Amp. Gain	x 10
Chart Speed	60 mm/min
Amp Filter	DC ~ 100KHZ
Amp Type	ITHACO 1201
Cancel (HT compensator)	MF: 8.2, LF: 6.3
Room Temperature	21°C
Humidity	18%
Detect Voltage	50.40 V

○ 측정값

0.79 ppm/min



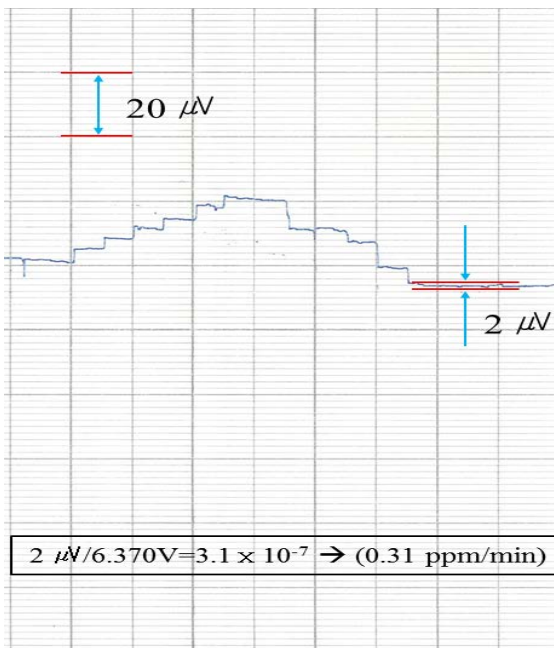
5. OL stability at 1250 kV

○ 측정 조건

Recorder	HIOKI PR8112 Pen Recorder
Recorder Range	± 10 mV
Amp. Gain	x 100
Chart Speed	60 mm/min
Amp Filter	DC ~ 100 KHZ
Amp Type	ITHACO 1201
Cancel (HT compensator)	MF: 8.2, LF: 6.3
Room Temperature	21°C
Humidity	18%
Objective Lens Voltage	6.372 V

○ 측정값

0.31 ppm/min



[OC101] Bio-High Voltage Electron Microscope

생물전용 초고전압투과전자현미경

2019. 1. 1

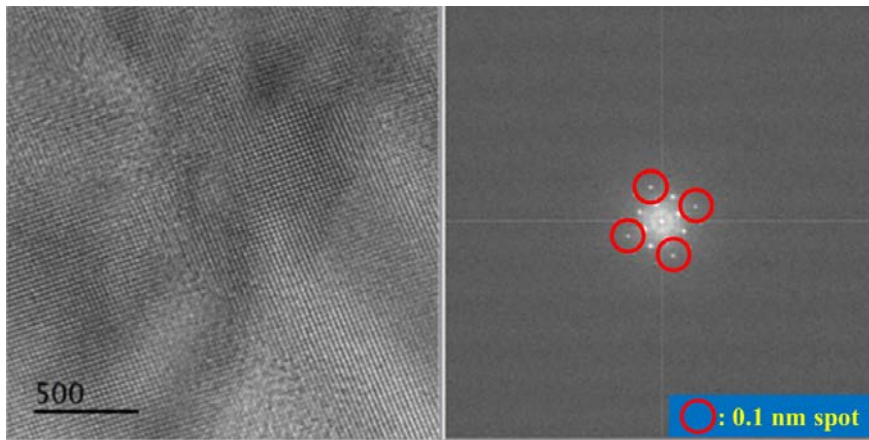
1. Image Resolution

○ 측정 조건

Au single crystal, 1000 kV, Mag. 500K, GATAN ORIUS

○ 측정값

0.1 nm (resolution)



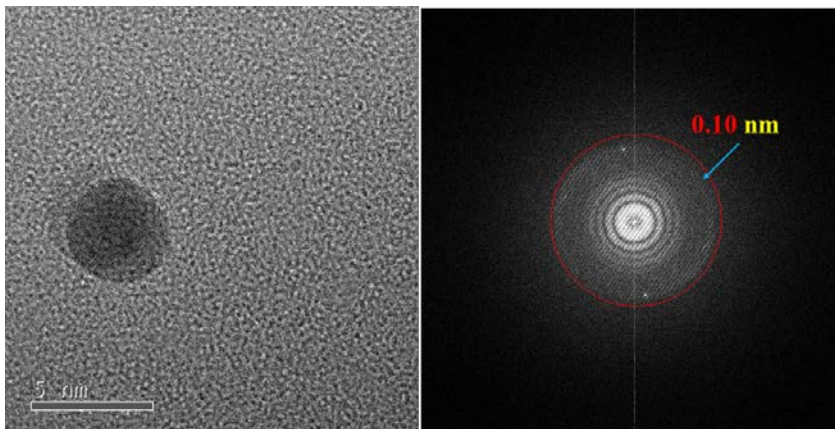
2. Information limit (Young Fringe)

○ 측정 조건

Amorphous Ge, 1000 kV, Mag. 200K, GATAN K2

○ 측정값

0.1 nm (resolution)



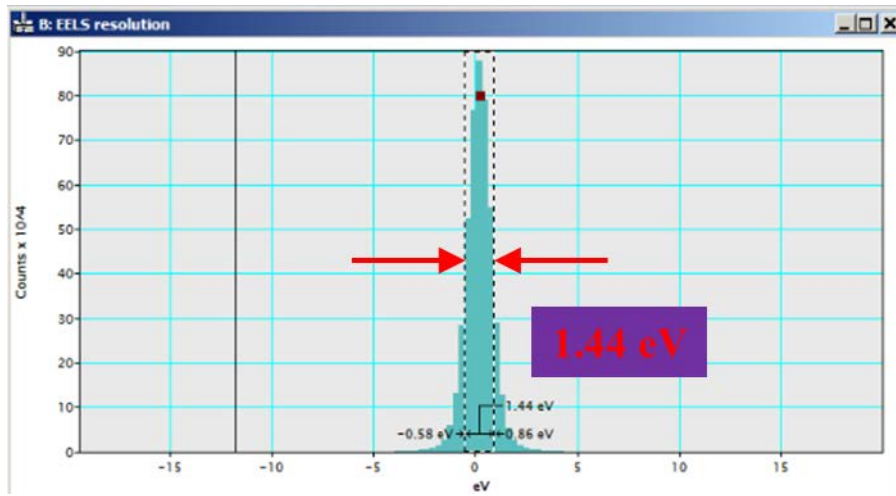
3. Energy Resolution

○ 측정 조건

Filament: under saturation, without specimen, acquisition time: 0.2 sec,
Aperture size: CL3, SA3, 1000 kV, Mag. 500K, GATAN ORIUS

○ 측정값

1.44 eV (resolution)



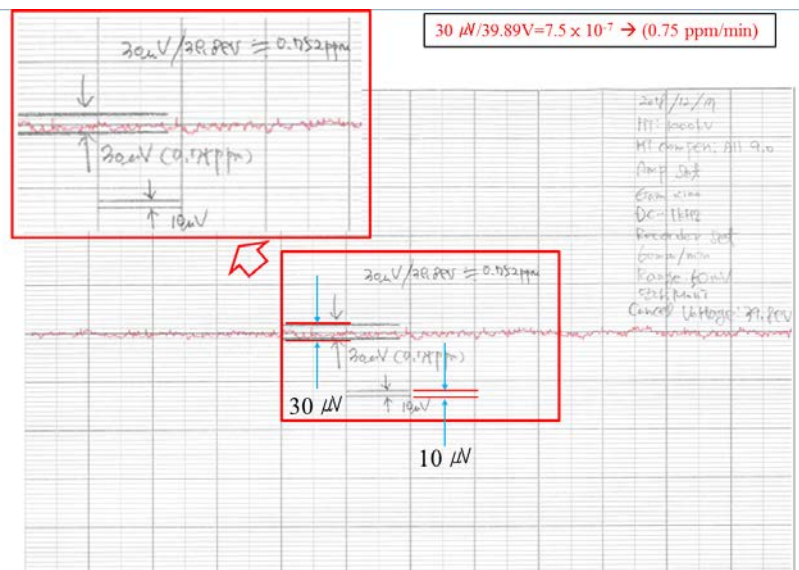
4. HT Stability (DC)

○ 측정 조건

Date	2018. 12. 24
Recorder	HIOKI PR8112 Pen Recorder
Recorder Range	±50mV
Amp. Gain	x 100
Chart Speed	60mm/min
Amp Filter	DC ~ 1KHZ
Amp Type	ITHACO 1201
Cancel (HT compensator)	HF: 9.0, MF: 9.0, LF: 9.0
Room Temperature	21°C
Humidity	35%
Detect Voltage	39.88V
Result	0.75 ppm / 1min

○ 측정값

0.75 ppm/1min



5. OL Stability (DC)

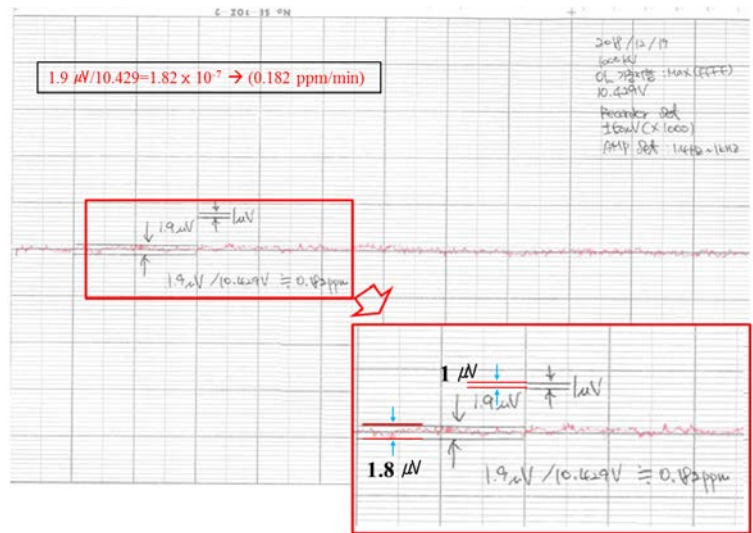
(1) 측정 조건

Date	2018. 12. 24
Recorder	HIOKI PR8112 Pen Recorder
Recorder Range	±50mV
Amp. Gain	× 1000
Chart Speed	60mm/min
Amp Filter	1.4KHZ ~ 1KHZ
Amp Type	ITHACO 1201
Room Temperature	23℃
Humidity	35%
Objective Lens Voltage	10.429V
Result	0.182 ppm / 1min

(2) 측정값

0.182 ppm/1 min

(3) 결과



[OC102] High Resolution Bio-Transmission Electron Microscope

고분해능 바이오투과전자현미경

2019. 1. 1

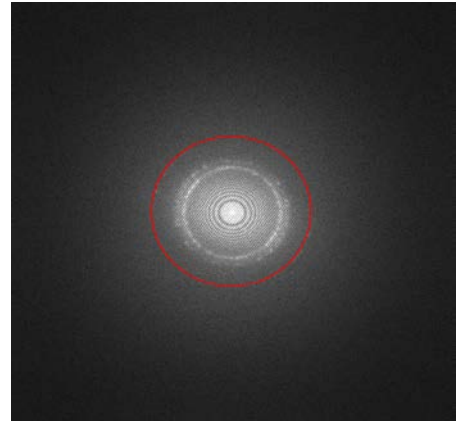
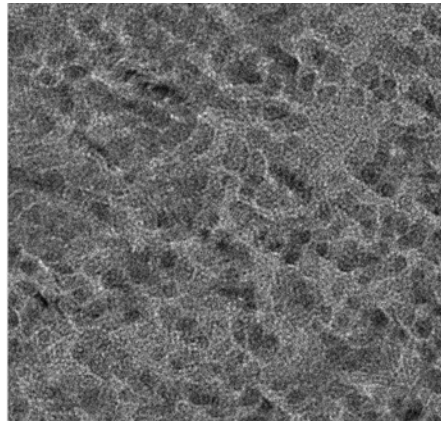
1. Information Limit

○ 측정 조건

Au crystal

○ 측정값

0.14 nm



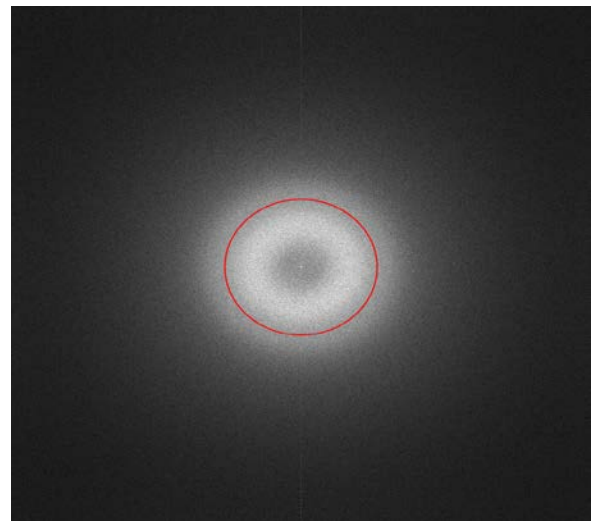
2. Point Resolution

○ 측정 조건

Amorphous carbon

○ 측정값

0.33 nm



3. Specimen drift

○ 측정 조건

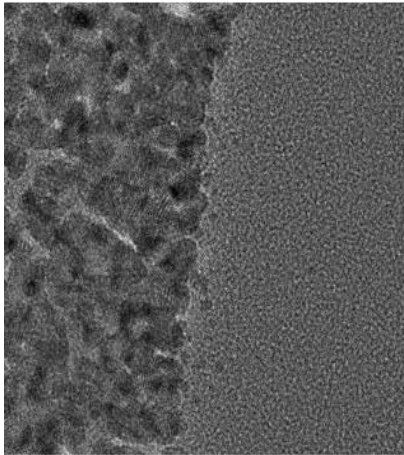
Au crystals

○ 측정값

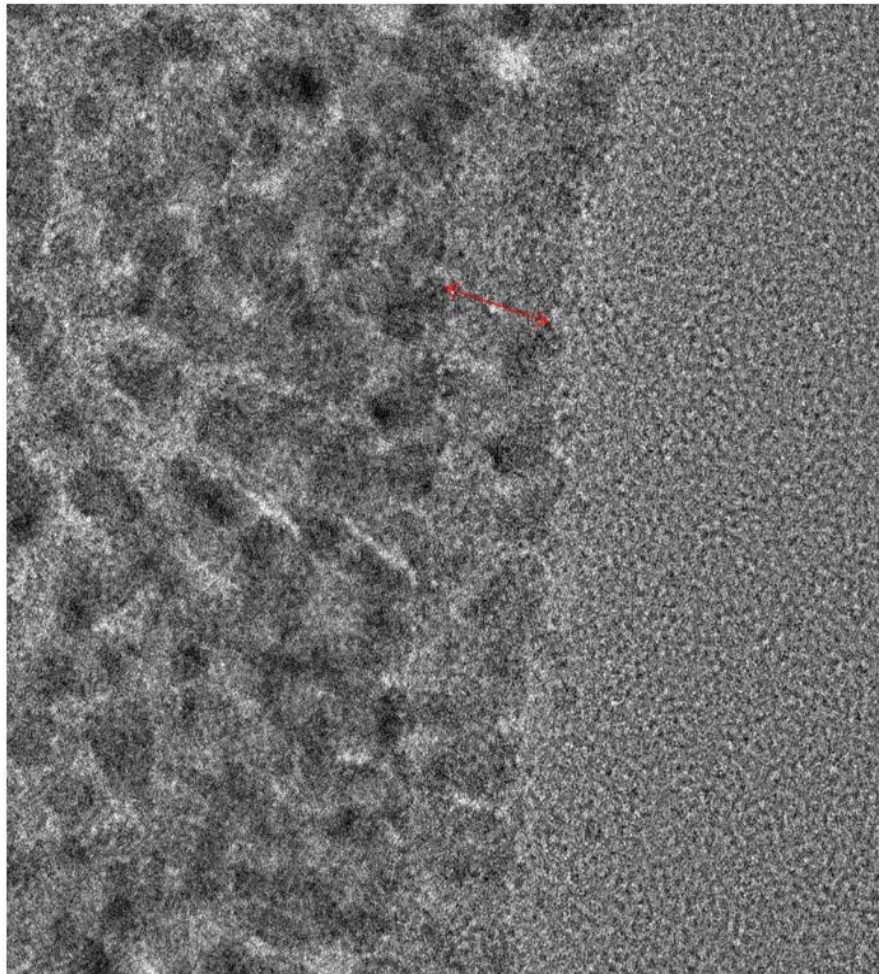
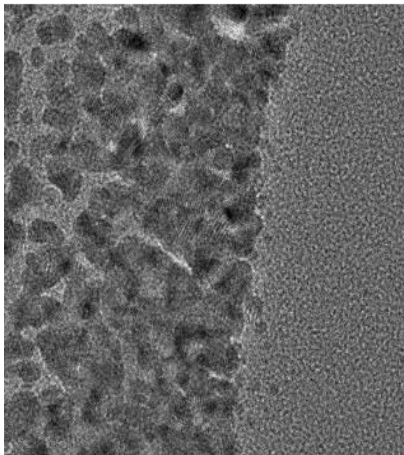
0.4 nm/min

0 min

Merged two images



After 10 min



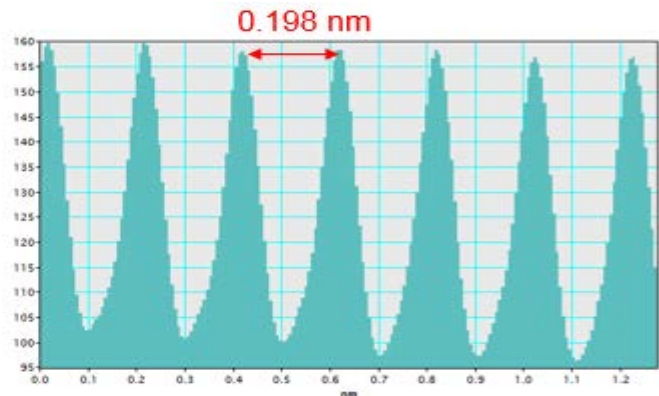
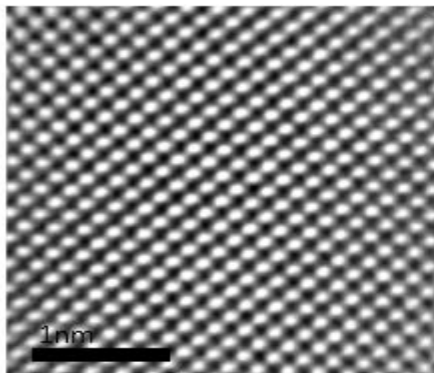
[AE02] Field Emission Transmission Electron Microscope

전계방출형 투과전자현미경

2019. 1. 1

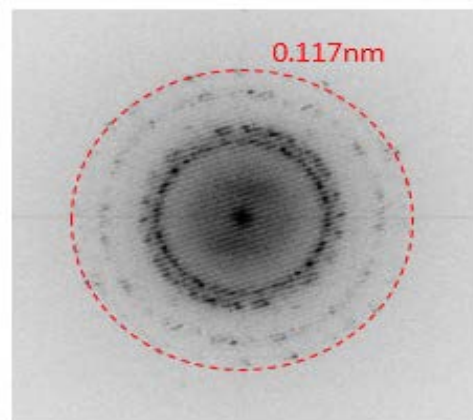
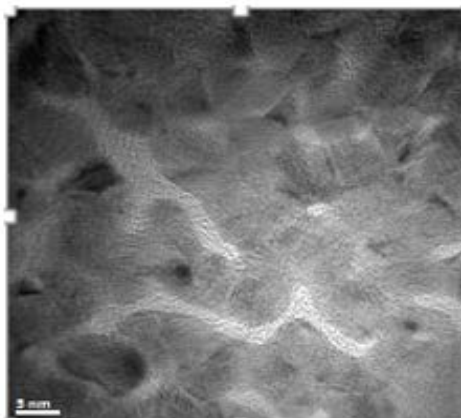
1. Point Resolution

- 측정 조건
Au single crystal, 200 kV
- 측정값
0.198 nm



2. Information Limit

- 측정 조건
Au polycrystal, 200 kV
- 측정값
0.117 nm



3. EDS Resolution

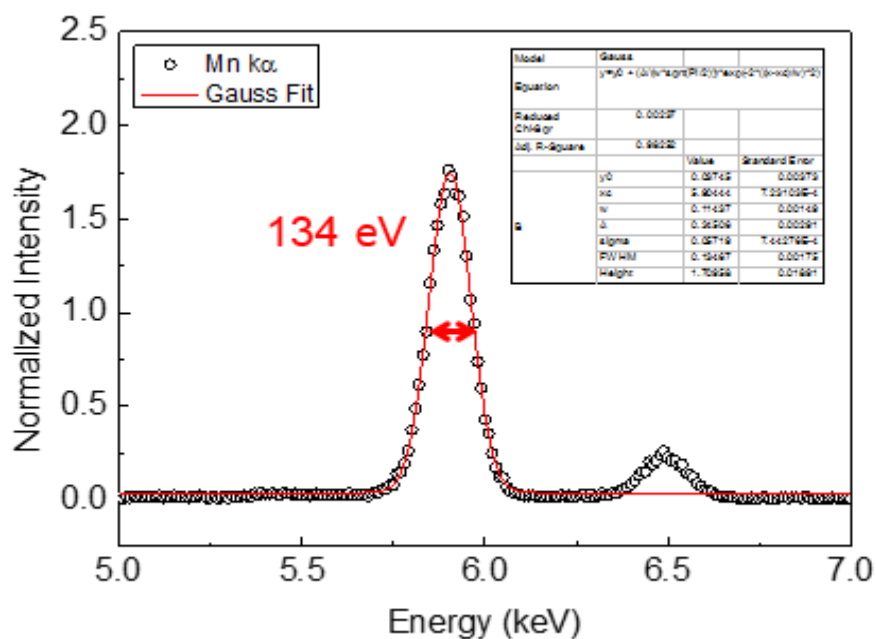
- 측정 조건

MnO₂, 200 kV

Acquisition time: 60 s

- 측정값

134 eV



[AE12] Ultra Corrected Energy Filtering Transmission Electron Microscope

수차보정에너지여과투과전자현미경

2019. 1. 1

1. Point Resolution

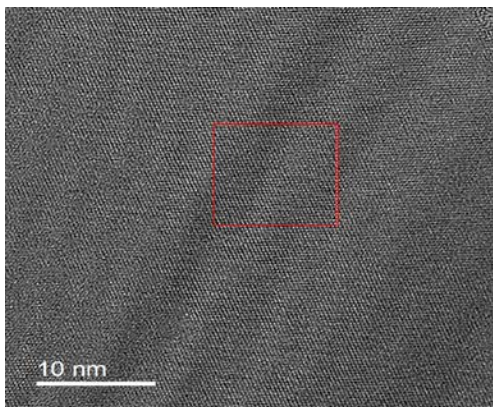
○ 측정 조건 : Si [110]

1.1. 200 kV with MC

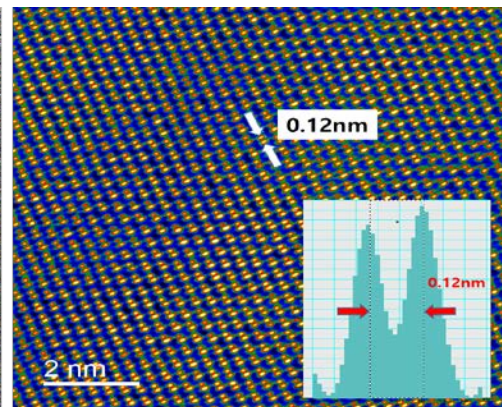
○ 측정값

0.12 nm

Single Image



Cropped Image

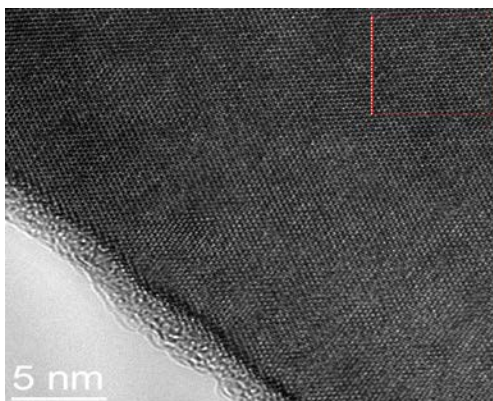


1.2. 60 kV with MC

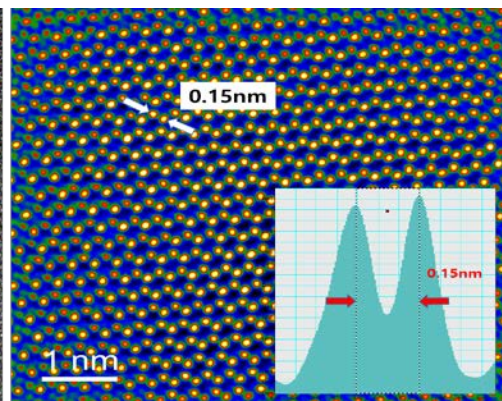
○ 측정값

0.15 nm

Single Image



Cropped Image



2. Information Limit

○ 측정 조건

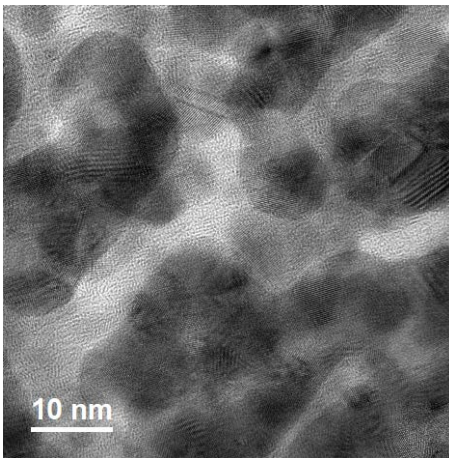
Au islands on Amorphous Carbon thin film (Replica Grating)

2.1. 200 kV with MC

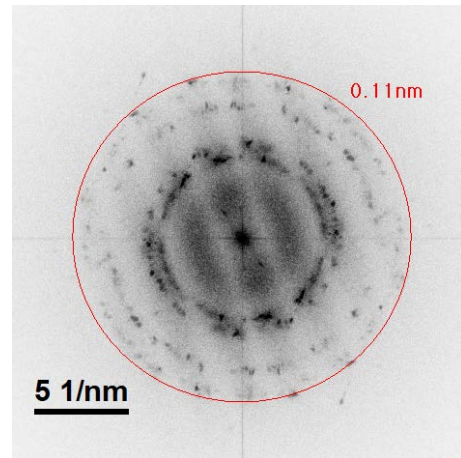
○ 측정값

0.11 nm

Single Image



Young Fringes

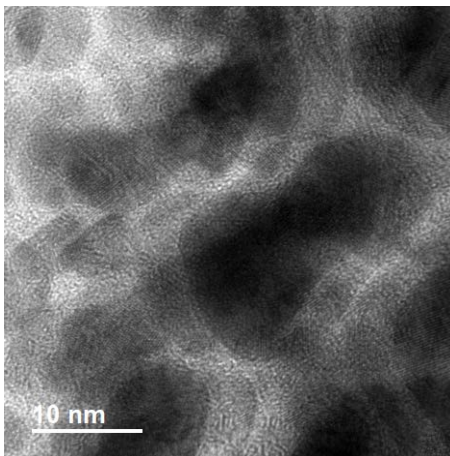


2.2. 60 kV with MC

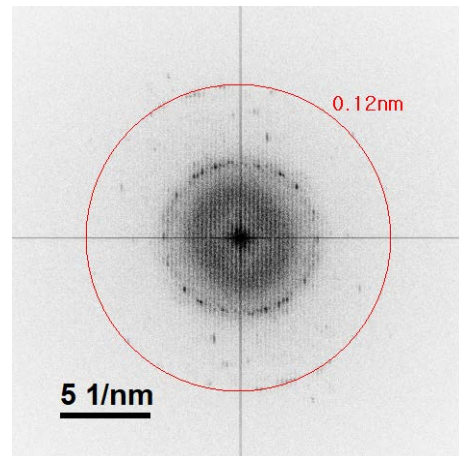
○ 측정값

0.12 nm

Single Image



Young Fringes



3. Energy Resolution

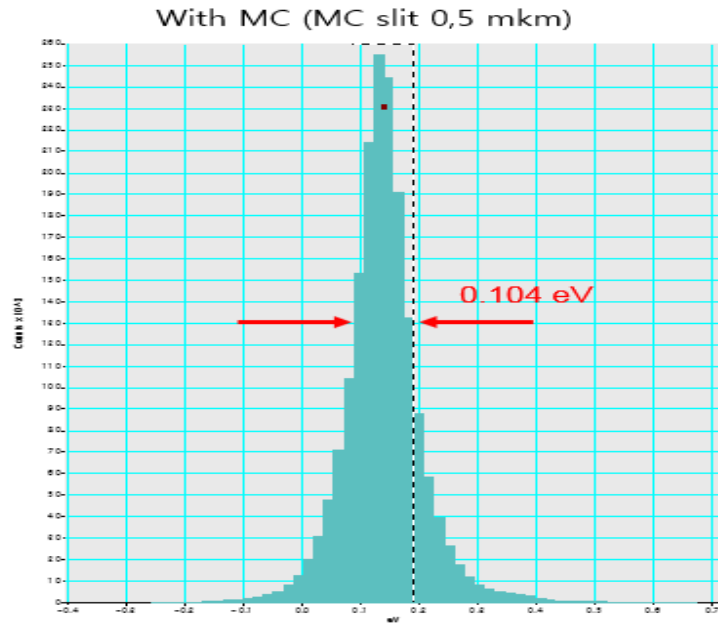
○ 측정 조건

Filament: under saturation, without specimen

3.1. 200 kV with MC

○ 측정값

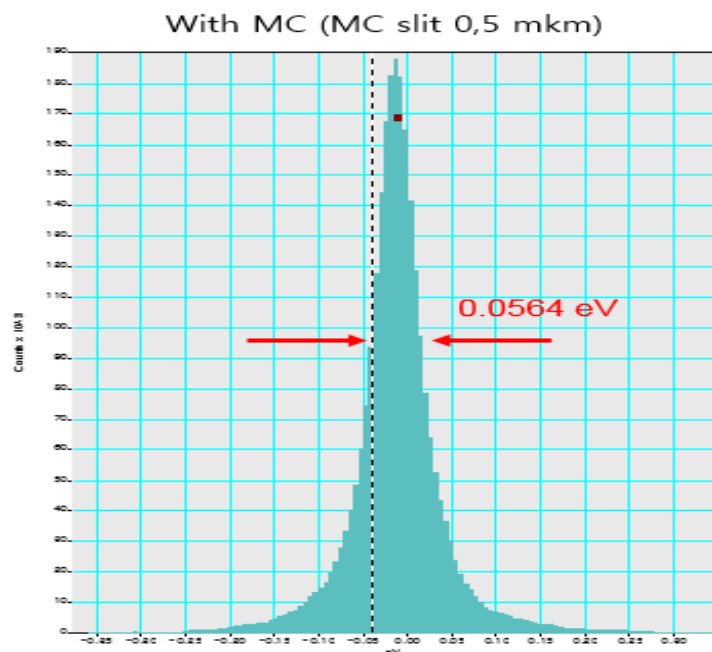
0.104 eV



3.2. 60 kV with MC

○ 측정값

0.0564 eV



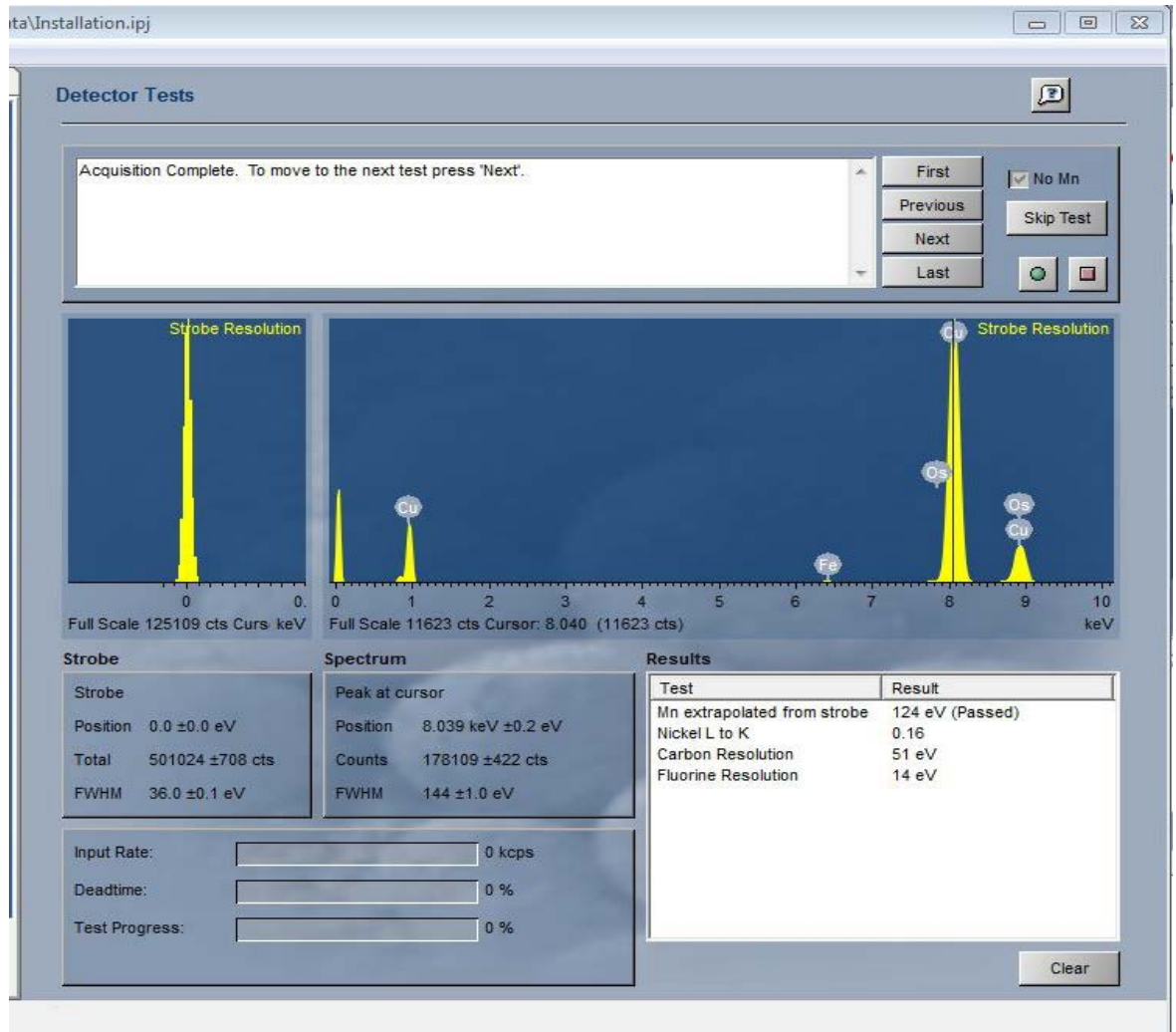
4. EDS Resolution

○ 측정 조건

Only Cu TEM grid, 200 kV

○ 측정값

124 eV



[AE03] Bio-Transmission Electron Microscope

생물 전용 투과전자현미경

2019. 1. 1

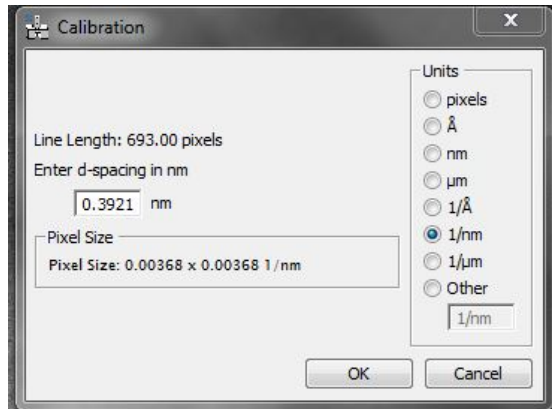
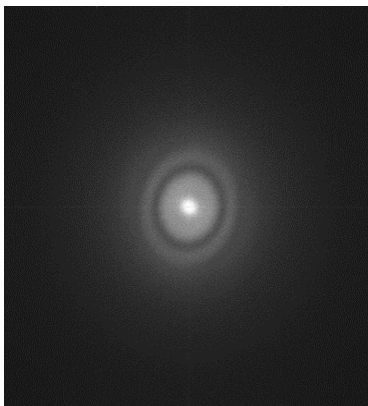
1. Point Resolution

○ 측정 조건

S106 Cross Grating 2160 1/mm 3.05 mm, 120 kV

○ 측정값

0.392 nm



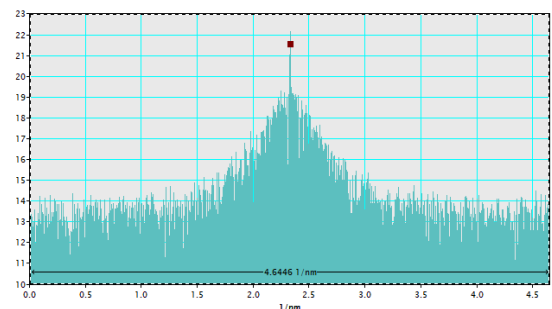
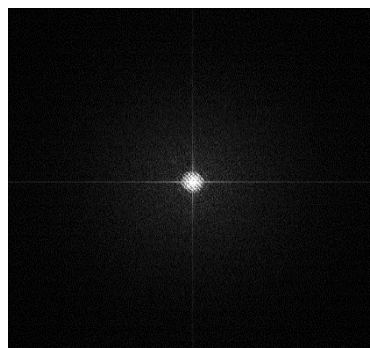
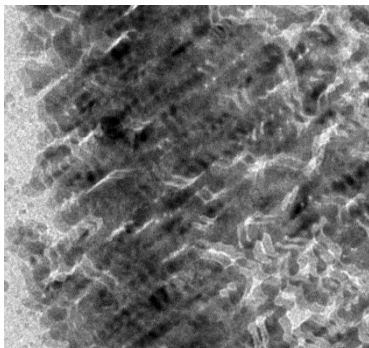
2. Information limit

○ 측정 조건

S106 Cross Grating 2160 1/mm 3.05 mm, 120 kV

○ 측정값

0.42 nm



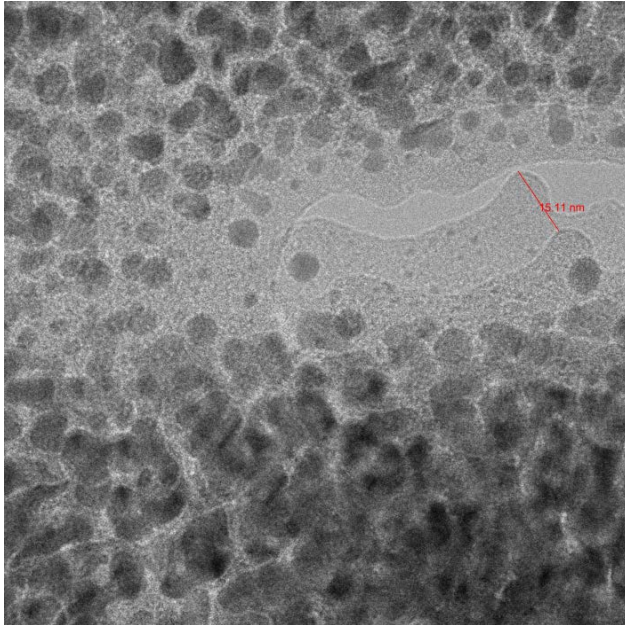
3. Specimen Drift

- 측정 조건

S106 Cross Grating 2160 1/mm 3.05mm, for 5 min, 120kV

- 측정값

3.022 nm/min



[AE14] Ultra High Analytical Scanning Electron Microscope

초고분석능 주사전자현미경

2019. 1. 1

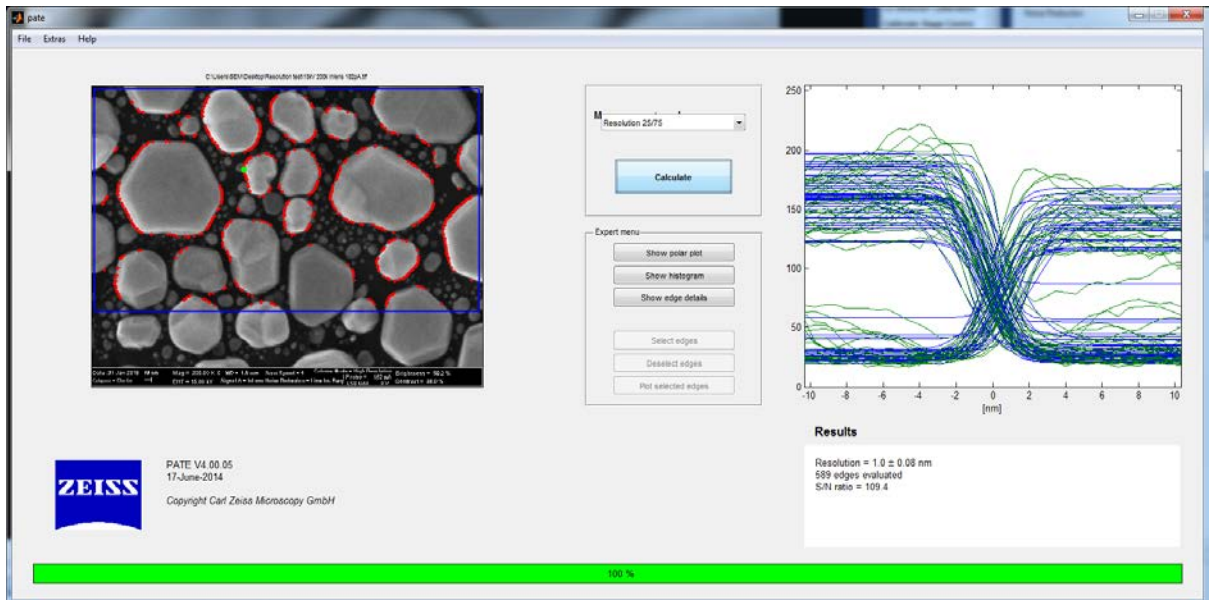
1. Point Resolution

○ 측정 조건

Au on Carbon, 15 kV

○ 측정값

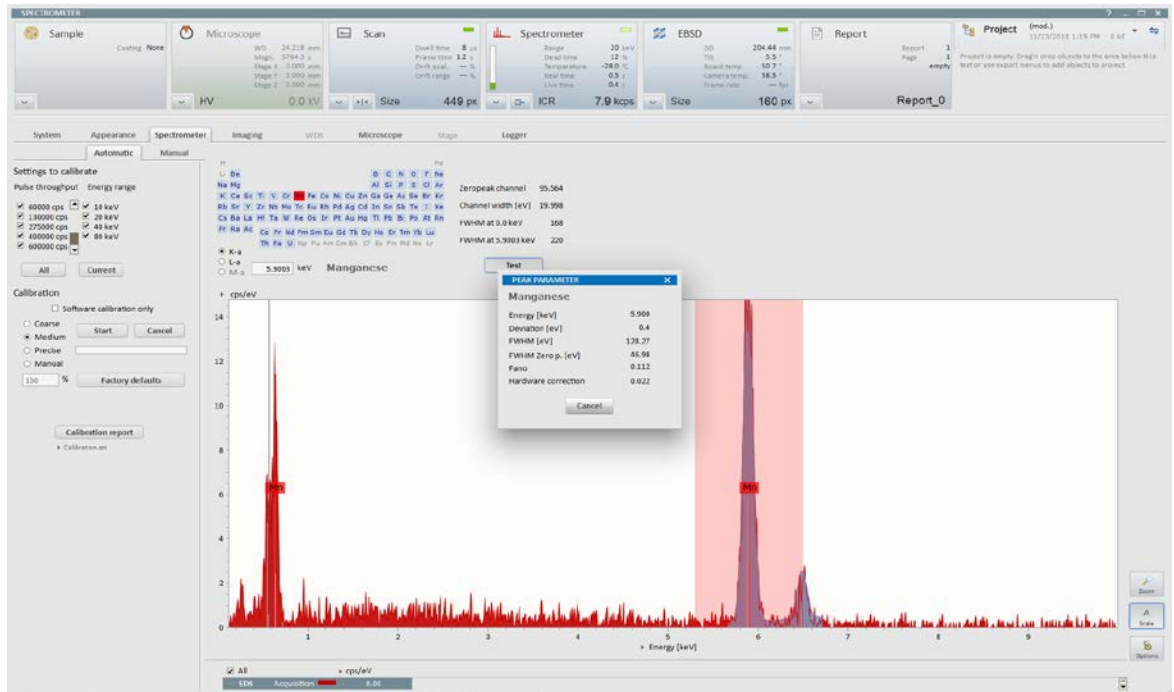
$1.0 \pm 0.08 \text{ nm}$



2. Energy Resolution

○ 측정 조건 Mn 99.99%, 15 kV

○ 측정값 128.27 eV [FWHM]



[NE02] Focused Ion Beam 집속이온빔시스템

2019. 1. 1

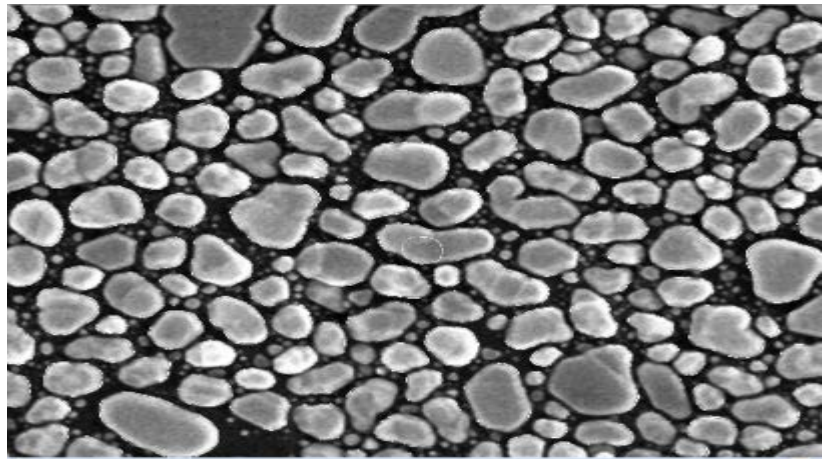
1. Image Resolution of e-beam

○ 측정 조건

Au on carbon, 30 kV spot 2-3

○ 측정값

1.001 nm



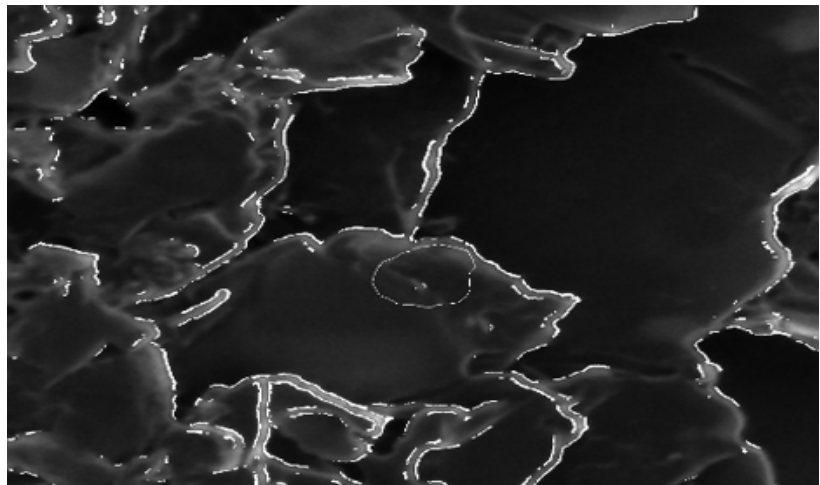
2. Image Resolution of Ga-beam

○ 측정 조건

Graphite 30 kV 1.5 pA

○ 측정값

6.629 nm



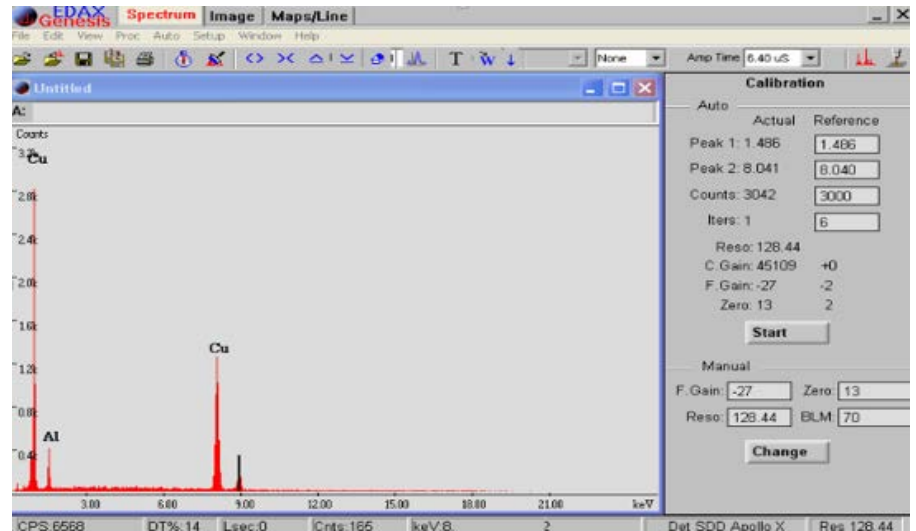
3. EDS Resolution

○ 측정 조건

Cu on Al 20 kV 4 nA

○ 측정값

128.44 eV



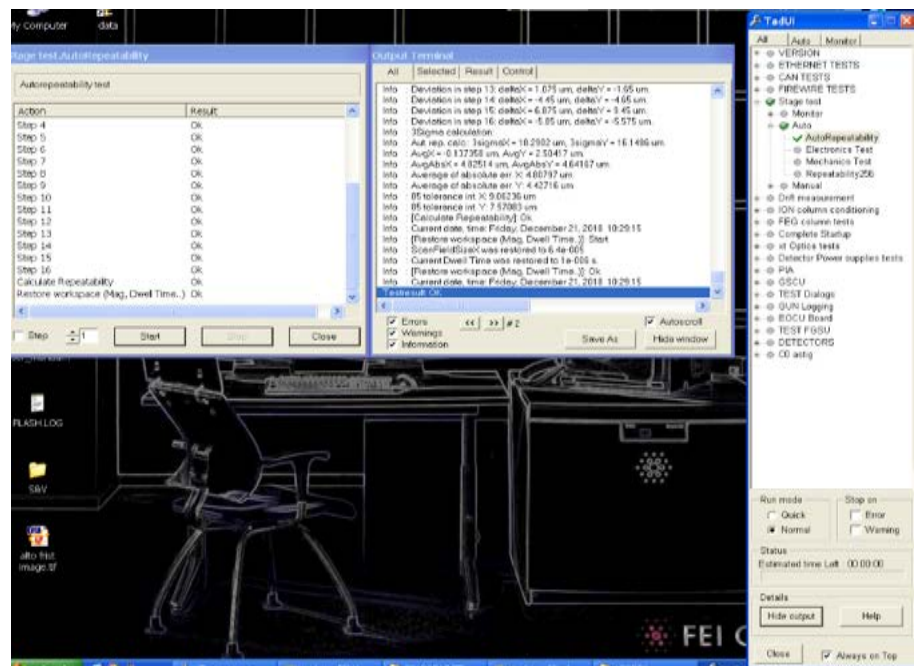
4. Stage Repeatability

○ 측정 조건

Auto repeatability

○ 측정값

$\leq 2 \mu\text{m}$



[QM05] Gas Adsorption-Desorption Measurement System

가스흡착측정장비 시스템

2019. 1. 1

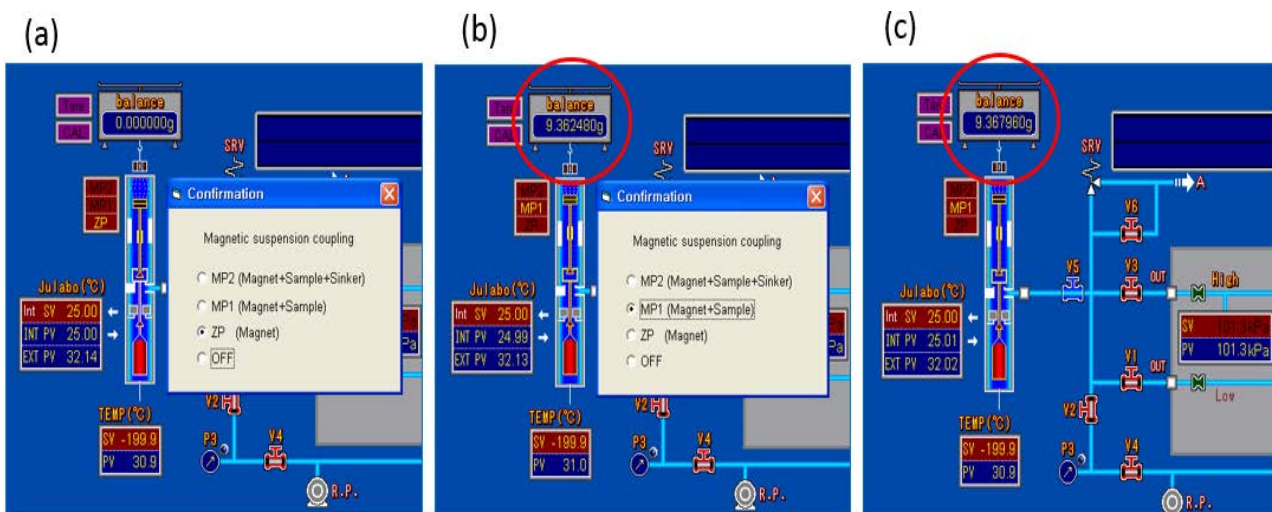
1. Weight Resolution

○ 측정 조건

상온, AC

○ 측정값

$\geq 10^{-5}g$



(a) ZP=Magnet=2.72019g

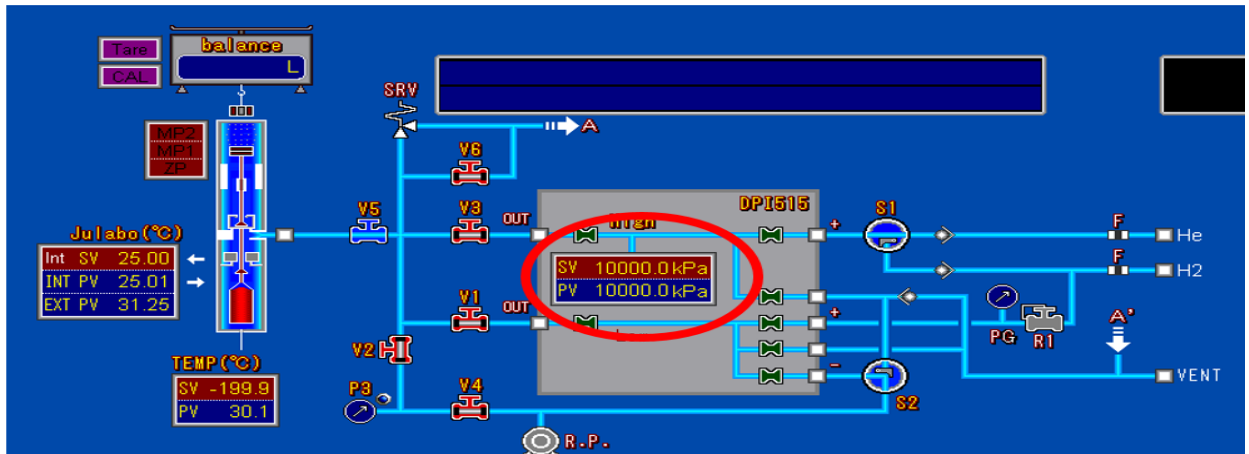
(b) MP1=2.72019g+Basket weight= 9.36248g $\therefore$ Basket weight=6.64229g

(c) MP1=2.72019g+6.64229g+Sample weight=9.36796g

$\therefore$ Sample weight=0.00548g

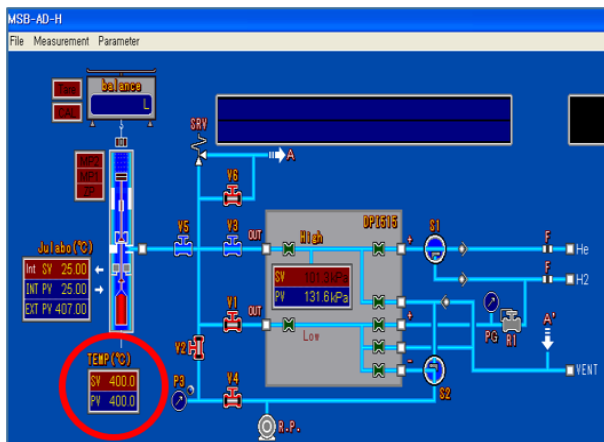
2. Pressure Limit

- 측정 조건
상온, AC
- 측정값
 ≤ 100 bar

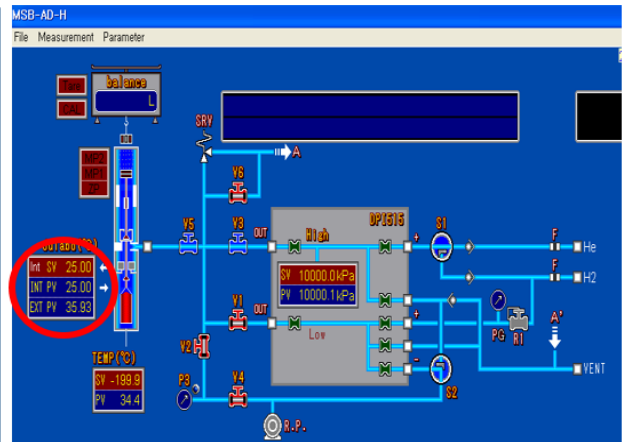


3. Temperature Limit

- 측정 조건
전처리 온도, 측정 온도
- 측정값
 ≤ 673 K



전처리 온도(673K)



측정 온도(298K)

[NE03] Multipurpose X-ray Diffractometer

다목적 X-선회절분석기

2019. 1. 1

1. Linearity

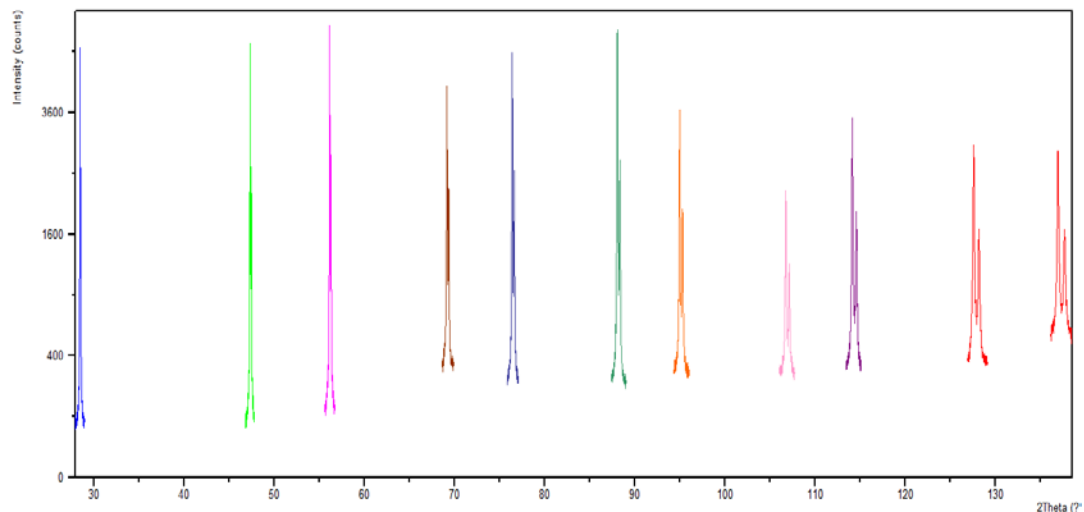
○ 측정 조건

Si standard pellet, 45 kV / 30 mA

○ 측정값

0.0067°

no	ref. peak pos.	start angle	end angle	steps	step size	measured peak pos.	difference
1	28.436	27.936	28.939	152	0.0065652	28.4598	0.0238
2	47.292	46.792	47.789	152	0.0065652	47.3175	0.0255
3	56.11	55.6102	56.7	166	0.0065652	56.1366	0.0266
4	69.117	68.6183	69.8	90	0.0131303	69.1434	0.0264
5	76.362	75.8577	77	87	0.0131303	76.39	0.028
6	88.016	87.5163	89	113	0.0131303	88.0465	0.0305
7	94.939	94.4375	96	119	0.0131303	94.9659	0.0269
8	106.696	106.1951	107.6	107	0.0131303	106.7239	0.0279
9	114.08	113.5819	115	108	0.0131303	114.1086	0.0286
10	127.535	127.037	129.0065	150	0.0131303	127.565	0.03
11	136.886	136.386	138.5	161	0.0131303	136.914	0.028
						min	0.0238
						max	0.0305
						linearity [deg.]	0.0067



2. Reproducibility

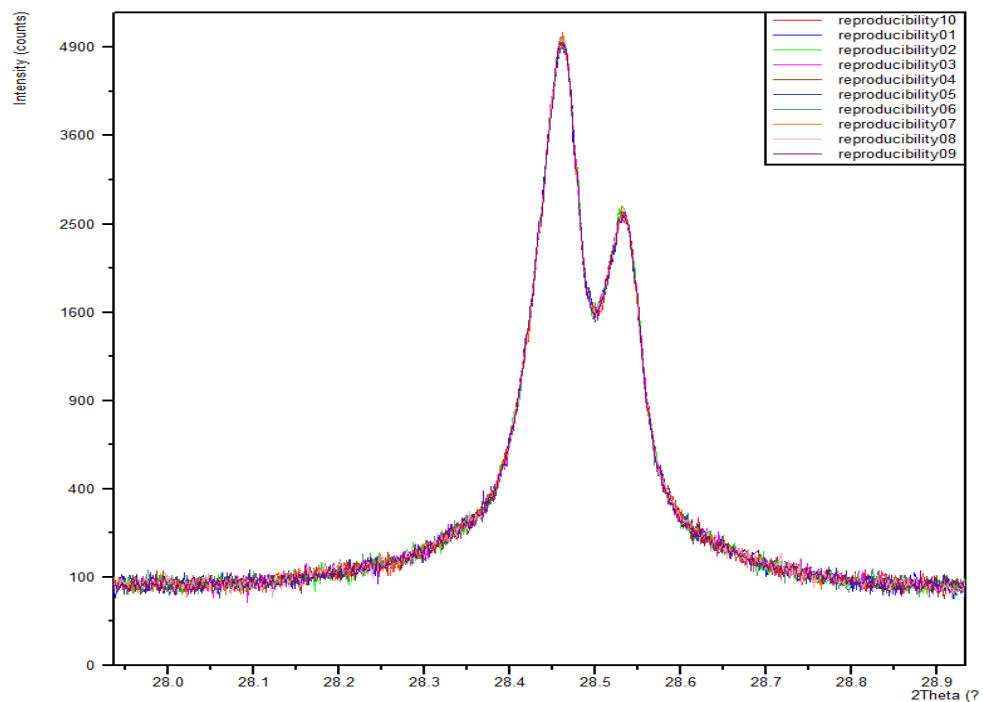
○ 측정 조건

Si standard pellet, 45 kV / 30 mA

○ 측정값

0.0005°

no	peak pos.	counts	peak pos. diff.
1	28.4604	4819.6	-0.0002
2	28.4603	4849.2	-0.0003
3	28.4606	4862	0.0000
4	28.4608	4901.9	0.0002
5	28.4607	4809.6	0.0001
6	28.4605	4907.7	-0.0001
7	28.4605	4878.1	-0.0001
8	28.4606	4894.5	0.0000
9	28.4608	4902.7	0.0002
10	28.4608	4831.5	0.0002
counts max.		4907.7	
counts min.		4809.6	
counts avg.		4865.68	
peak pos. avg.	28.4606		
peak pos. std. dev.	0.00017		
peak pos. diff. max.			0.0002
peak pos. diff. min.			-0.0003
reproducibility [deg.]			0.0005



3. Modulation

○ 측정 조건

Si standard pellet, 45 kV / 30 mA

○ 측정값

0.0624° , 31.4%

Background Int.			
	K-a1	K-a2	Interm.
Peak position	56.1373	56.2895	56.2165
net Int.	5373.7	2696.5	847
FWHM	0.0586	0.0662	
a2/a1 ratio [%]	50.17958		
Modulation depth [%]	31.41109		
Resolution [deg.]	0.0624		

