

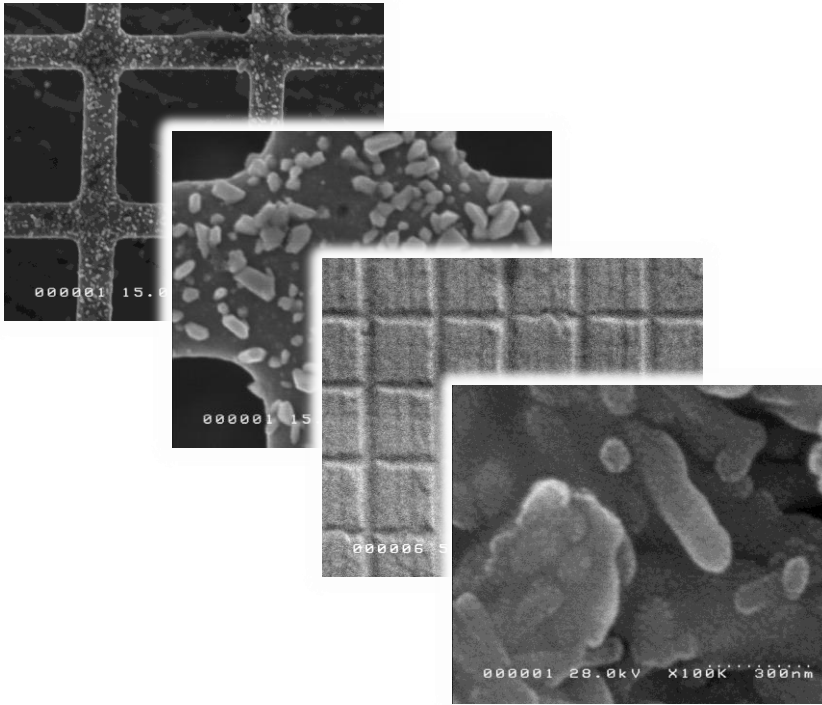
## **Experimental setup for proof of concept**

- **High probe current with high resolution for high throughput**
- **Extreme small energy dispersion for brighter e-beam**

# PC-SEM : CFE e-gun replaced with PeS product e-gun on the conventional SEM system

The conventional SEM replaced with PeS product e-gun (PC-SEM system) consists of a photocathode e-gun with the laser and a photo-electron beam adjustment system and the SEM.

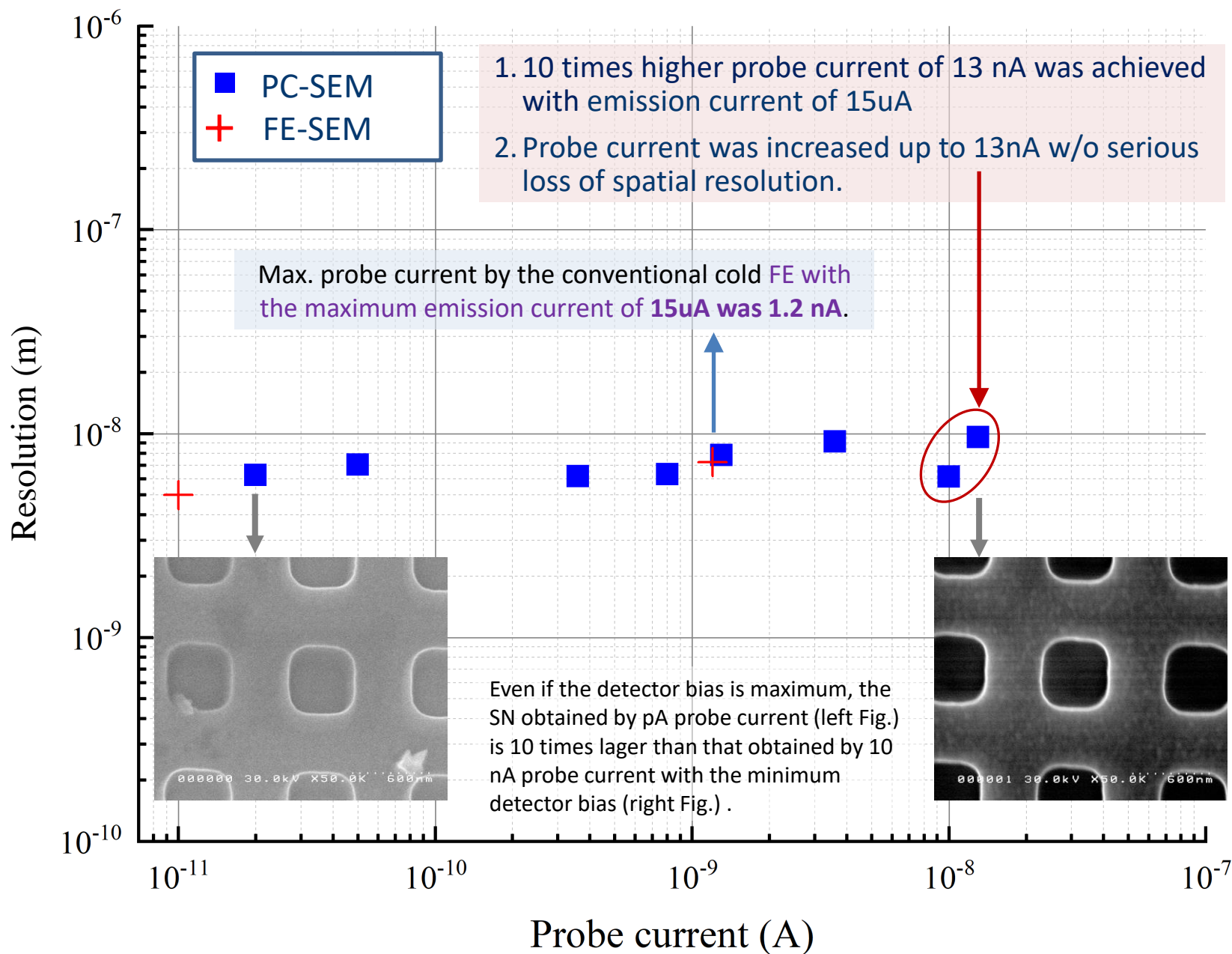
The beam axis, convergence, and divergence of the electron beam into the SEM column were optimized by the e-beam adjuster.



## **Measurement data**

- High probe current with high resolution for high throughput -**

# Result: Probe current dependence based on 10 nm resolution

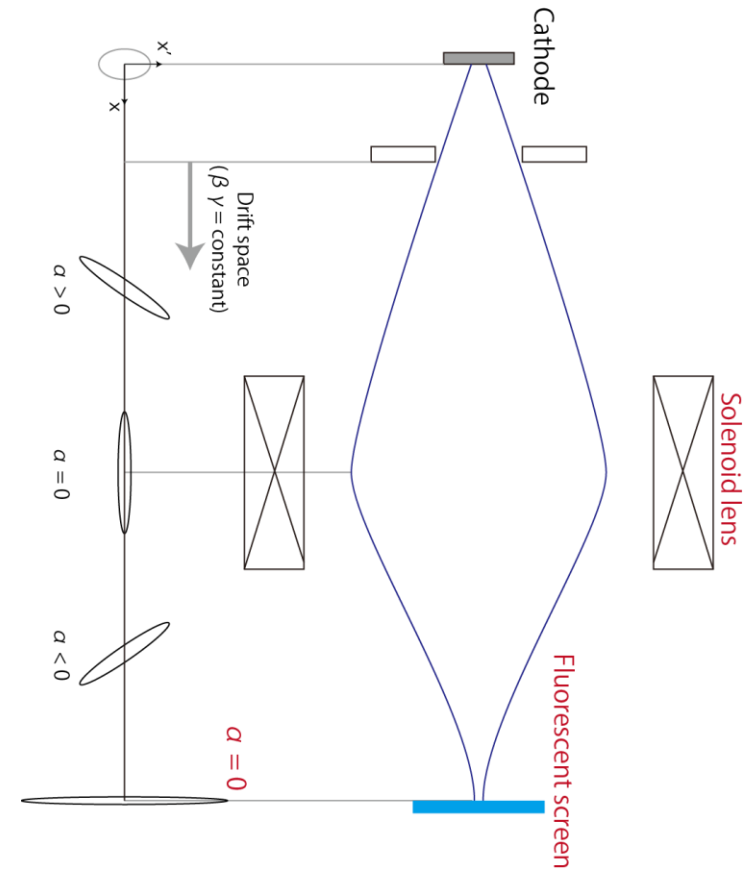
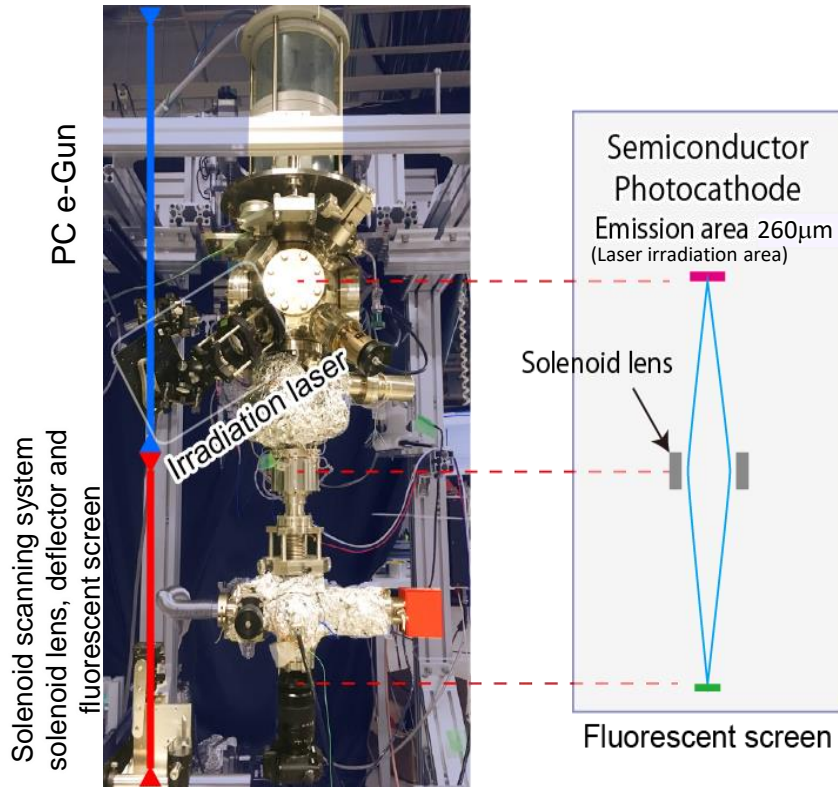


## **Measurement data**

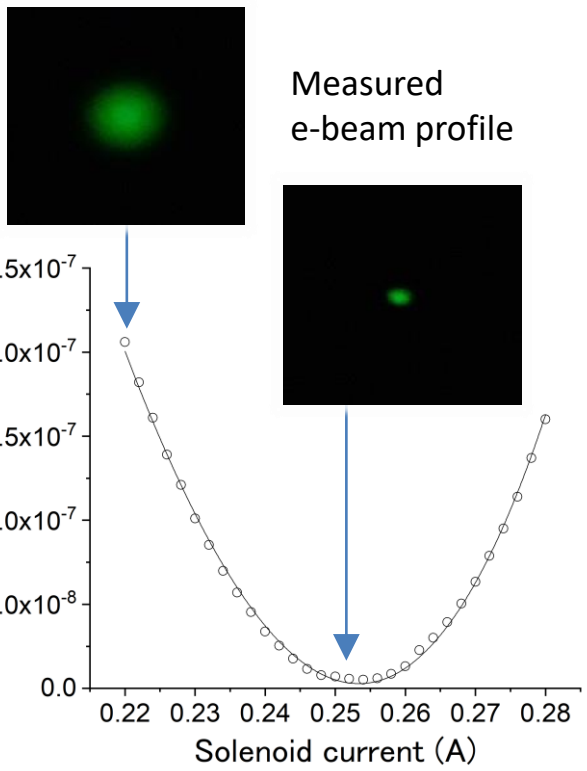
- **Extreme small energy dispersion for brighter e-beam -**

# Measurement of electron energy dispersion by solenoid scan method

Brightness, electron energy dispersion ( $k_B T$ ) can be calculated by the geometric emittance. Geometric emittance evaluation by measurement of beam envelope around focus point.



# Results of electron energy dispersion by solenoid scan method



- Measurement of beam size ( $\sigma$ ) dependence on solenoid coil current ( $i$ )
- Calculation of beam envelope by the following fitting function:

$$\sigma^2 = A(i^2 - B)^2 + C$$

A, B, C are fitting parameters

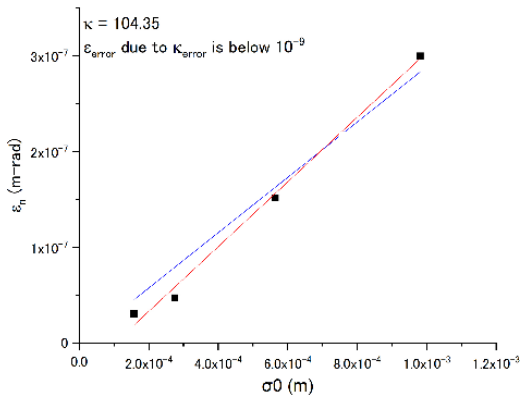
- Geometric emittance can be expressed by fitting parameters:

$$\epsilon = \frac{\sqrt{AC}}{L^2 \kappa}, \quad \frac{1}{f} = \kappa I^2$$

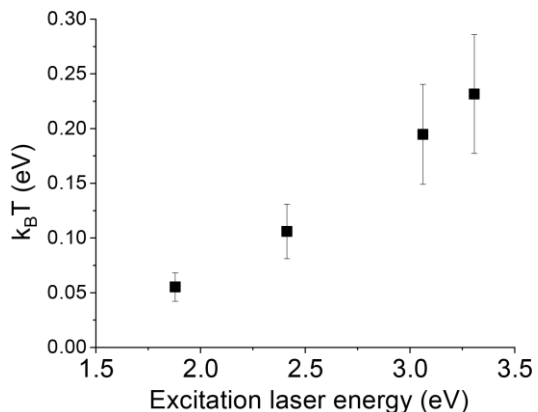
- Brightness and  $k_B T$ :

$$B = \frac{I}{(\pi \epsilon)^2}, \quad \epsilon = \frac{\sigma_0}{\beta \gamma} \sqrt{\frac{k_B T}{m c^2}}$$

I: emission current,  $\sigma_0$ : emission size



Dependence of irradiation laser energy on e-beam emittance.



Dependence of irradiation laser energy on electron energy spread

**Electron energy dispersion:**  
**0.05eV (AlGaAs)**  
**0.08eV (InGaN)**

**\*Energy spread of the cold FE: 0.3 eV**

"Observation of a 0.055 nm Spacing Lattice Image in Gold", Takeshi K AWASAKI, Tsuyoshi MATSUDA, Junji ENDO and Akira TONOMURA, J APANESE JOURNAL OF APPLIED PHYSICS, VOL. 29, No. 3, pp. L 5 08-L 510, 1990