Preliminary Report on Single and Multi-Crystal Diamond Electron Cathodes

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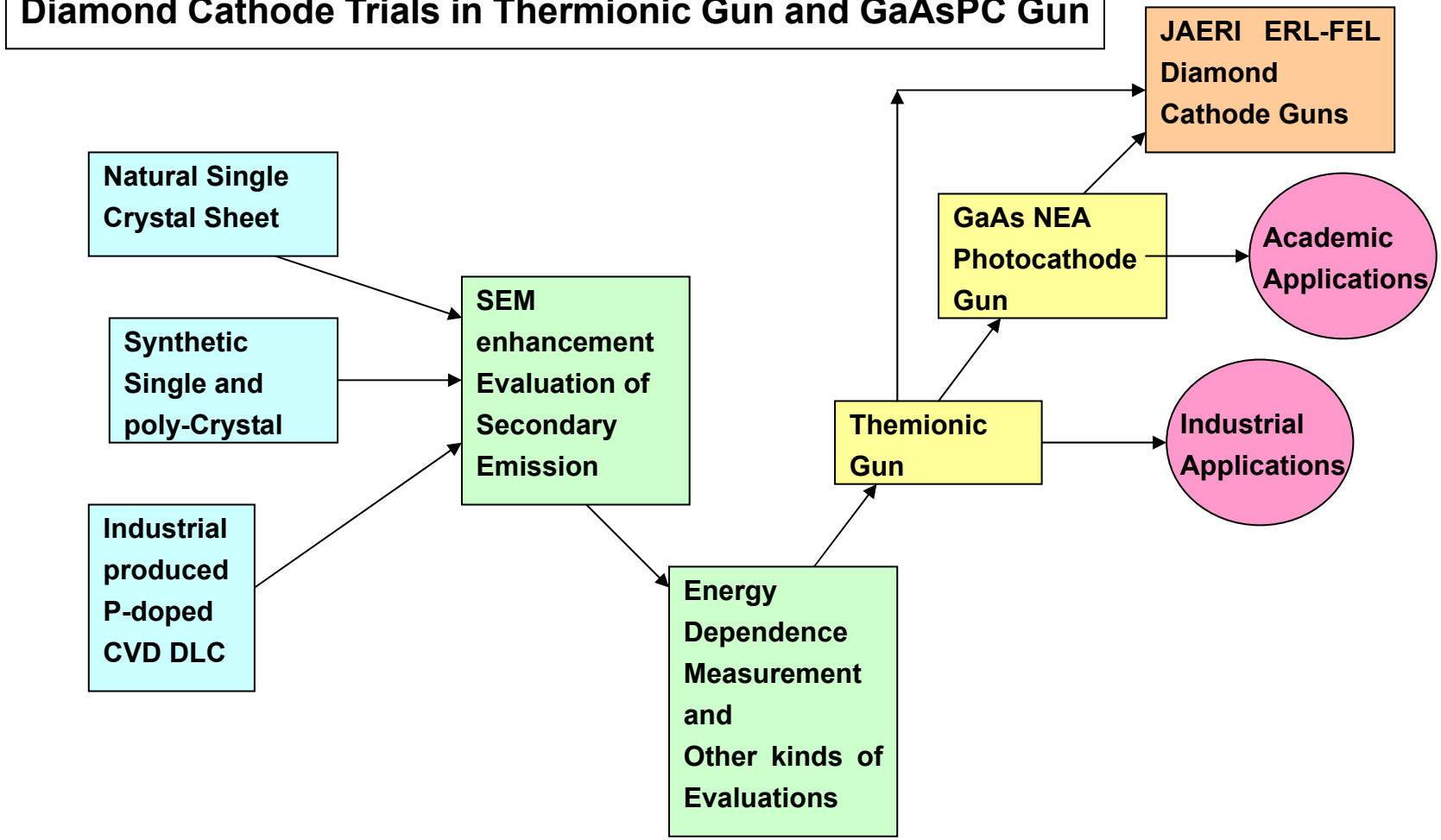
The next generation high brightness and high current electron source like a photo cathode, a thermionic cathode, a crystal Diamond electron cathode and others would be expected to realize the next generation ERL (energy recovery linac) based light source and SASE X-Ray free-electron laser. The JAERI FEL group has recently started to develop a new crystal Diamond electron cathode technology for high current, high brightness, and long life electron source. In the presentation, we plan to explain and to discuss our strategy and a preliminary experimental work of the crystal Diamond cathode, and related extreme high vacuum evacuation system.

Diamond Cathode Trials in Thermionic Gun and GaAsPC Gun



Diamond and Diamond Like Carbon SEM Material Evaluation

Material Evaluation by using SEM brightness.

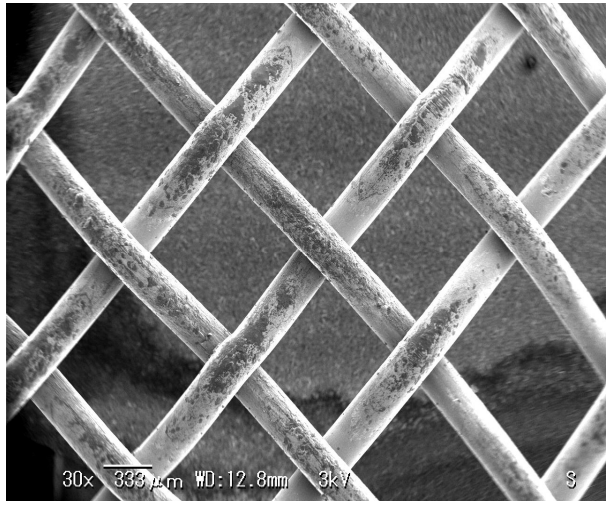


fig.1, 0.3mm thick CVD DLC film. Dark because of No NEA Layer and No P-doped.

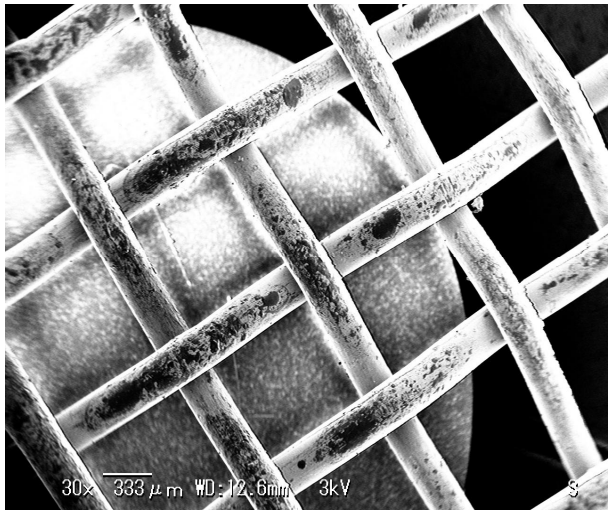


fig.2, H-terminated and B doped hot W preparation. Bright because of NEA Layer..

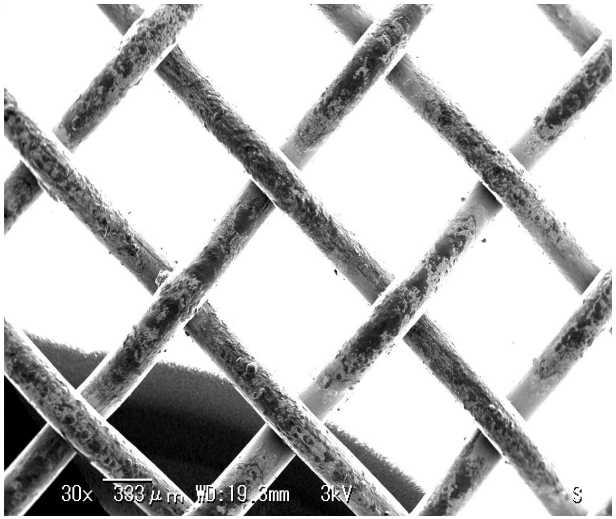


fig.3, H-terminated and B doped RF plasma preparation. Bright because of NEA Layer.

Diamond secondary emission cathode will be discussed here as Diamond electron cathode using primary electron as the exciting quanta to produce many electron hole pairs instead of the laser photon. In the scheme, we can expect very high quantum efficiency, say 10% quantum efficiency means 10 photons need to produce one electron, on the other hand, 2.6keV primary electron can produce about 200 electrons in principle.

N: Mutliplication Factor(is proportional to E.)

$$\mathbf{N=E/\ E_{eh}=E/(2.2\cdot\Delta+Nr\cdot E_{phonon})}$$

E : Primary Electron Kinetic Energy

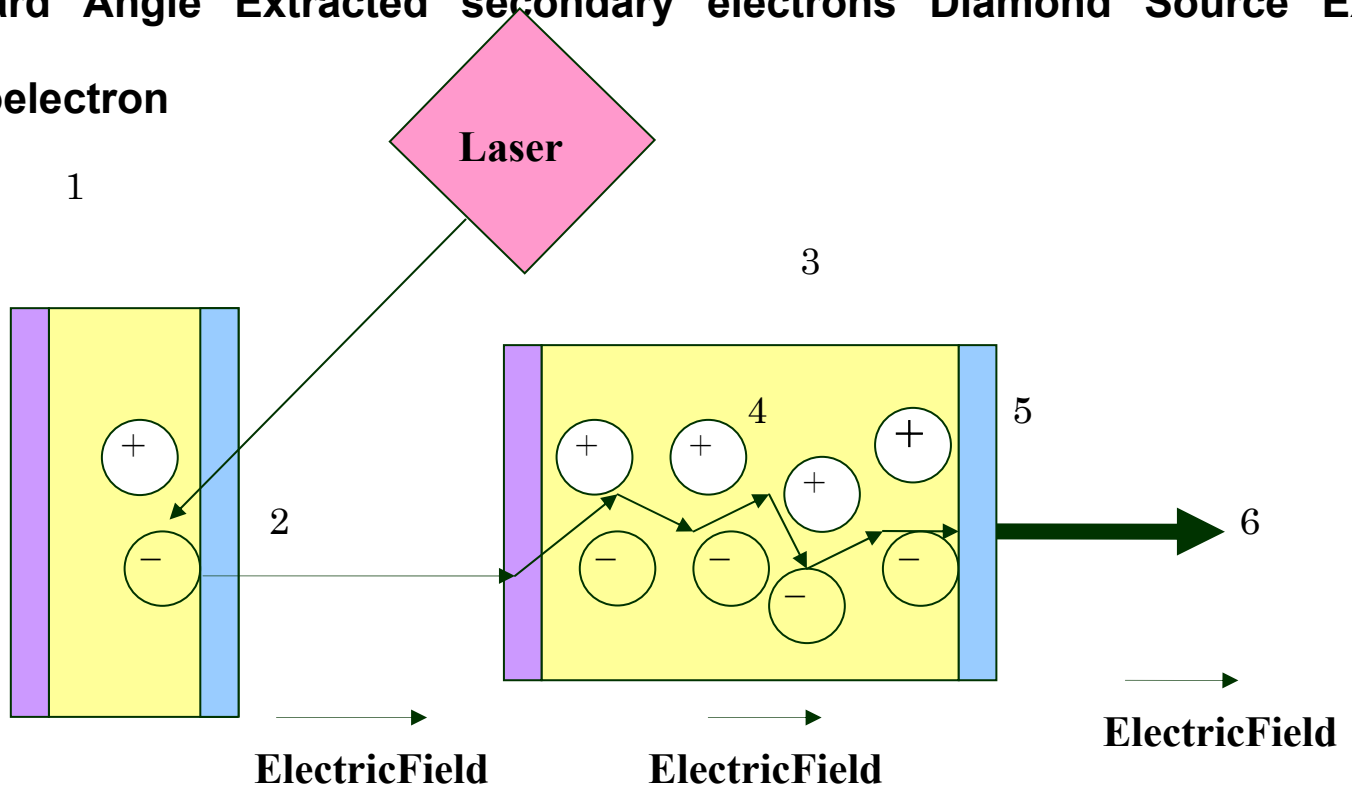
$\mathbf{E_{eh}}$:Energy needed for producing single electron hole pair=~13eV

Δ: Gap Energy of Diamond=~5.5eV,

Nr: Averaged Number of Primary Electron Excited Phonon、

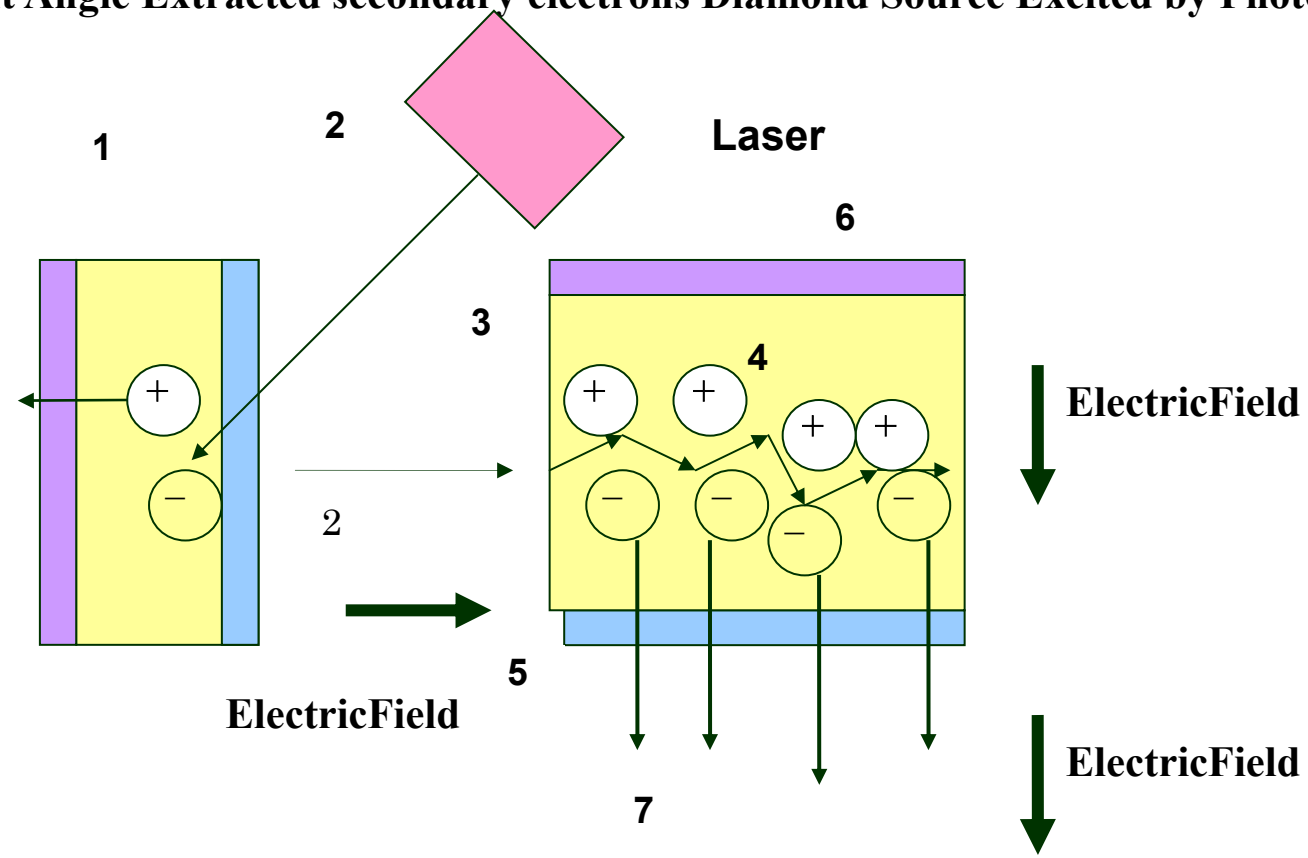
$\mathbf{E_{phonon}}$: Dissipated Phonon Energy ~several tens meV

Forward Angle Extracted secondary electrons Diamond Source Excited by Photoelectron



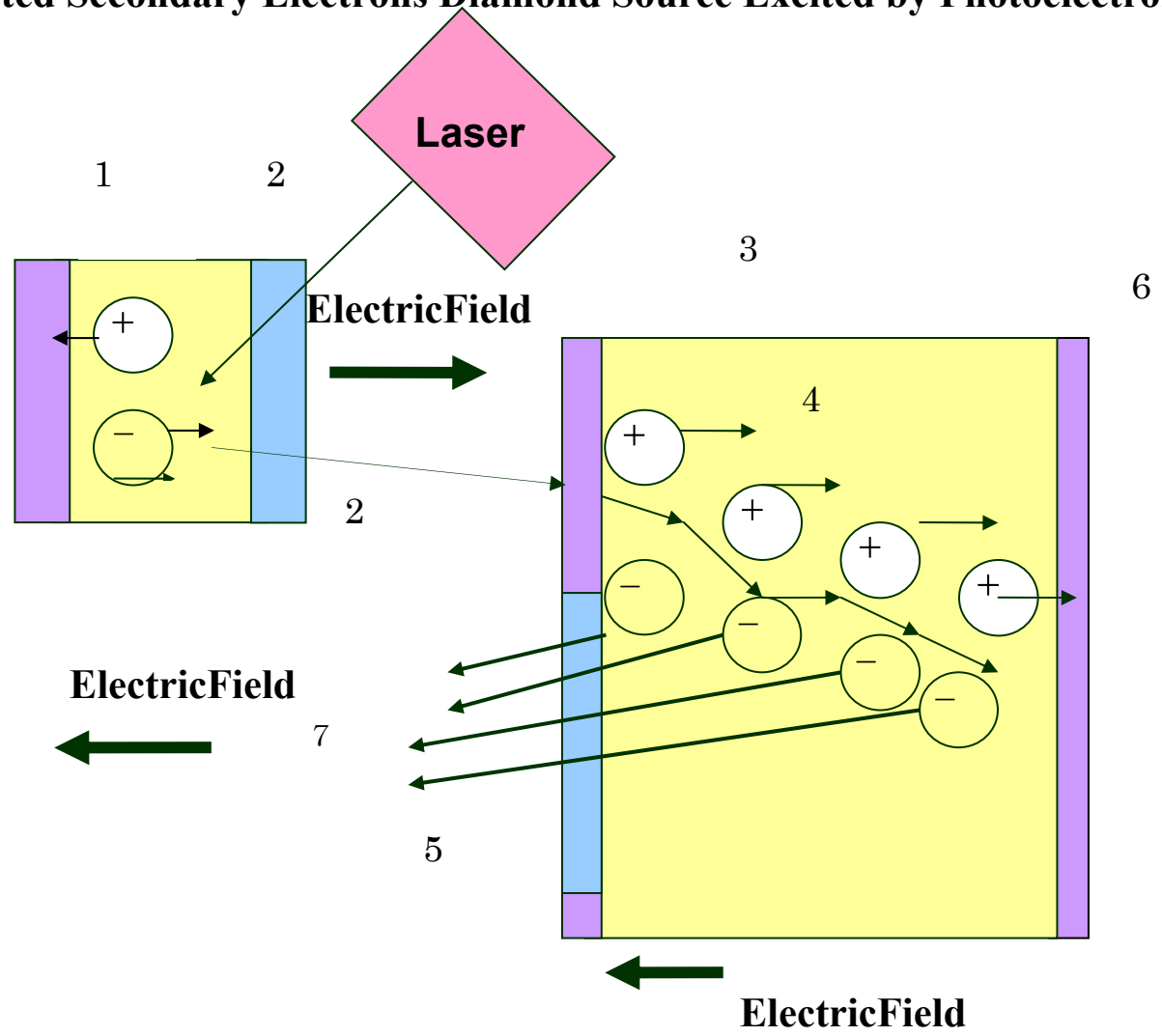
1.Primary Electron Generating Photo Cathode, 2. High Energy Quanta for Exciting Secondary Electrons, 3. Diamond Semiconductor and Insulator Multiplying Film, 4.Many Excited Electron Hole Pairs, 5. Negative Electron Affinity Surface, 6.Secondary Electrons Extraction to Vacuum,

Right Angle Extracted secondary electrons Diamond Source Excited by Photoelectron

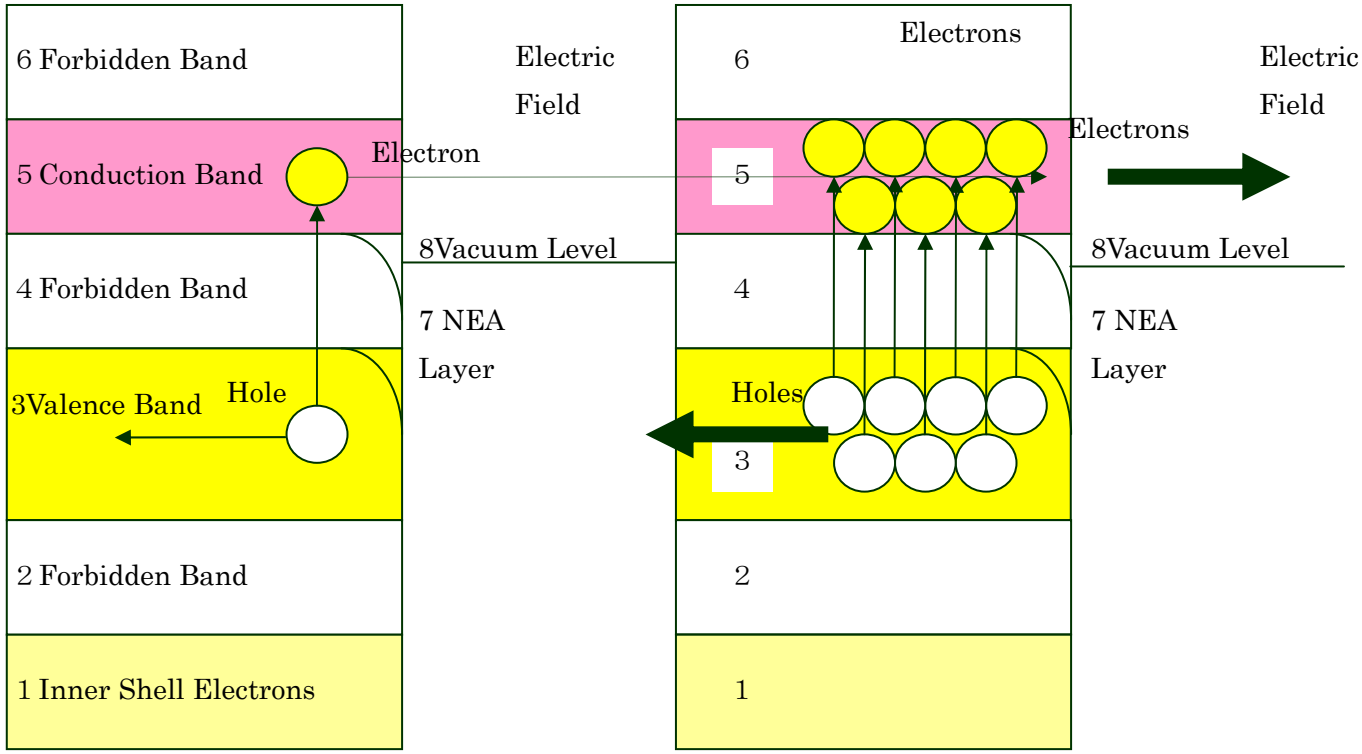


1.Primary Electron Generating Photo Cathode, 2. High Energy Quanta for Exciting Secondary Electrons, 3. Diamond Semiconductor and InsulatorMultiplying Film, 4.Many Excited Electron Hole Pairs, 5. Negative Electron Affinity Surface, 6.Secondary Electrons Extraction to Vacuum,

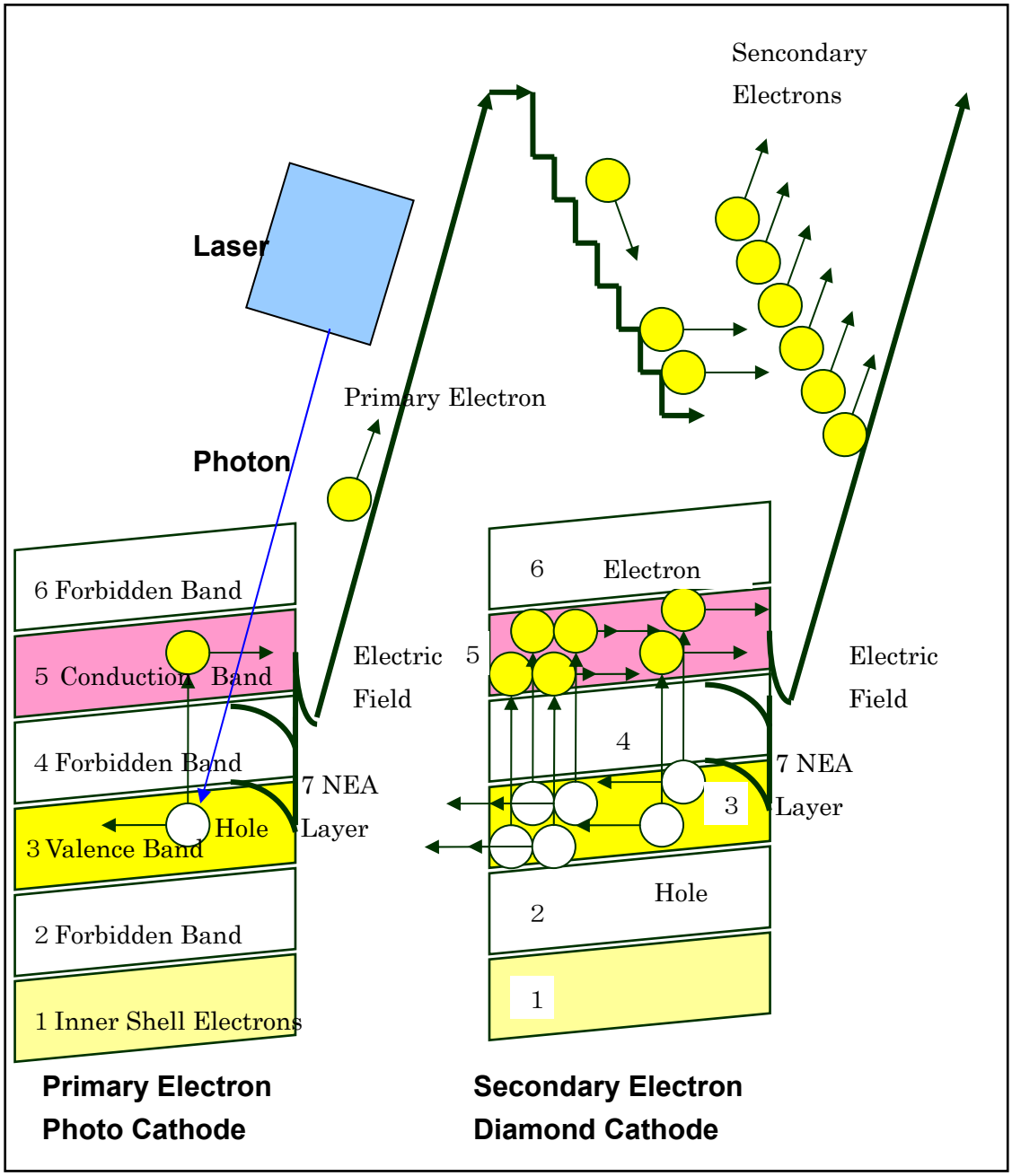
Reflected Secondary Electrons Diamond Source Excited by Photoelectron

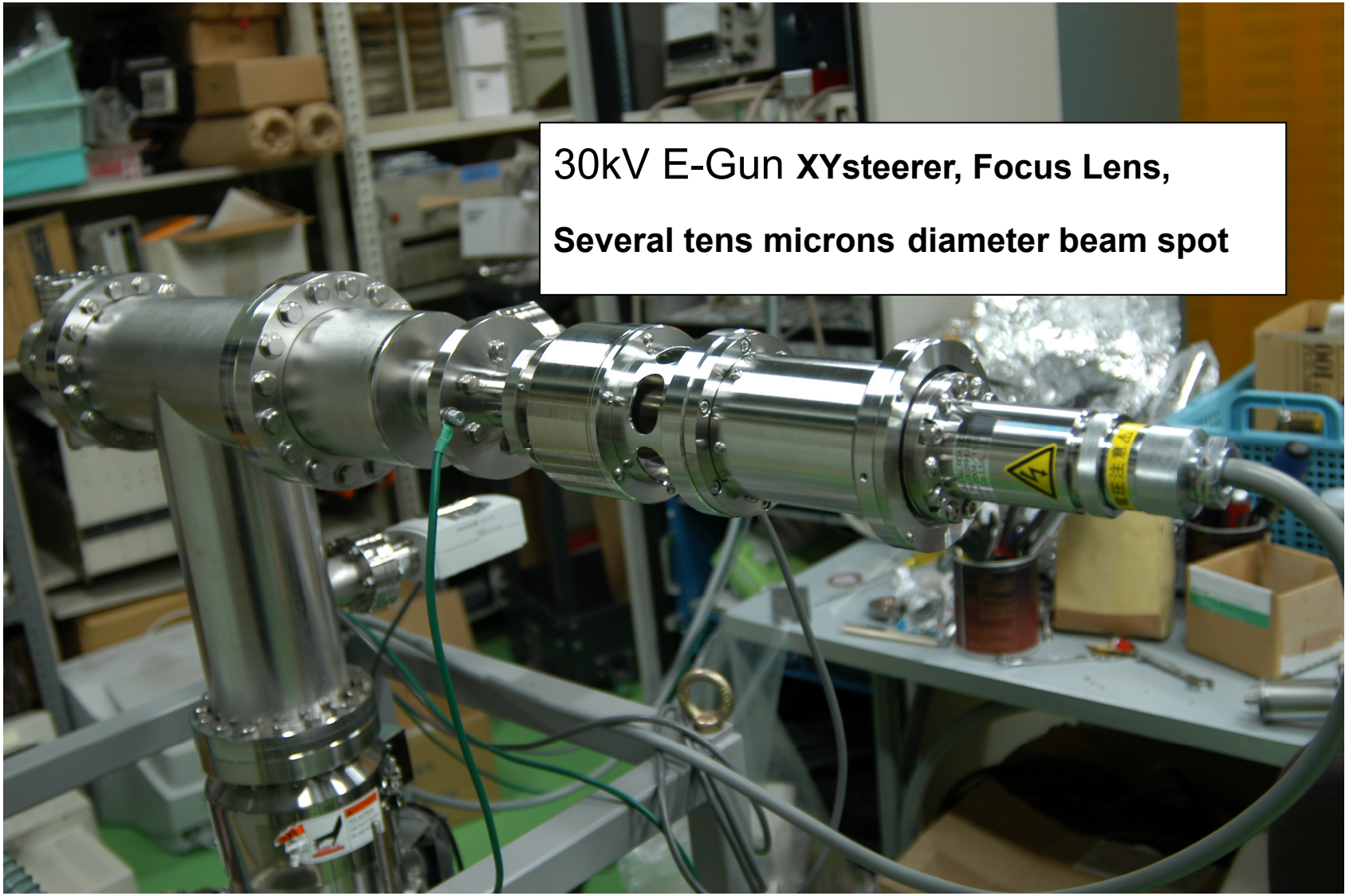


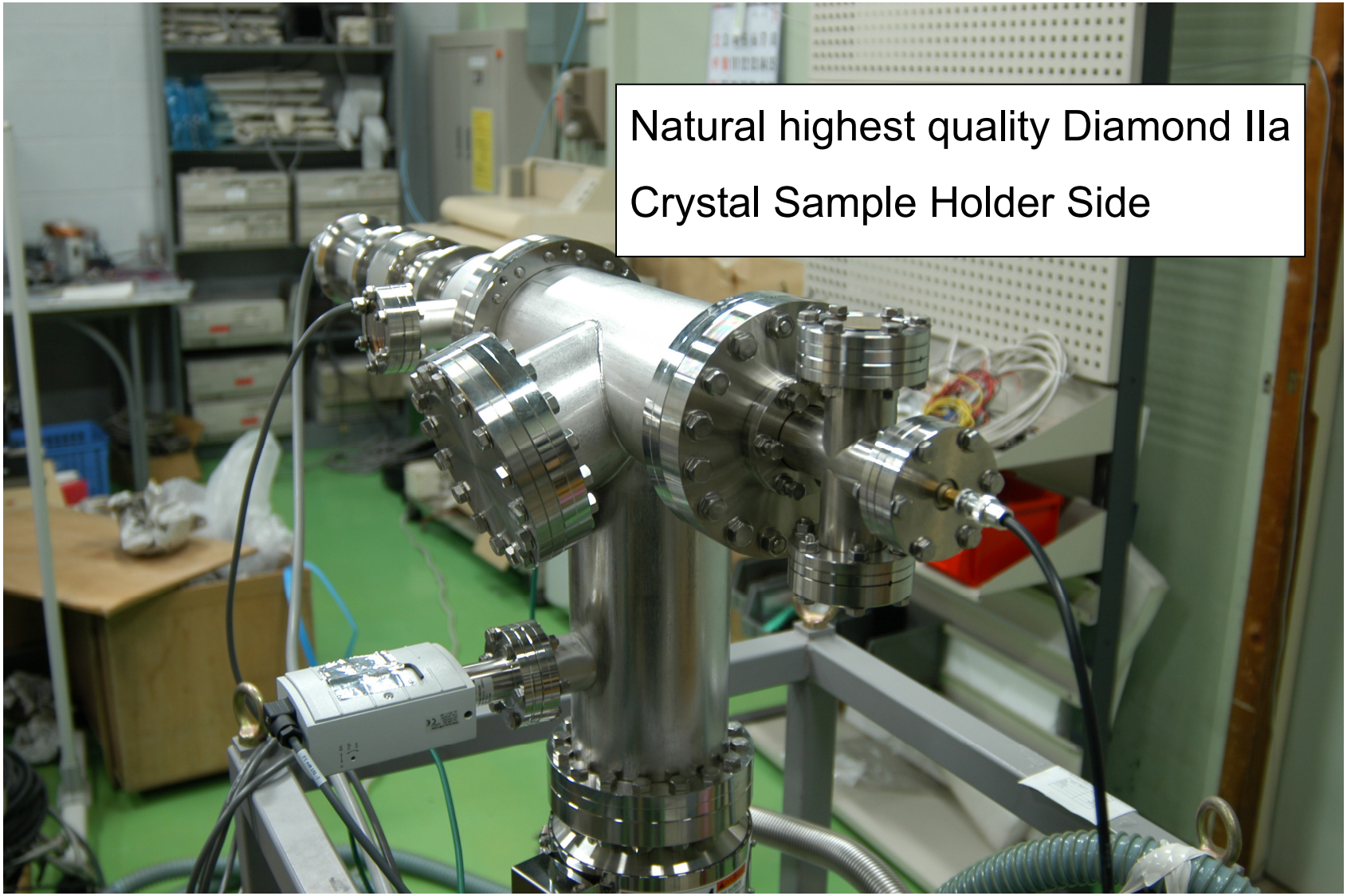
Band Structures of NEA Layered Secondary Electron Diamond Cathode and Primary Electron Photo Cathode

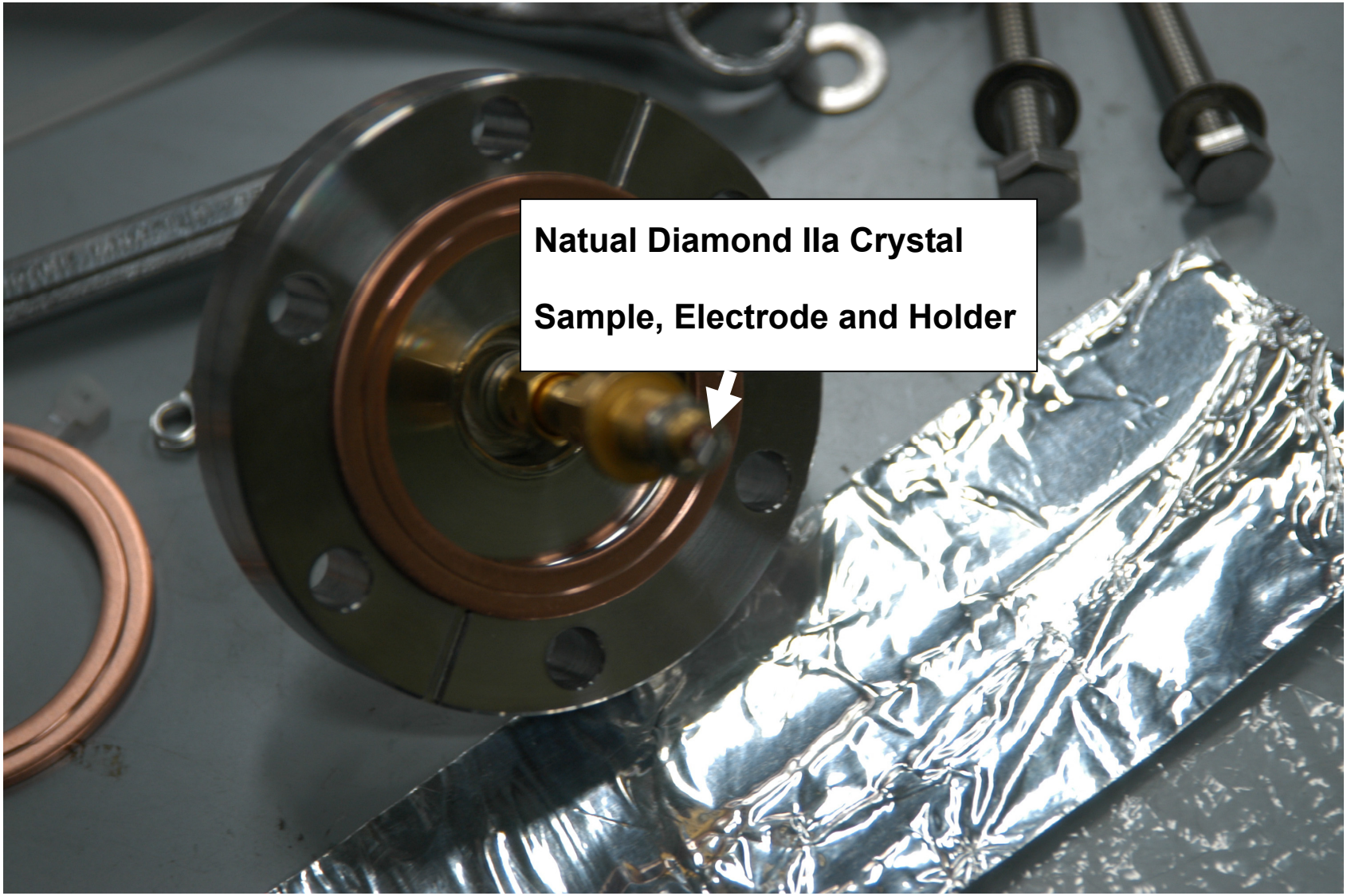


Multiplication Process in the Band Structure of NEA Layered Secondary Electron Diamond Cathode and Primary Electron Photo Cathode




30kV E-Gun **XYsteerer, Focus Lens,**
Several tens microns diameter beam spot


Natural highest quality Diamond IIa
Crystal Sample Holder Side


Natual Diamond IIa Crystal
Sample, Electrode and Holder


KS120 Ti-Alloy Test Chamber
for Future JAERI-EGUN
5x10-13Torr Achieved

Summary

1. Current Status of JAERI Diamond Electron Cathode Development was discussed.

#Thermionic Gun and GaAs NEA Gun as the primary electron source are planned to realize the JAERI Diamond Electron Cathode for ERL-LS and ERL-FEL.

#A Simple and Emperical Multiplication factor is estimated to be proportional to primary electron kinetic energy in ideal case.

#Diamond Material Evaluation by SEM , Multiplication Factor and Others Now under way.

2. XHV(Extreme High Vacuum) Ti alloy chamber as a future Gun chamber candidate is shown as one of our Gun activities.