Highly Polarized and High Quantum Efficiency Electron Source Using Transmission-type Photocathode

N. Yamamoto[1],
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1. Synchrotron Radiation Research Center, Nagoya University
2. Graduate School of Engineering, Nagoya University
3. Graduate School of Science, Nagoya University

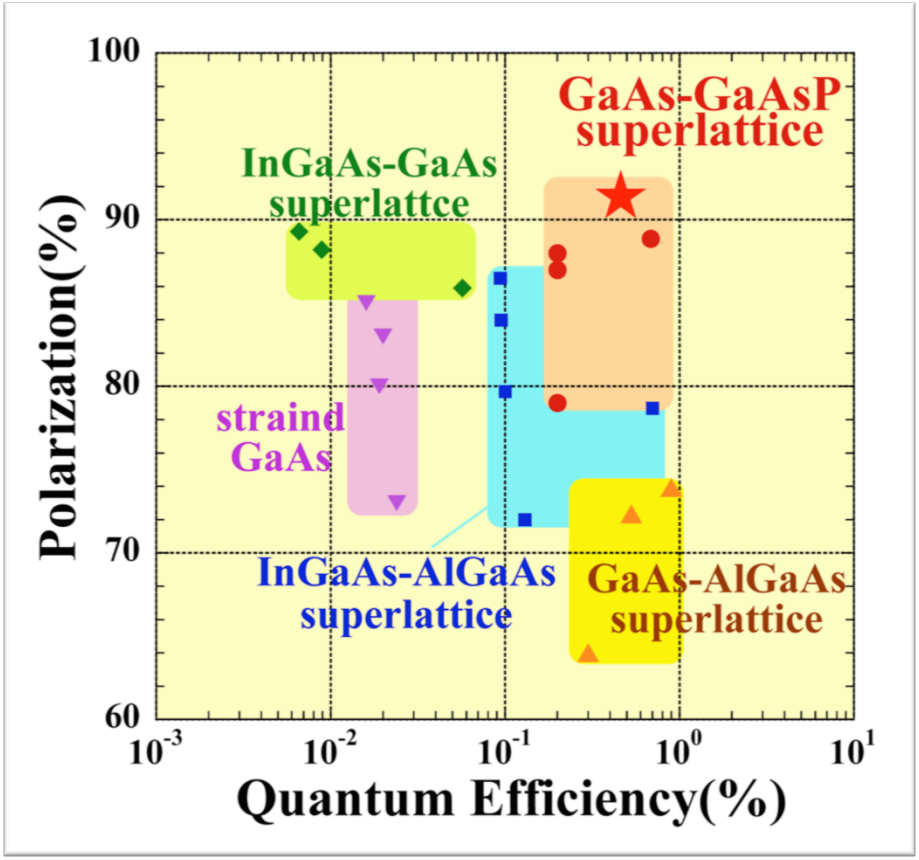
Outline

1. Back ground of our study
2. Concept of Transmission PES
3. Transmission Photocathode (T-PC)
    1. Design of T-PC
    2. Performances of T-PC
4. Electron gun (E-gun) for T-PC
    1. Design of E-gun
    2. Experimental results of T-PC
5. Summary & Future plan

1.Back ground

At Nagoya University (Japan),

We have developed NEA-GaAs photocathode for 20 yrs.



The performance of polarization and QE

NEA : Negative Electron Affinity

GaAs : Gallium Arsenide

High polarization (> 90%) and QE(~ 0.5 %)

T. Nakanishi et al., NIM A. **455** (2000)

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Low Emittance (0.1 pi.mm.mrad)

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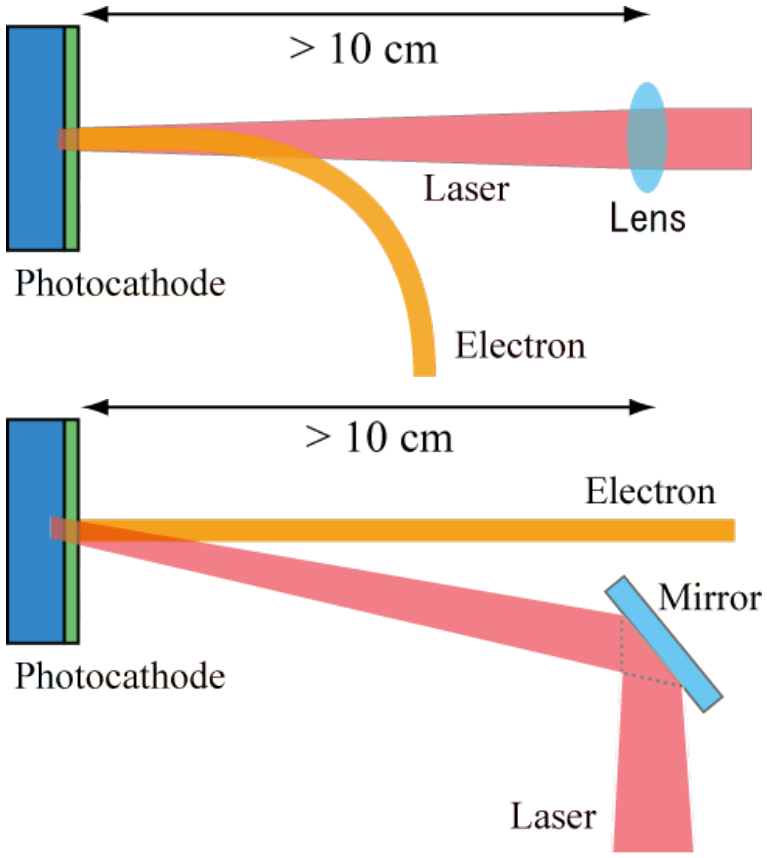
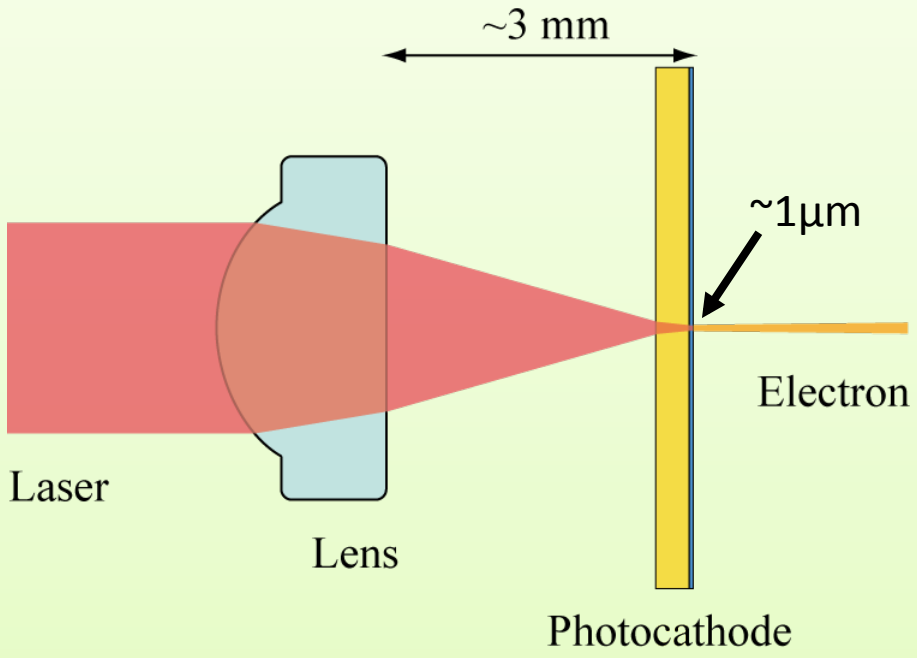
2.Concept of Transmission PC

Conventional (Reflection type)



Transmission Type



Merits :

small laser focusing

suppression of Photocathode laser-heating

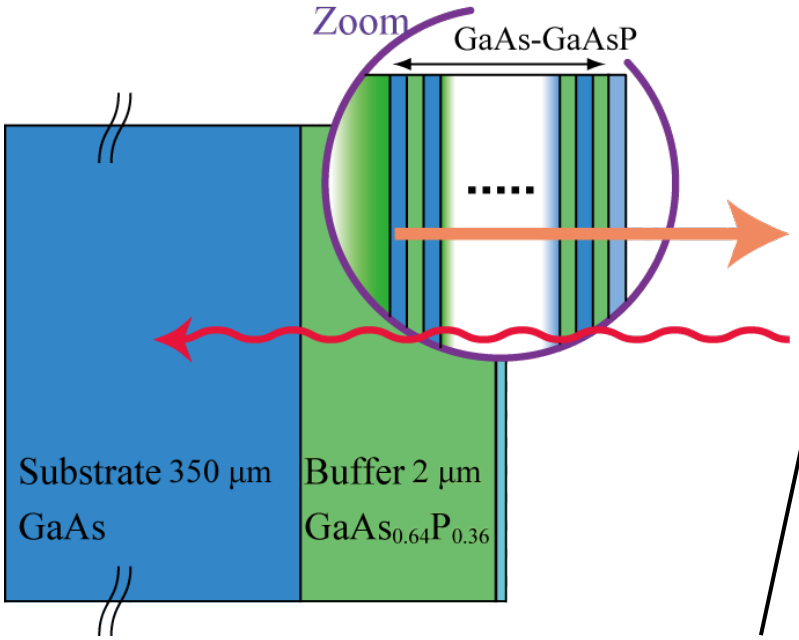
3-1.Design of Transmission Photocathode

Base design: Reflected-type GaAs/GaAsP

Substrate : GaAs -> **GaP**

Manufactured by OMCVD

Conventional (Reflection type)



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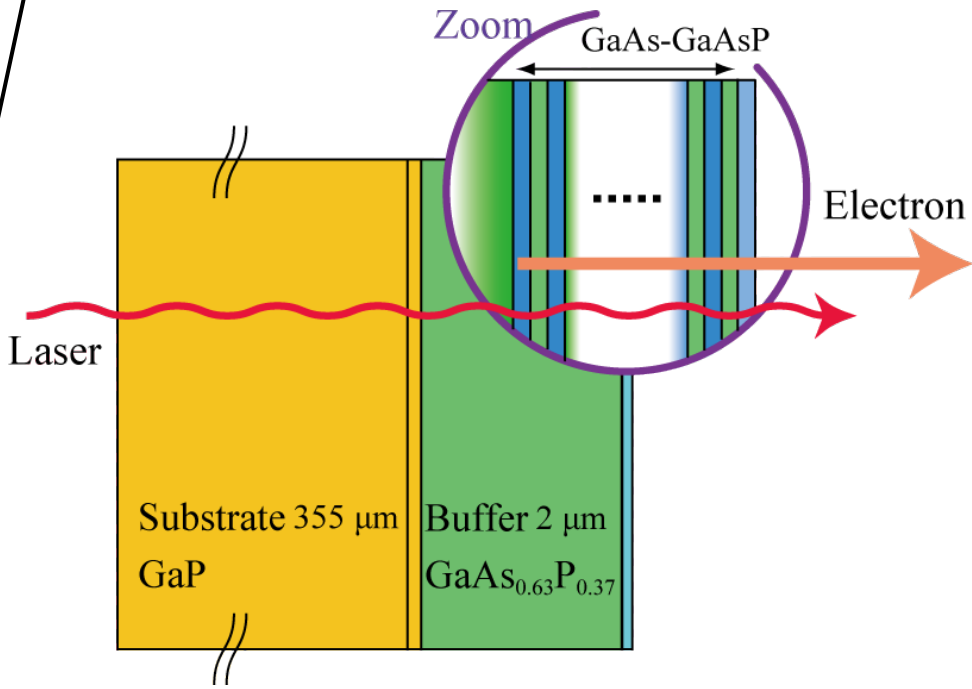

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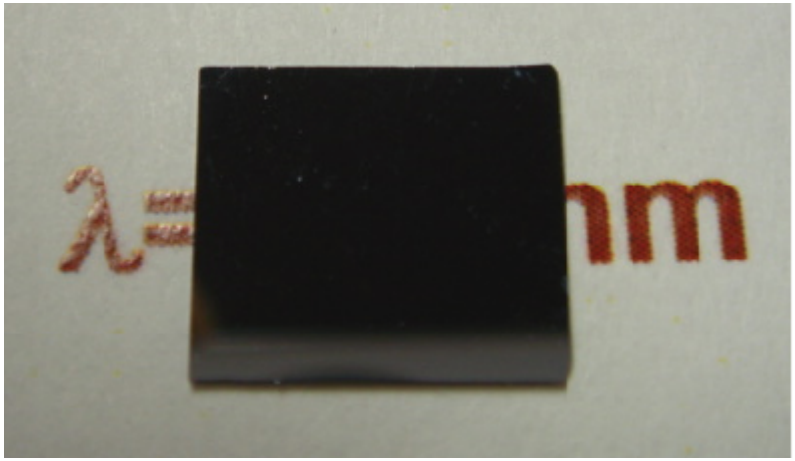
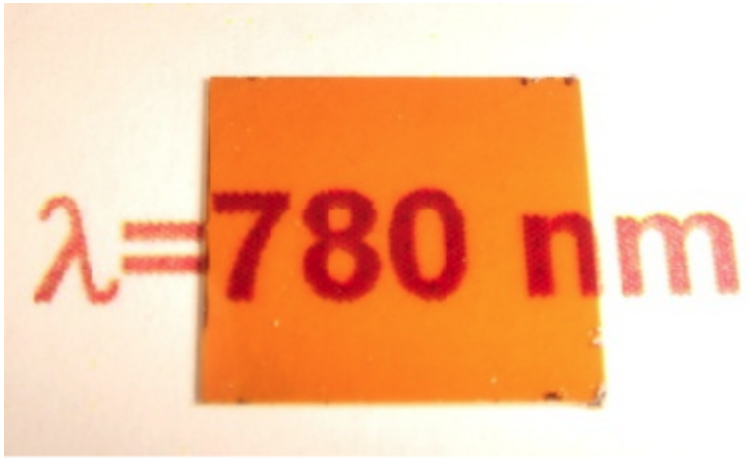


GaAs substrate
band gap energy: 1.42 eV

Transmission Type



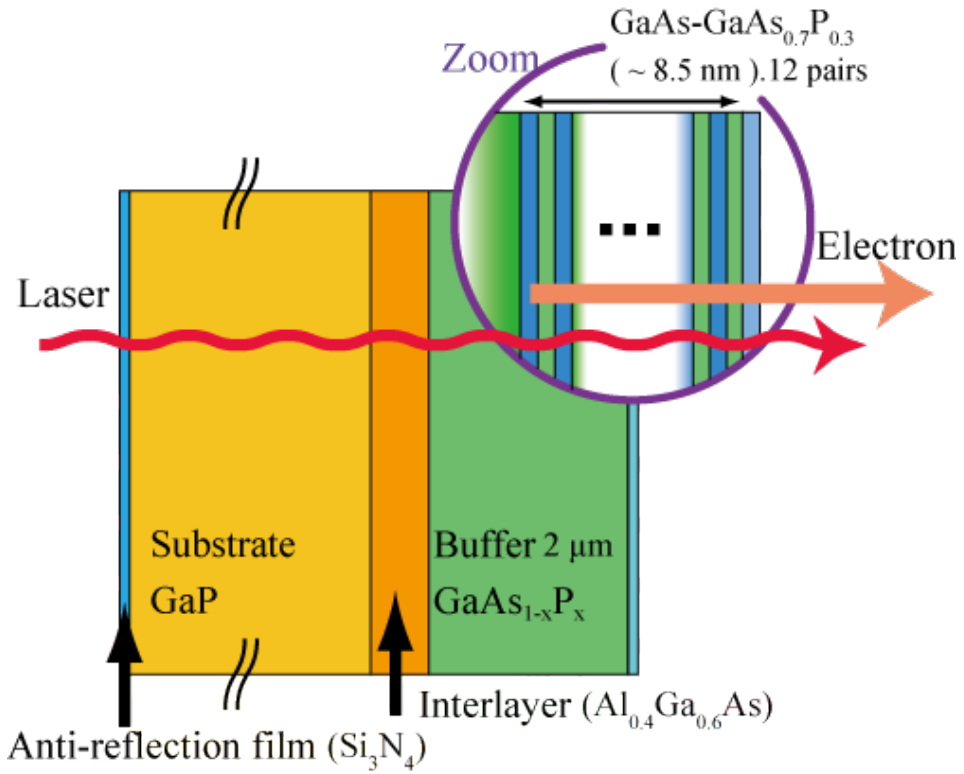
GaP substrate
band gap energy: **2.26 eV**

Pump laser light energy: **1.4~1.8 eV**

3-2.Performances of Transmission PC

One of recent PC samples

Ref. X.G. Jin, et al., JAP (2011)



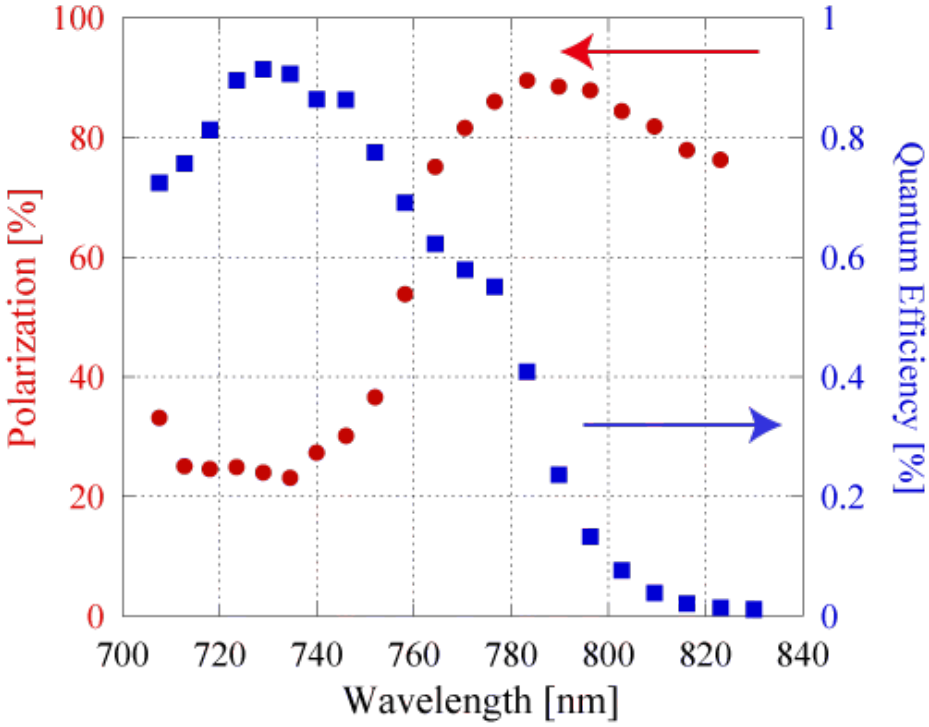


Fig. Polarization & QE spectra

Features:
- Inter-layer for good surface condition
  (compensation for lattice constant mismatch)
- Anti-reflection film
  (Reflection rate. 30 % -> 10%)

Polarization : ~ 90%

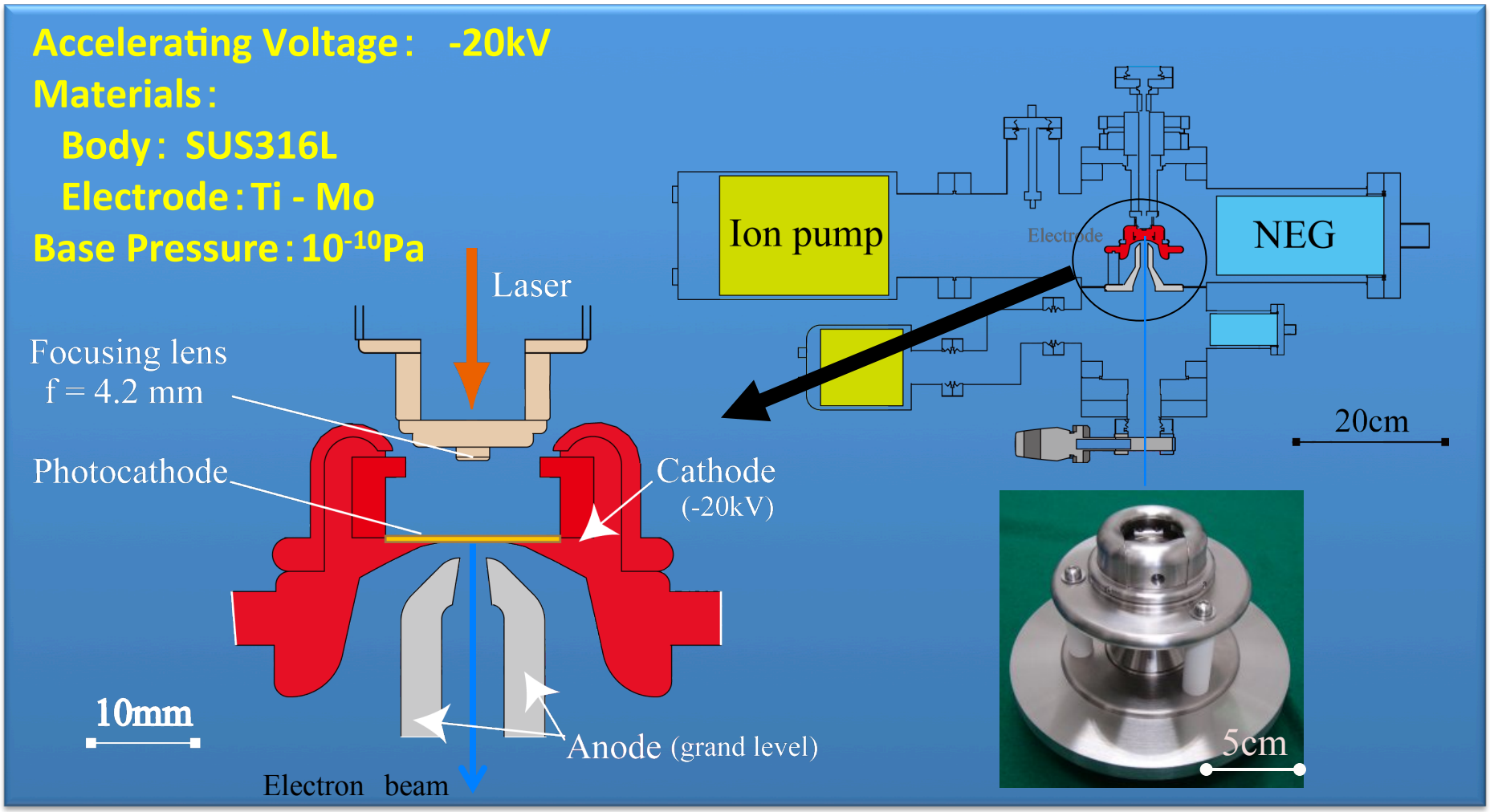
Quantum Efficiency : 0.4 %

4-1.Design of T-PC Electron gun

N. Yamamoto, et Al.,JAP,**103**,064905 (2008)

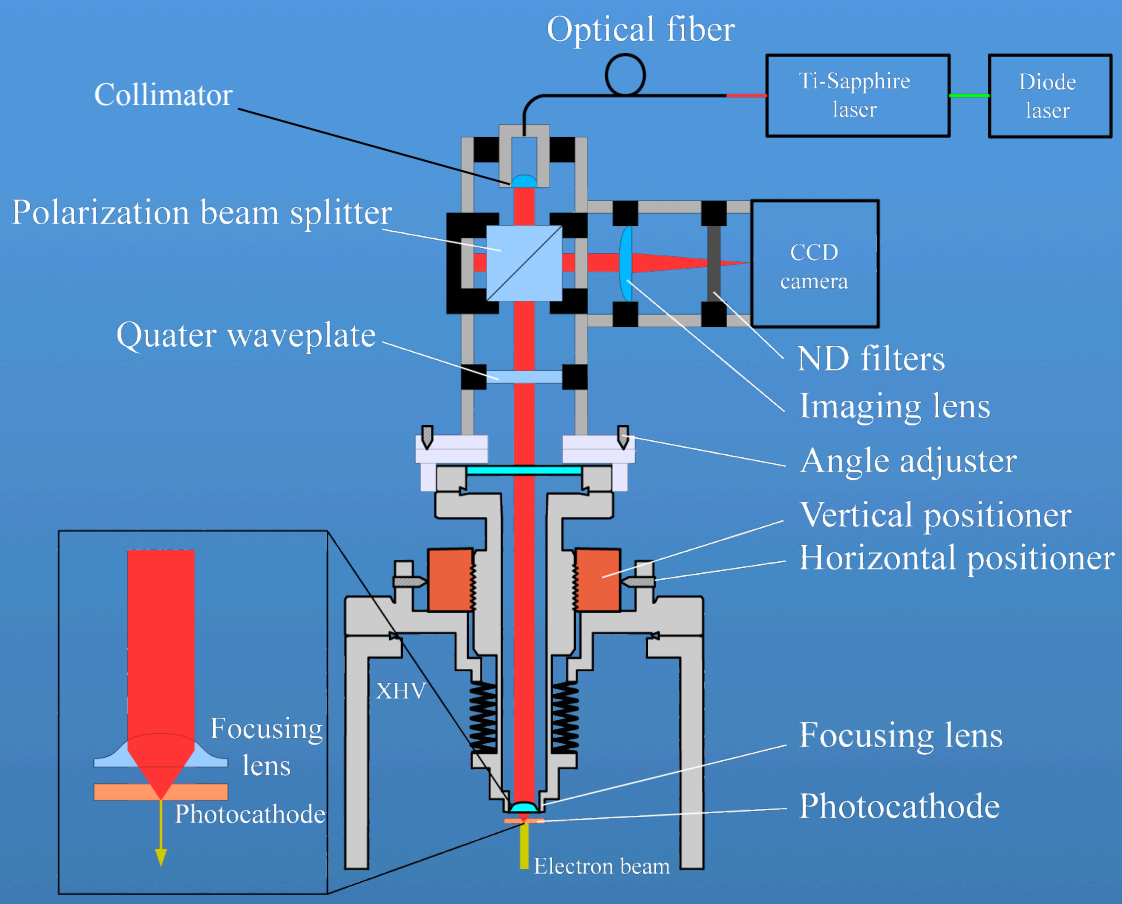
Electron gun for demonstrating Transmission PC

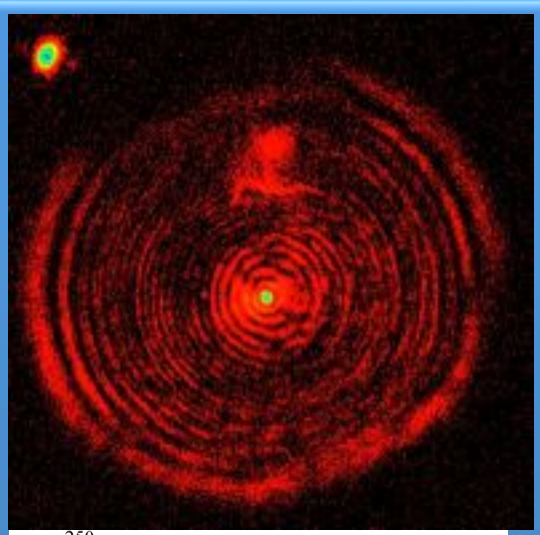
Accelerating Voltage : -20kV
Materials :
Body : SUS316L
Electrode : Ti - Mo
Base Pressure : 10^{-10}Pa

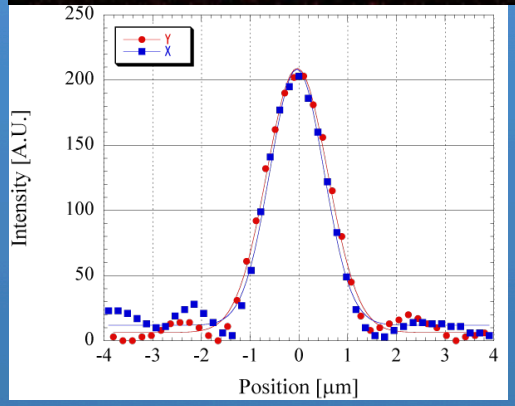


4-1.Design of T-PC Electron gun

Laser injection & focusing system







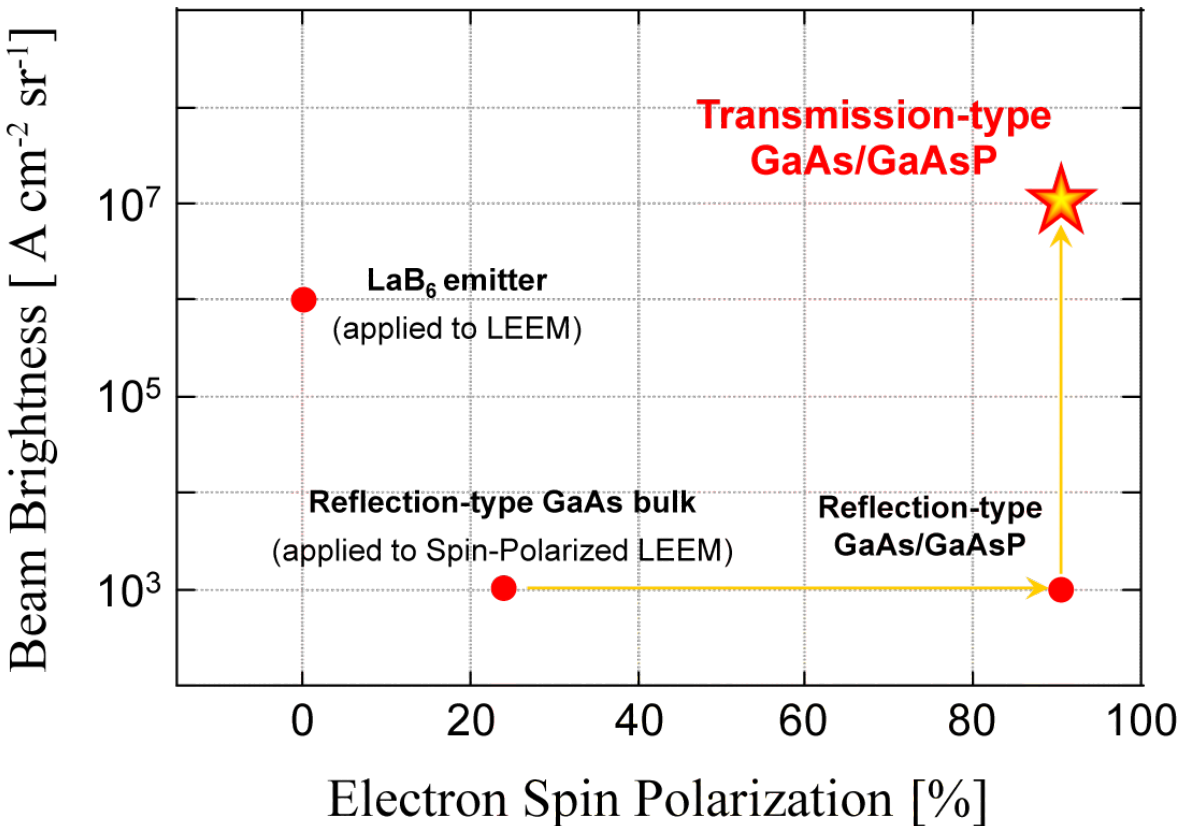
Focusing size: **1.3μm**

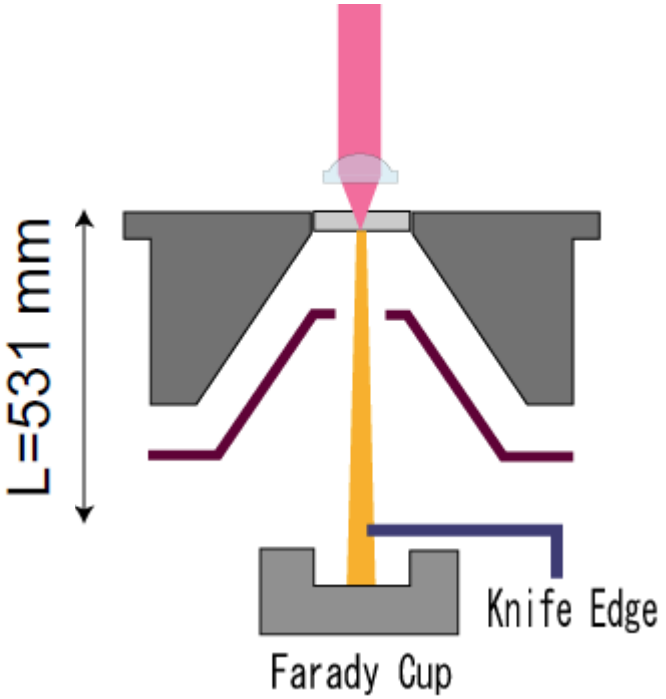
4-2. Exp. results of Electron gun

Beam Brightness (*B*)

$$B = \frac{I}{4\pi^2 \varepsilon_{nx} \varepsilon_{ny}} = \frac{I}{S\ d\Omega}$$

I:Charge, S:Beam size, dΩ:Solid angle





2×10^7 A.cm^{-2}.sr^{-1}

I = 5.3 μA

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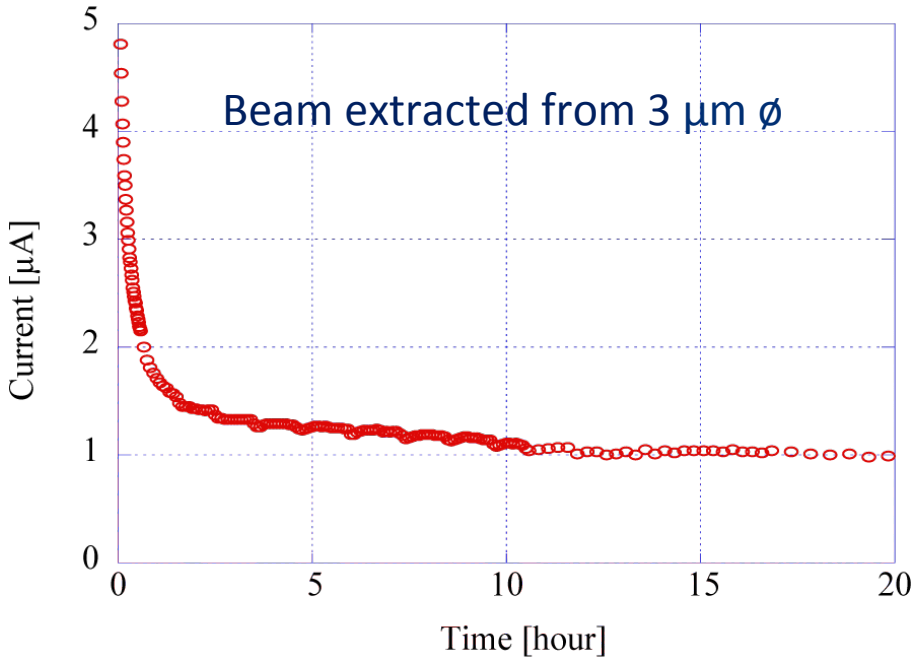
QE degradation in beam operation



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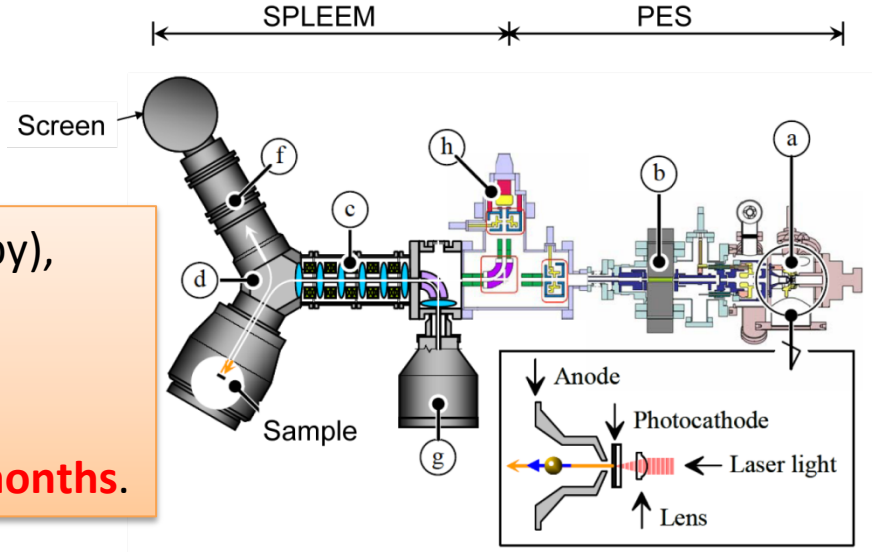
1.8×10^{8} C/cm^2
Total Charge (1/e) :
260 mC



In user experiments (Polarized Electron Microscopy),
A PC sample has been used for **> 3 years**.
(24 times NEA activation)
Once NEA surface is activated,
~ 1 μA currents can be extracted for **3 months**.

5.Summary & Future plan

We have developed Transmission-type PC.

Up to now, Electron Spin polarization of 90 %

& Quantum Efficiency of 0.4 % were achieved.

High brightness & Long lifetime were also demonstrated.

In future,

We are planning some experiments for

Quantum Efficiency improvements (1 %)

Pulse Beam generation (~1ps) by femtosecond laser.

Thank you for your attention.

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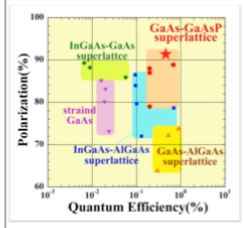

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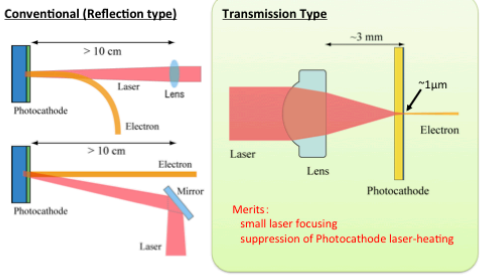

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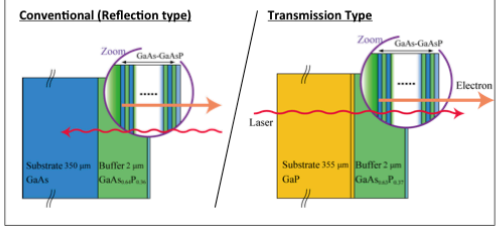

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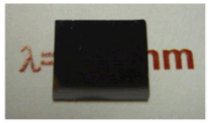

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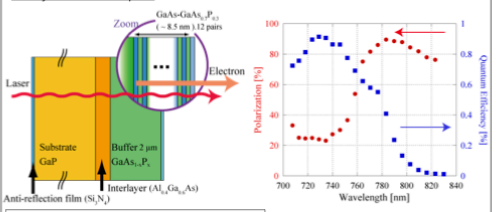

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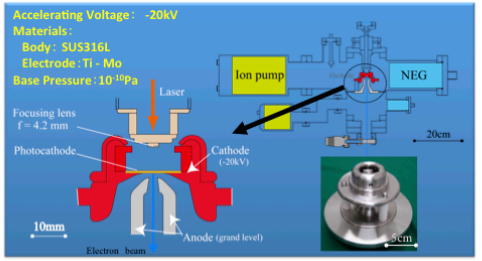

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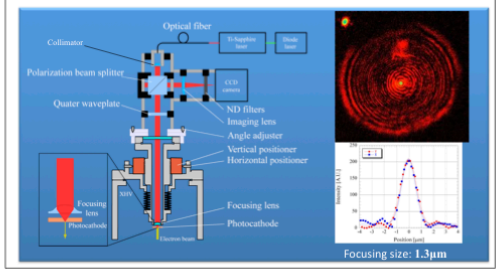

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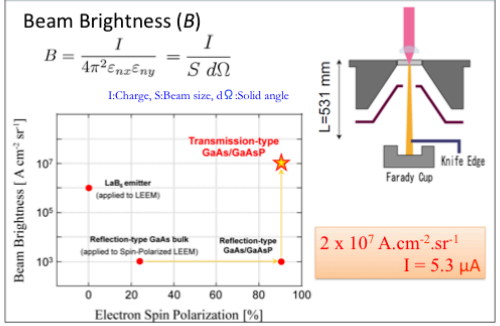

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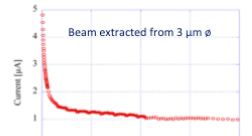

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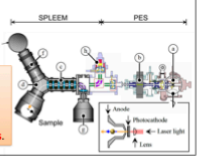

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BACK UP SLIDES

JOURNAL OF APPLIED PHYSICS 108, 094509 (2010)

Effects of defects and local thickness modulation on spin-polarization in photocathodes based on GaAs/GaAsP strained superlattices

Conventional PC

Transmission PC (w/o. interlayer)

Transmission PC (w. interlayer)

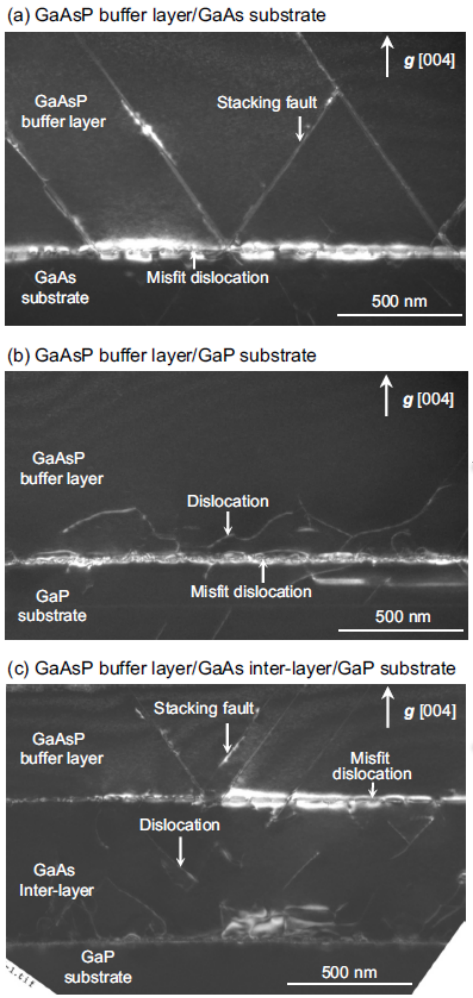
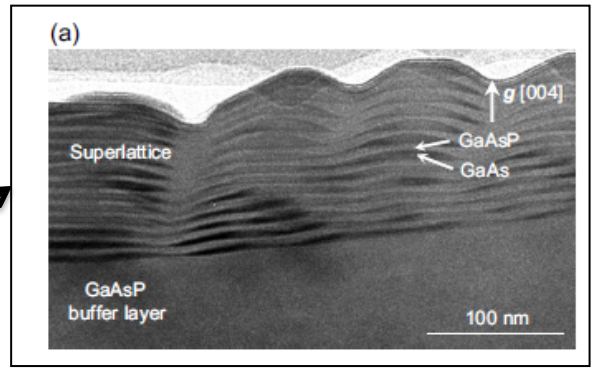
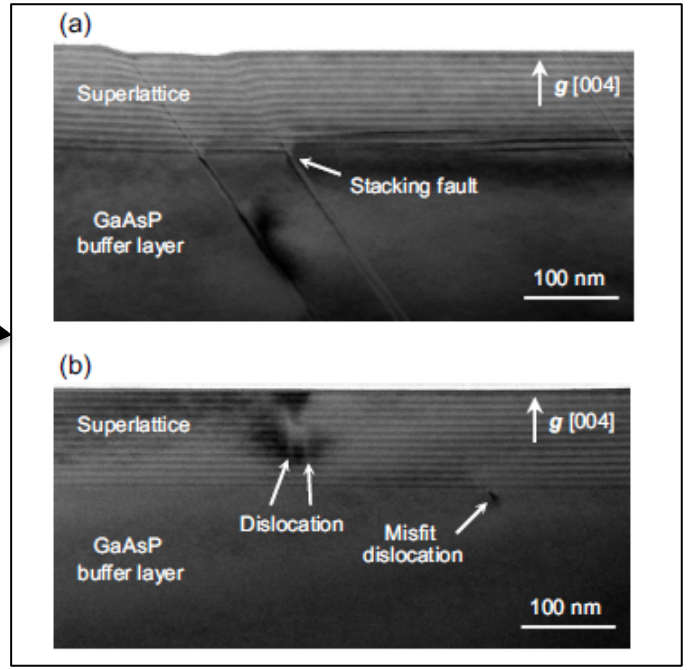


FIG. 2. Cross-sectional TEM images of the GaAsP buffer layer on (a) GaAs, (b) GaP, and (c) a GaP substrate with GaAs IL. Stacking faults are introduced into the GaAsP buffer layer on GaAs, while dislocations are introduced on GaP.





Strained super lattice photocathode