Electron Source Update

N. Yamamoto[1],

X.G. Jin[2], A. Mano[1], and Y. Takeda[1]

1. SR Center, Nagoya University, Japan

2. KEK, Japan

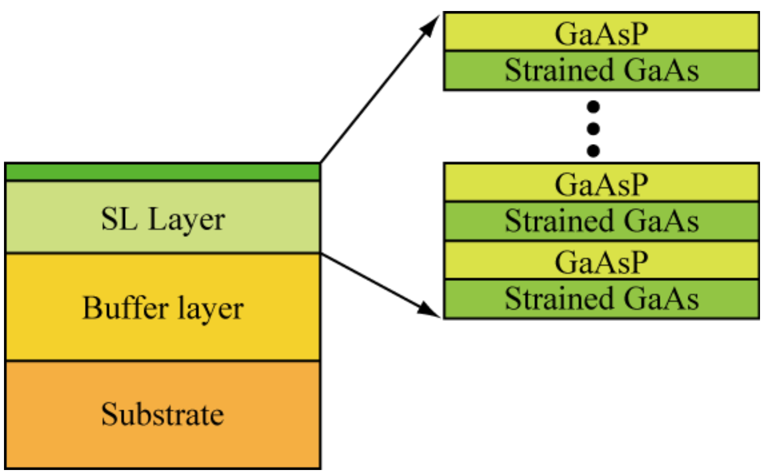
Outline

1. Required parameters for LC
2. Strain-compensated SL
3. Experimental Results
4. Summary

Max. Pol. (~ 92%)
QE(~ 2.2 %) were achieved

1. Required Parameters for LC (TDR)

Parameter	Symbol	Value	Units
Electrons per bunch (at gun exit)	N_-	3×10^{10}	
Electrons per bunch (at DR injection)	N_-	2×10^{10}	
Number of bunches	n_b	1312	
Bunch repetition rate	f_b	1.8	MHz
Bunch-train repetition rate	f_{rep}	5	Hz
FW Bunch length at source	Δt	1	ns
Peak current in bunch at source	I_{avg}	3.2	A
Energy stability	σ_E/E	<5	% rms
Polarisation	P_e	80 (min)	%
Photocathode Quantum Efficiency	QE	0.5	%
Drive laser wavelength	λ	790 ± 20 (tunable)	nm
Single-bunch laser energy	u_b	5	μJ



Candidate Design:

GaAs-GaAs$_x$P$_{(1-x)}$ Strained SL

High polarization (> 90%)

QE(~ 0.5 %)

T. Nakanishi et al., NIM A. **455,** 109-112 (2000)

T. Nishitani et al., J. Appl. Phy. **97,** 094907 (2005)

X.G. Jin, et al., APEX, **51,** 108004 (2012)

2. Strain–Compensated SL

To realize high QE and high polarization,

High crystal quality (High Pol.)

Thick thickness SL (High QE) are essential.

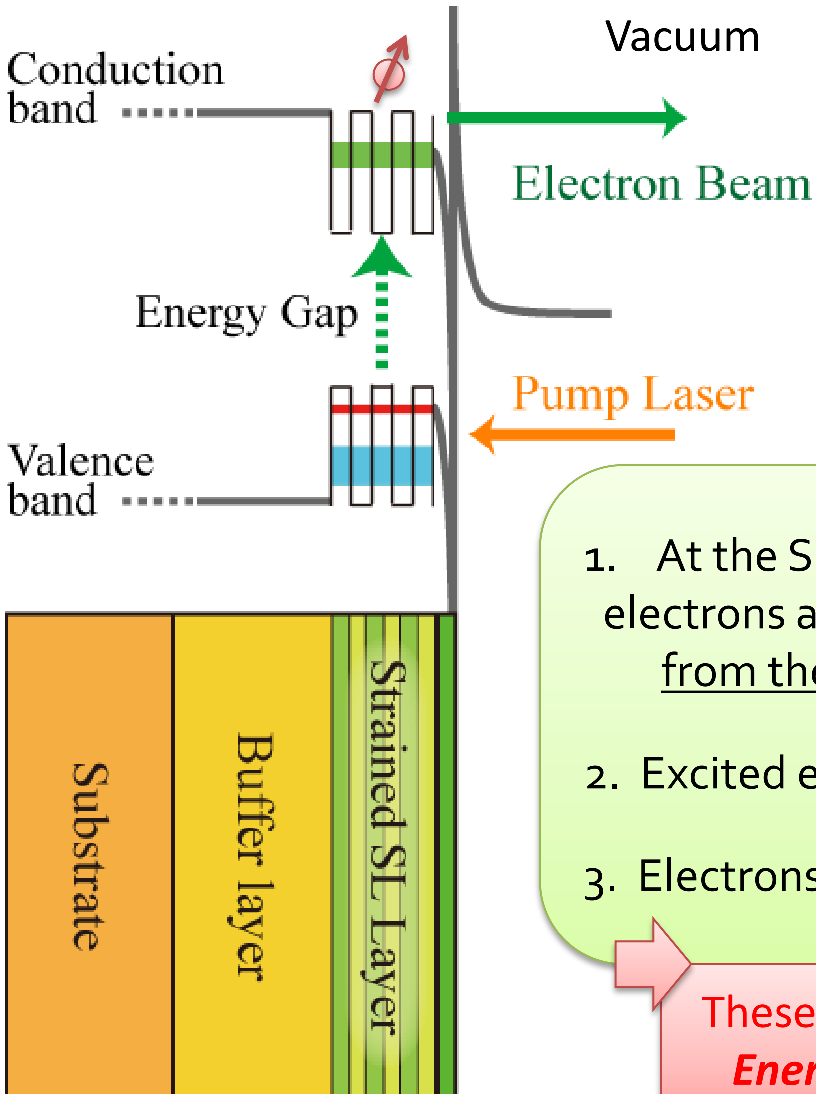
New PC design

Strain-Compensated Superlattice

X.G. Jin, Applied Physics Express **6,** 015801 (2013)

2-1. Generation of polarized electron

3 step model for electron emission



3 step model
1. Optical pump
2. Diffusion at conduction band
3. Emission from NEA surface

1. At the SL layers,
electrons are pumped by ***Circularly polarized laser***
from the highest valence band to conduction band.

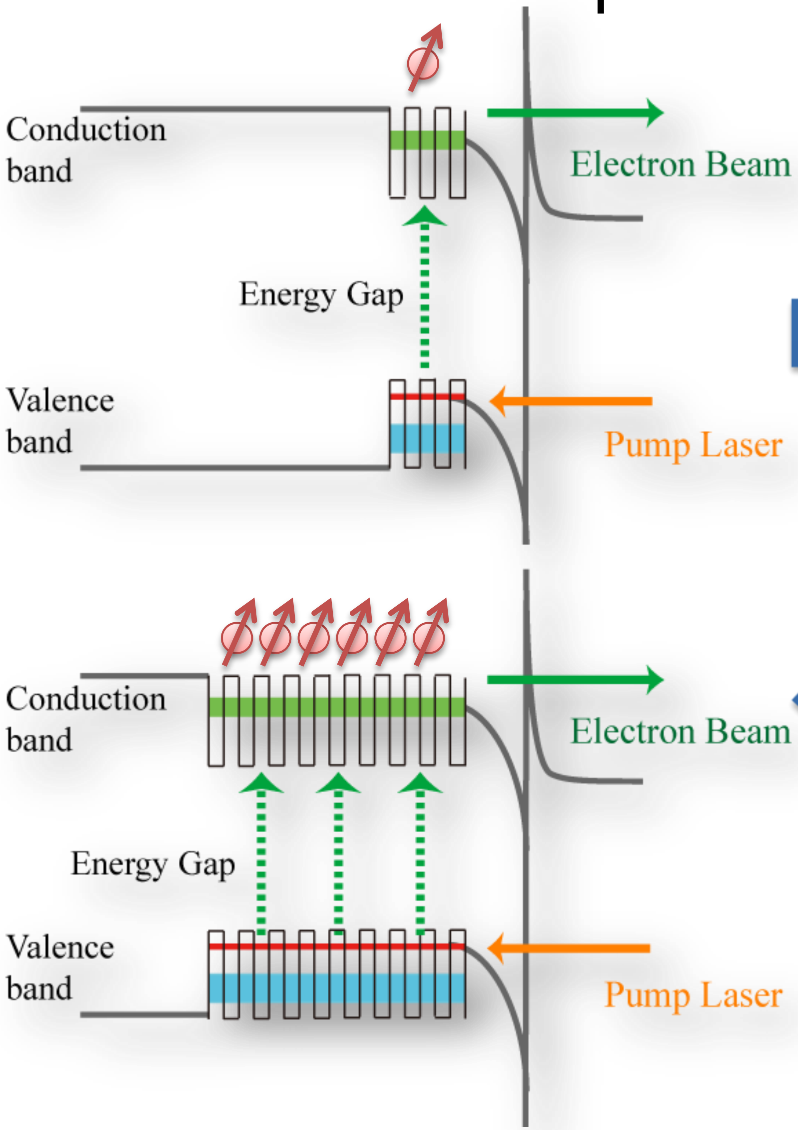
2. Excited electrons are diffused to PC surface .

3. Electrons are emitted through the ***NEA surface***.

These processes contribute PC parameters (***Pe, QE***).
Energy Gap (structure design) corresponds to ***λ***.

2-1. Improving the QE

Thick Thickness Super Lattice

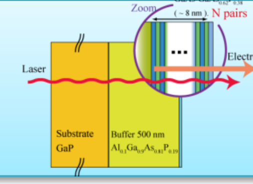


3 step model
1. Optical pump
2. Diffusion at conduction band
3. Emission from NEA surface

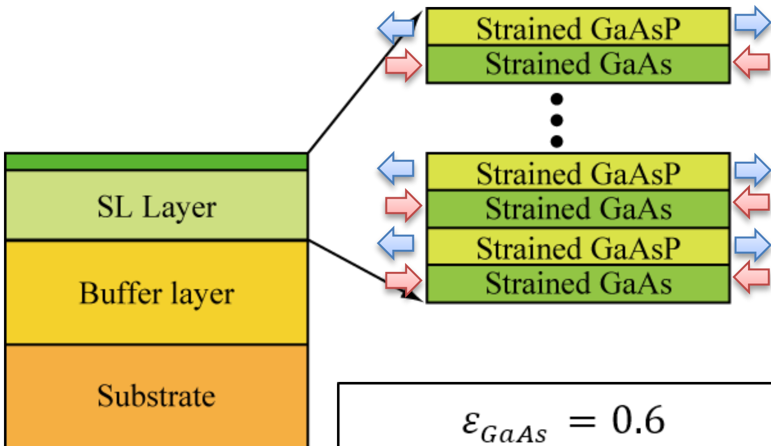
If the SL thickness increase,
The number of excited electron would be increased.
The QE improvement will be expected.

However, in Conventional PC,
Increasing the SL thickness was impossible due to the strain accumulation.

2-2.Strain–Compensated SL



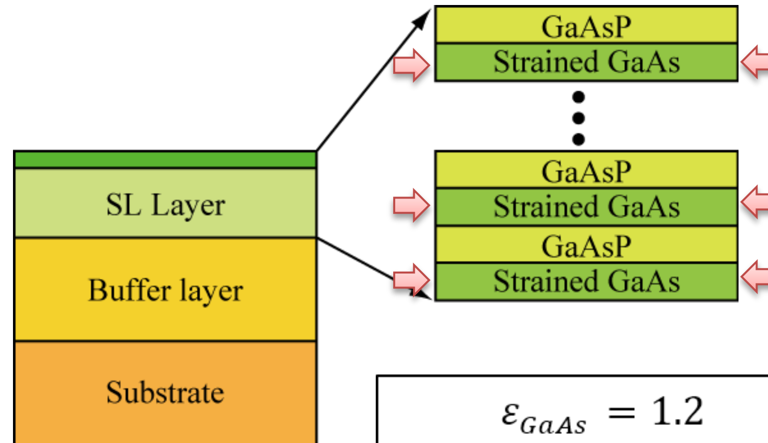
Strain-compensated SL



$$\varepsilon_{GaAs} = 0.6$$
$$\varepsilon_{GaAsP} = -0.6$$
$$L_{GaAs} \cong L_{GaAsP} = 4nm$$

Net strain $\cong 0$

Strained SL



$$\varepsilon_{GaAs} = 1.2$$
$$\varepsilon_{GaAsP} = 0$$
$$L_{GaAs} \cong L_{GaAsP} = 4nm$$

Net strain $\cong 0.6$

Strain accumulation and
Bad SL structure quality

High Crystal Quality

Higher Electron Polarization

Higher QE (Thickness SL layers)

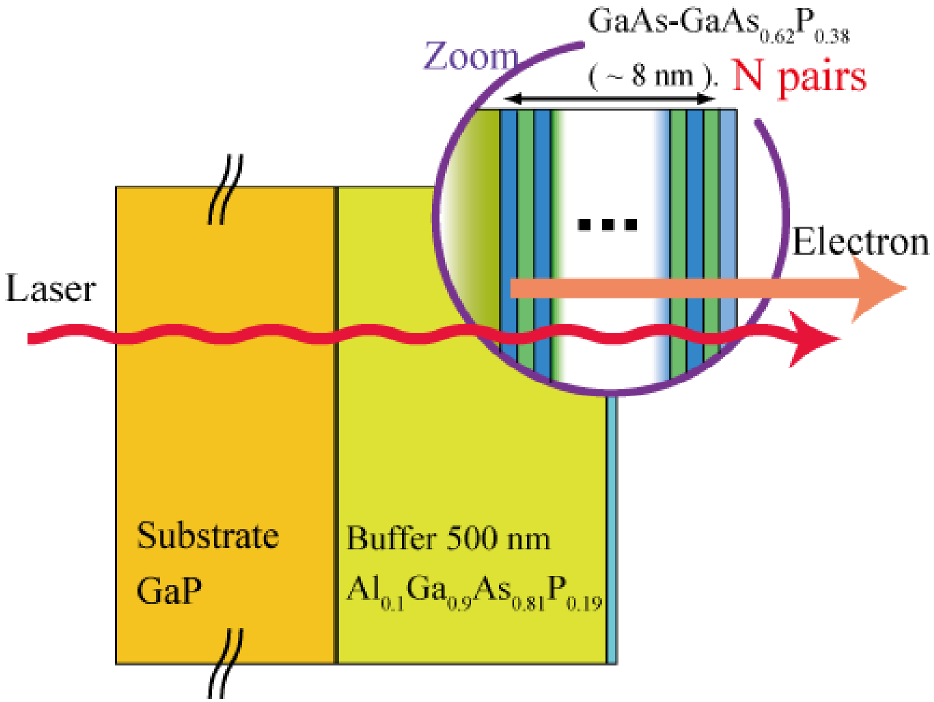
$$Net\ strain = \frac{\varepsilon_{GaAs} \cdot L_{GaAs} + \varepsilon_{GaAsP} \cdot L_{GaAsP}}{L_{GaAs} + L_{GaAsP}}$$

ε : Strain values for each SL layer

L : Thickness period of each SL layer

2-3.Strain–Compensated SL

GaAs-GaAsP Strain–Compensated SL

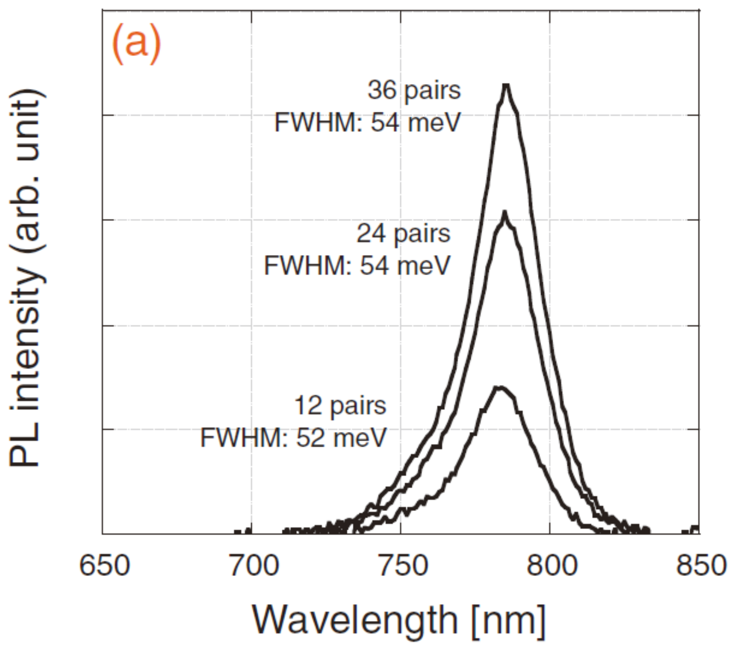


$Al_{0.1}Ga_{0.9}As_{0.81}P_{0.19}$ Buffer Layer :

Lattice constant →
medium value between GaAs and GaAsP

Band gap energy (1.77eV) →
higher than that of SL layers

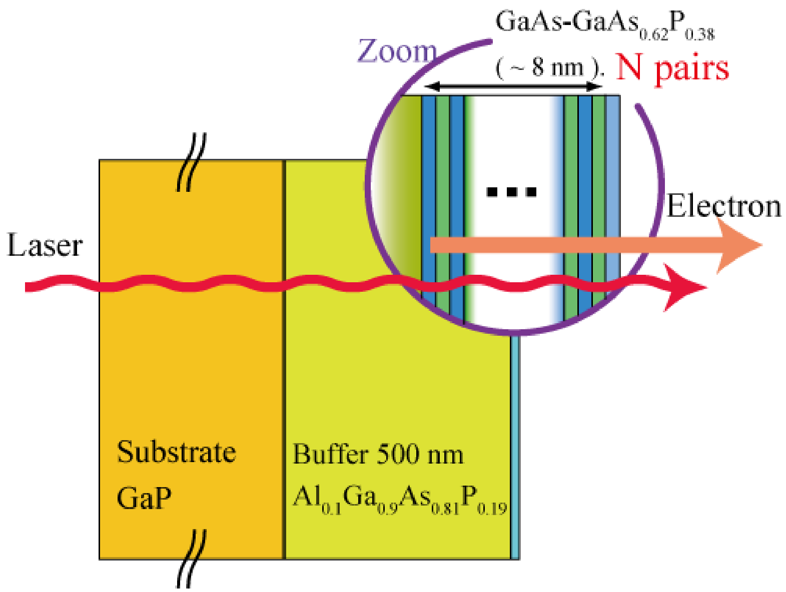
Ref. X.G. Jin, et al., APEX (2012)



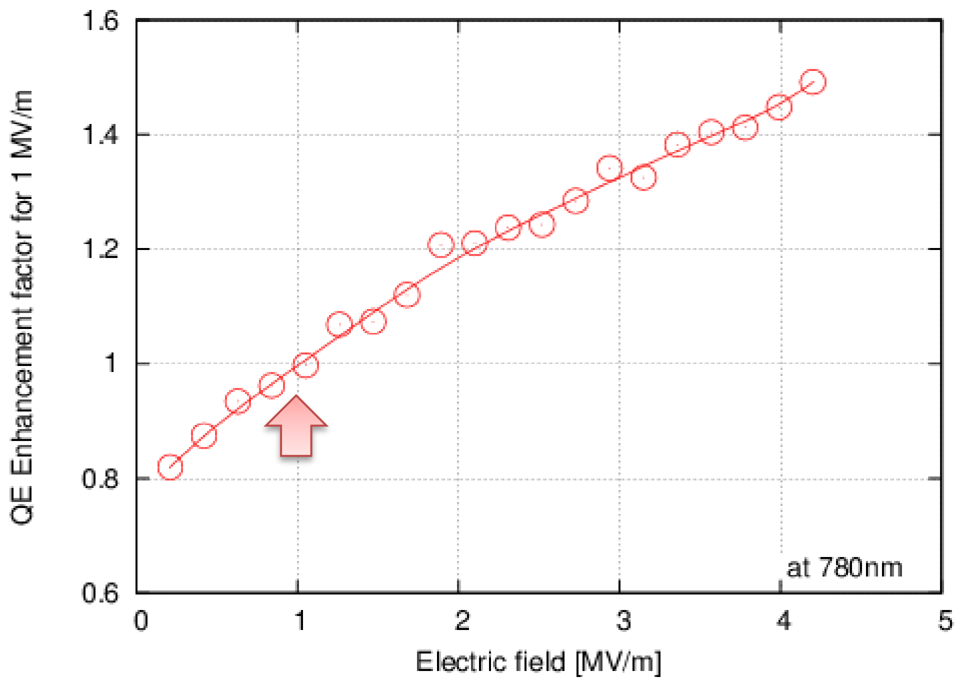
No shift of the PL peak or
broadening of the FWHM

No strain relaxation

EXPERIMENTAL RESULTS



QE dependence on Exracted Field

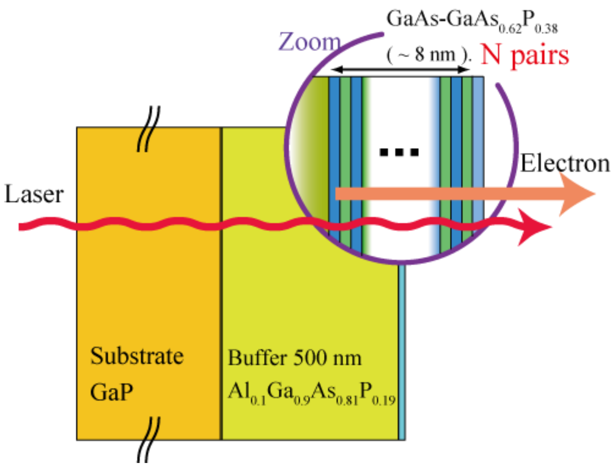


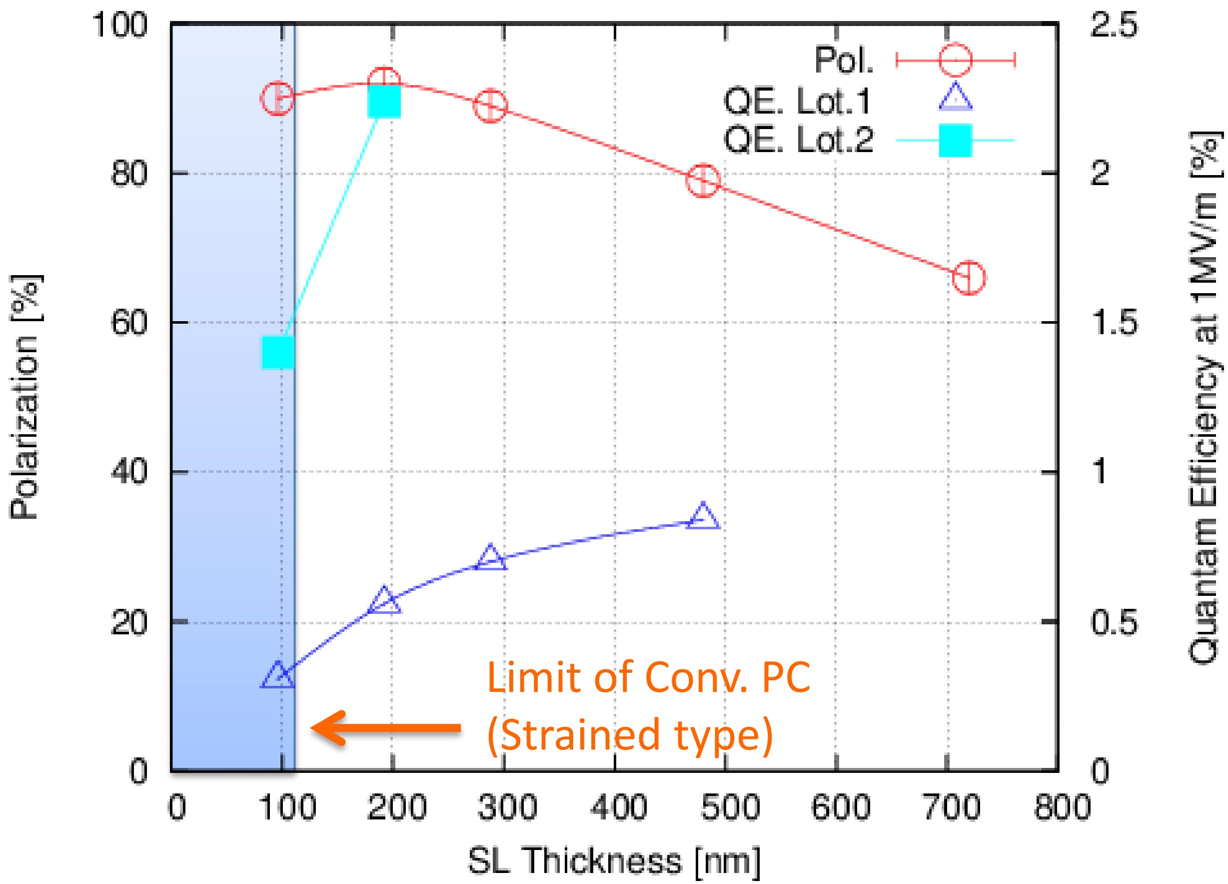
In this presentation, we use the scaled QE value at **1 MV/m**.

3. Strain–Compensated SL

GaAs-GaAsP Strain–Compensated SL

Ref. X.G. Jin, to be published



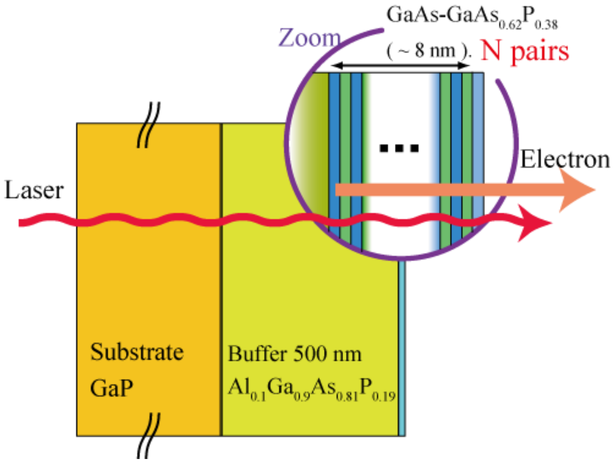


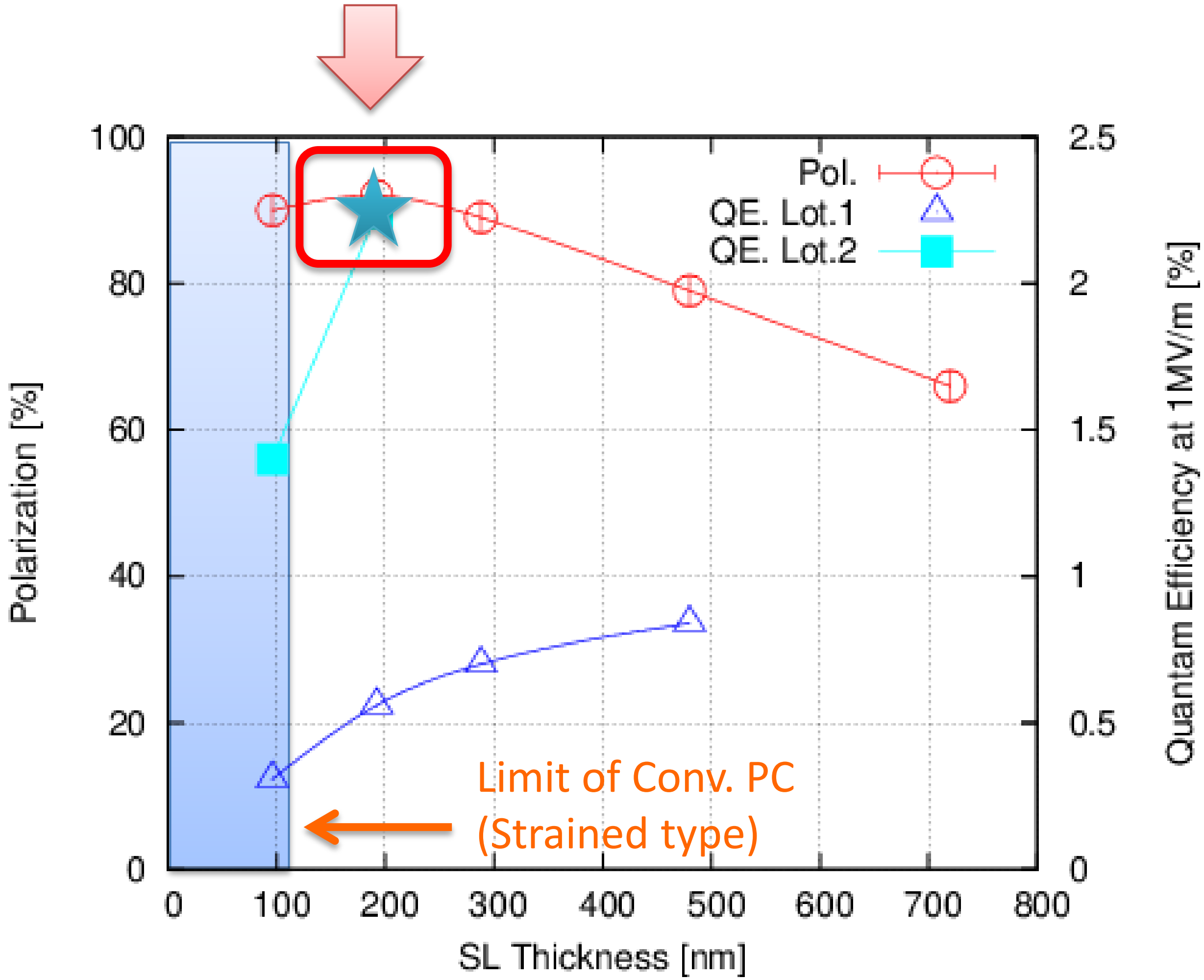
3. Strain–Compensated SL(w. new data)

Max. Pol. (~ 92%)
QE(~ 2.2 %) were achieved

GaAs-GaAsP Strain–Compensated SL

Ref. X.G. Jin, to be published





4.Summary & Future plan

We have proposed and developed Strain-Compensated SL PC.

Up to now,

We succeed to fabricate the Strain-Compensated SL PC.

Electron Spin polarization of 92 %

& Quantum Efficiency of 2.2 % were achieved.

In future,

We are planning

to develop higher performance PC.

to measure and improve the time response of PC

Thank you for your attention.