

Electrical and Optical studies of a p-n junction with GaFeN/AlGaN Quantum Wells

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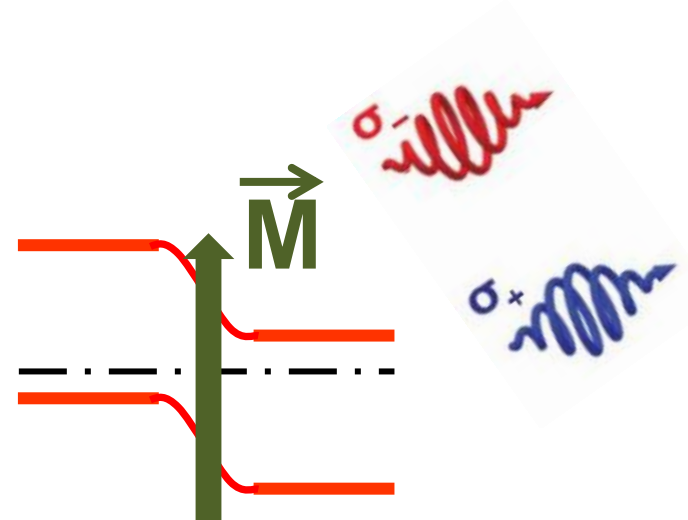
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University, Linz, Austria*

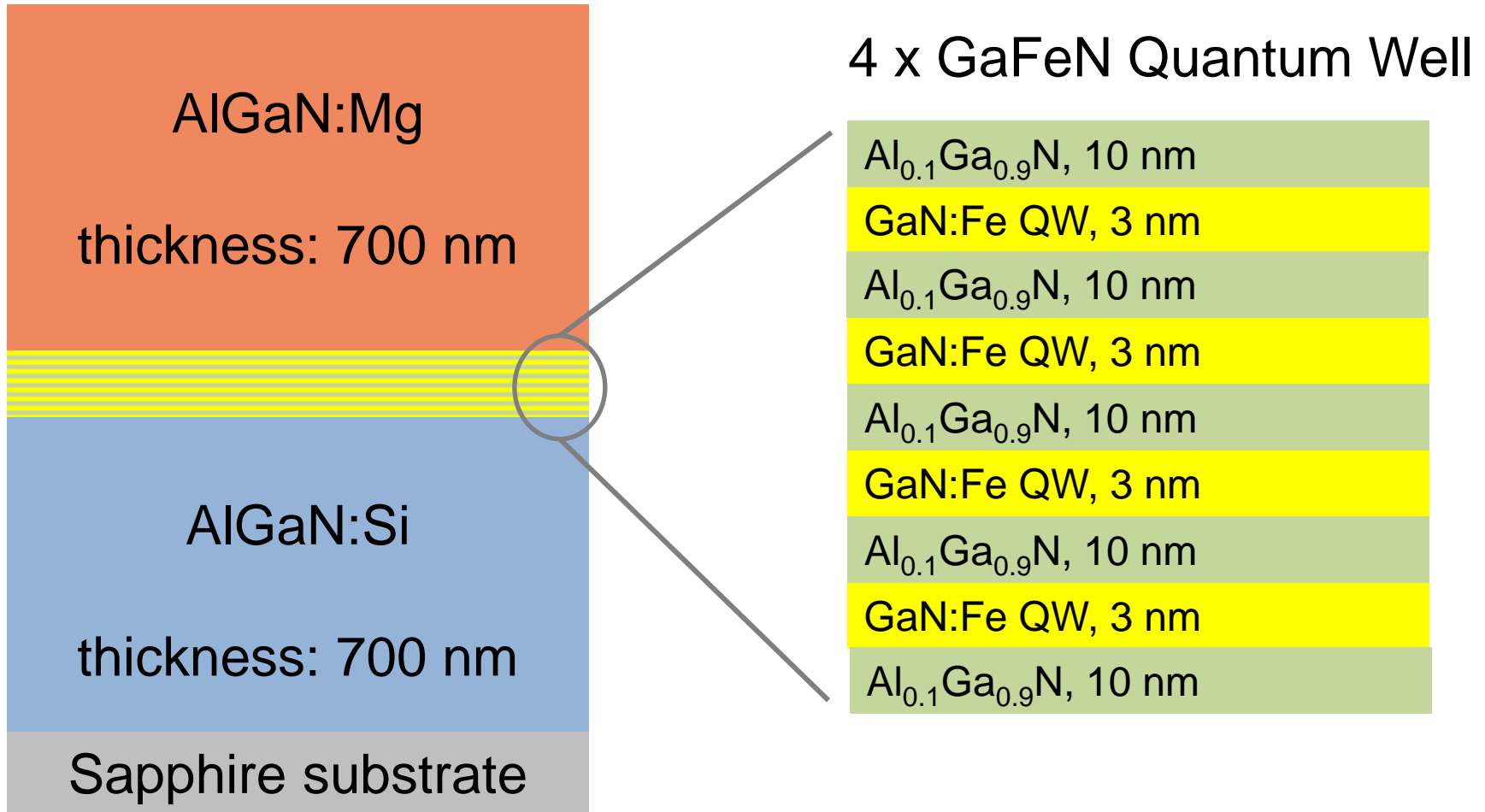
Aim

Incorporation of magnetic ions to GaN based p-n junctions = new capabilities and functionalities:

- The goal: electrical control of Circular Polarization Degree of Photoluminescence from GaFeN QWs



Sample design



- p-n junction with GaFeN QWs in the active region

**Bright
field
image**

684 nm

AlGaN

684 nm

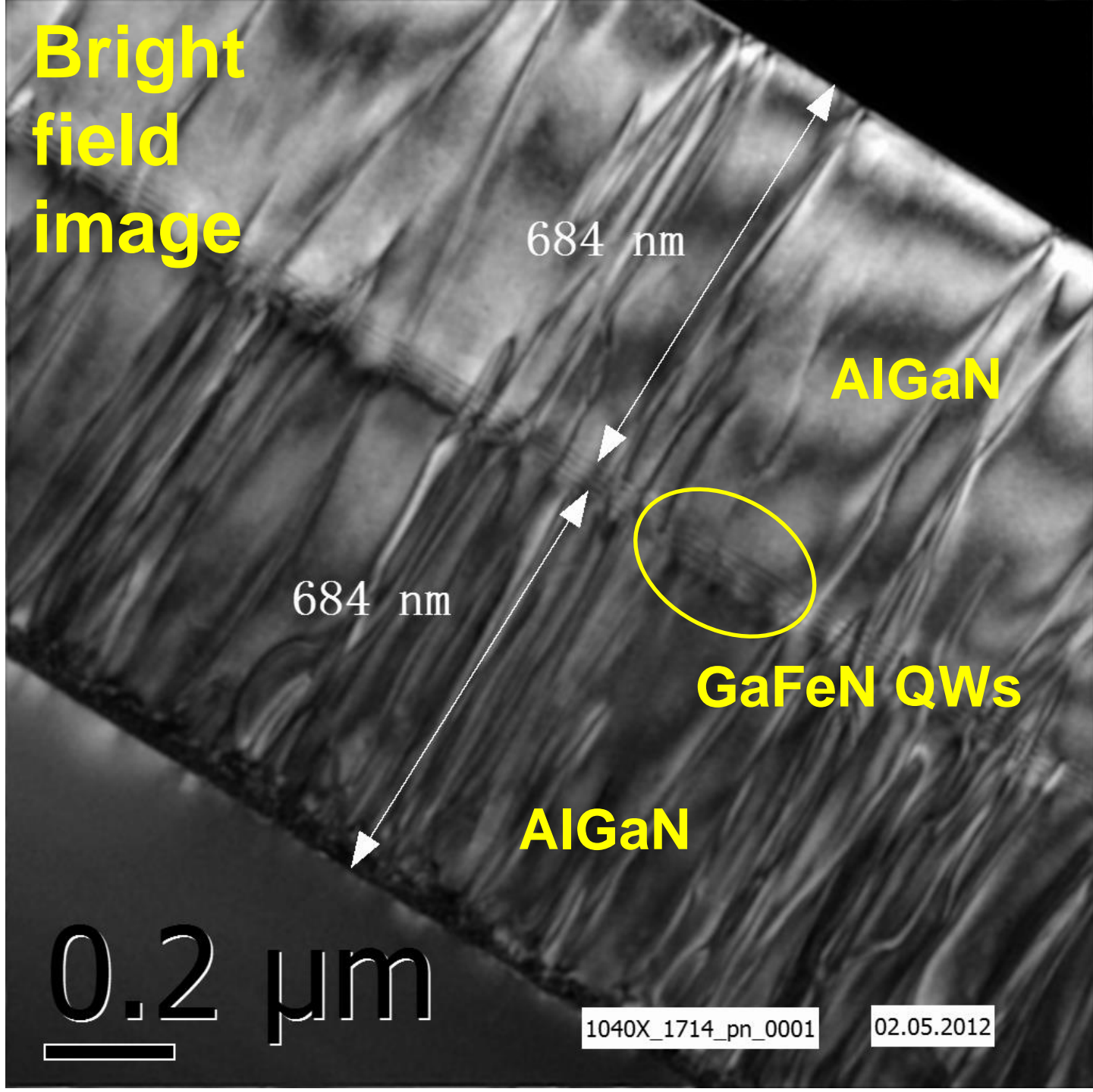
GaFeN QWs

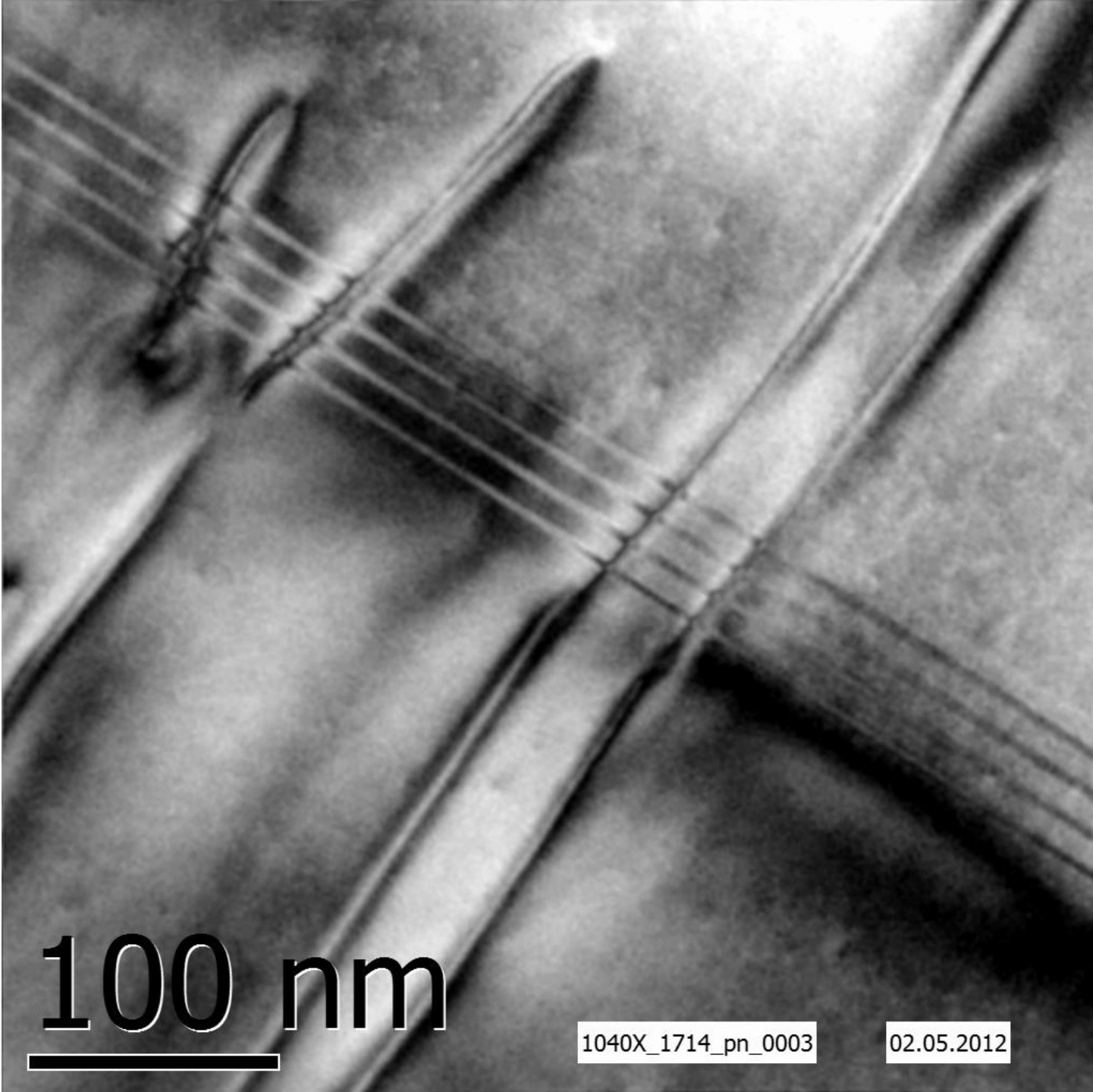
AlGaN

0.2 μm

1040X_1714_pn_0001

02.05.2012



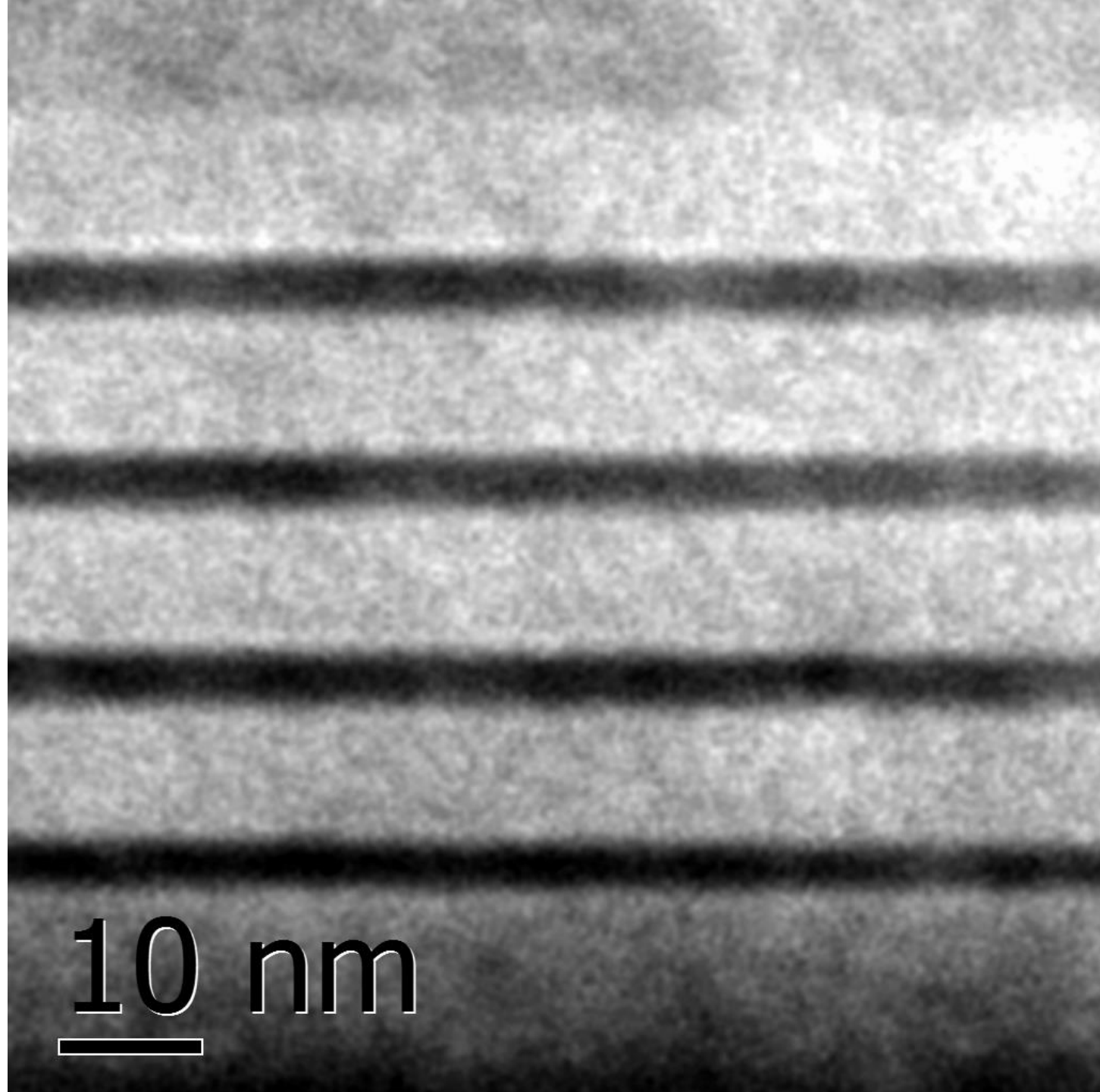


100 nm



1040X_1714_pn_0003

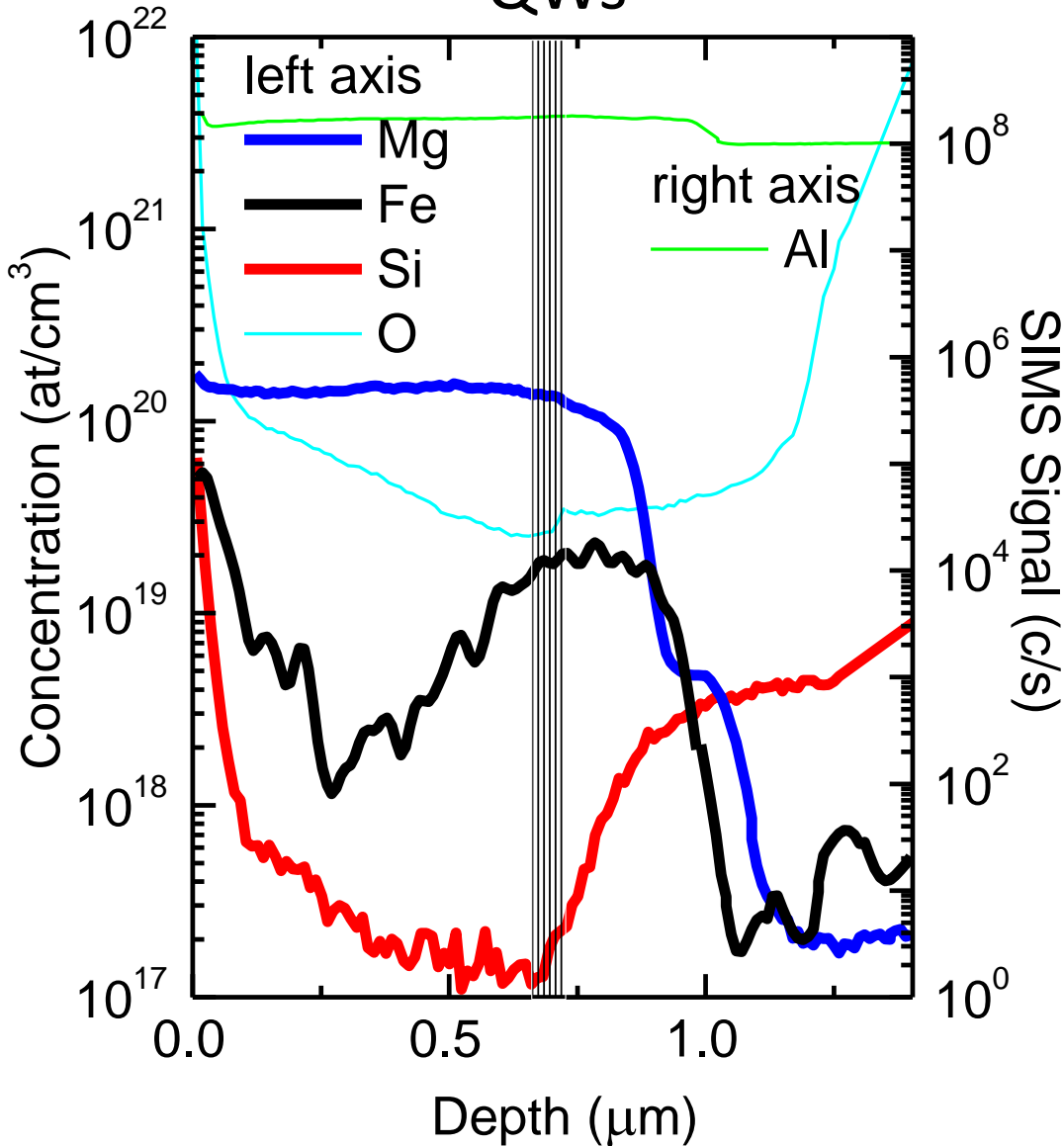
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10 nm

SIMS characterization

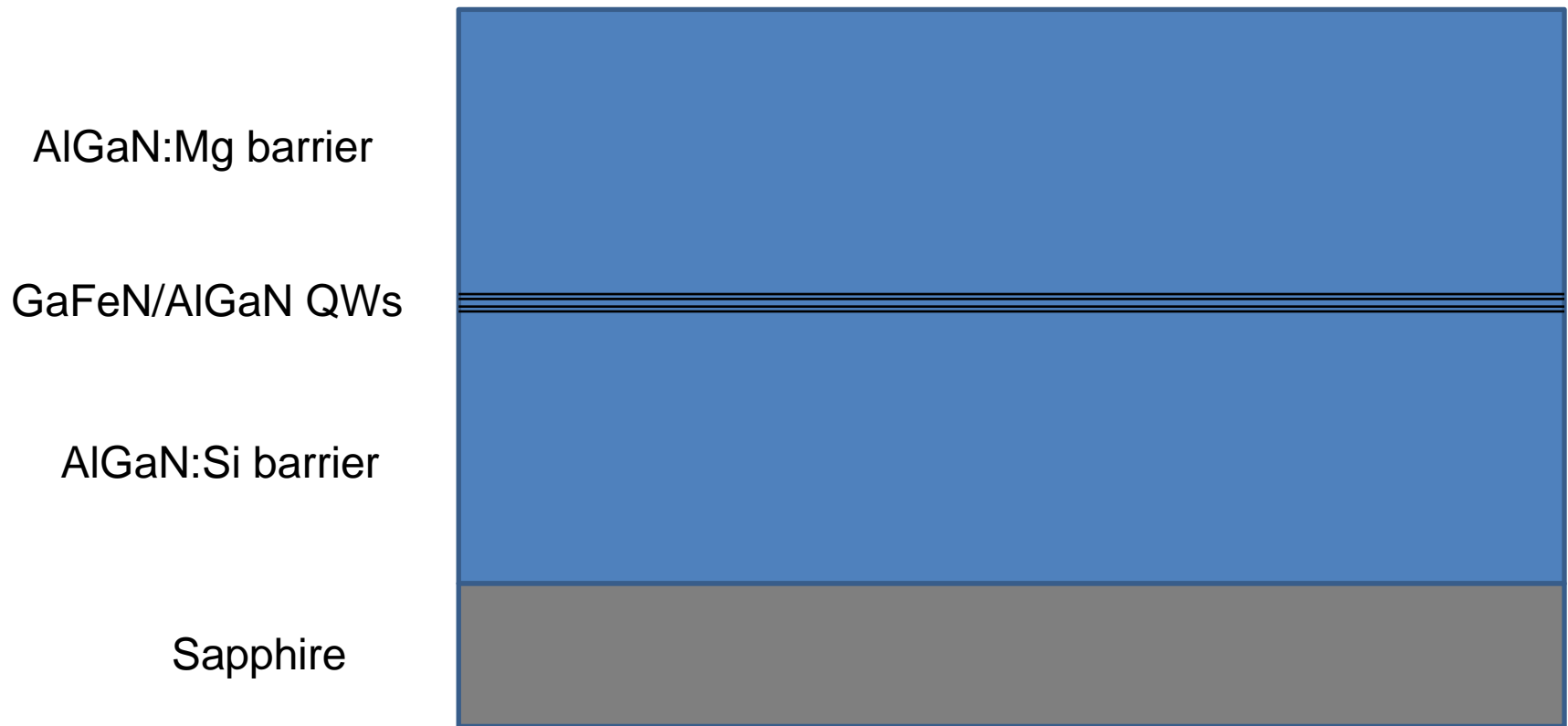
QWs



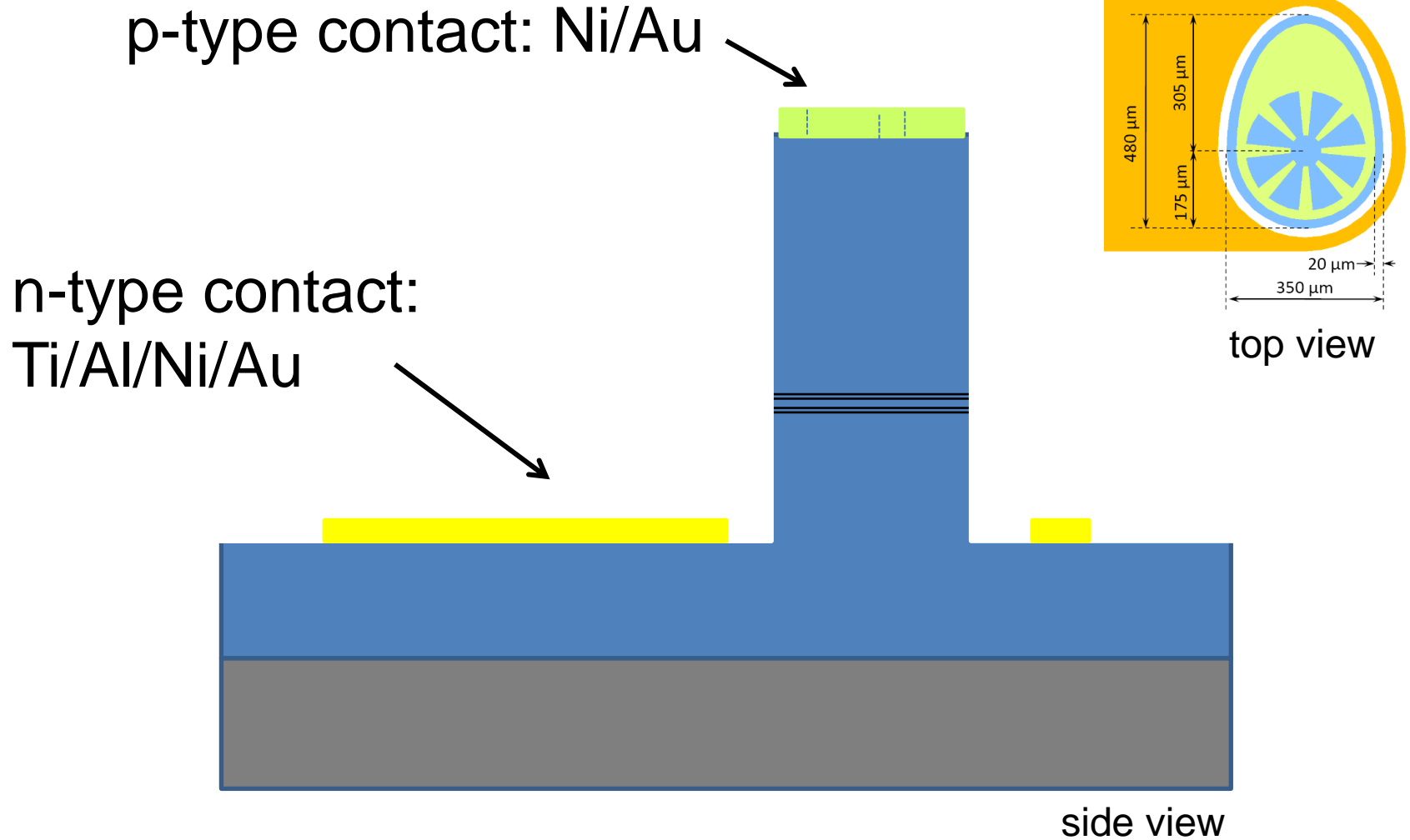
A successful incorporation of:

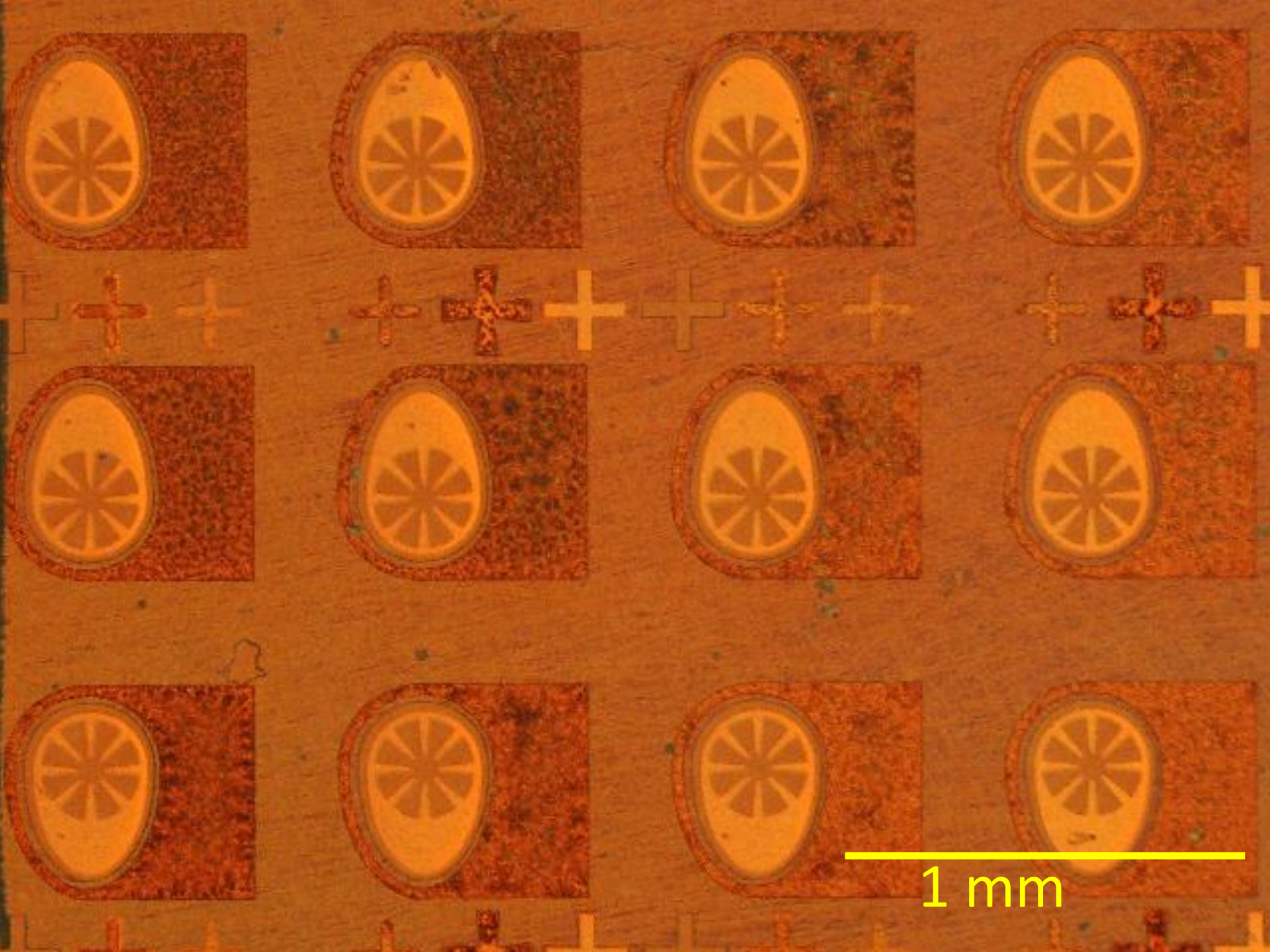
- Fe to the QWs ($\sim 2 \cdot 10^{19}$ at/cm³)
- Mg to the barrier and the QWs layers ($\sim 2 \cdot 10^{20}$ at/cm³)
- Si to the barrier layer ($\sim 0.6 \cdot 10^{19}$ at/cm³)

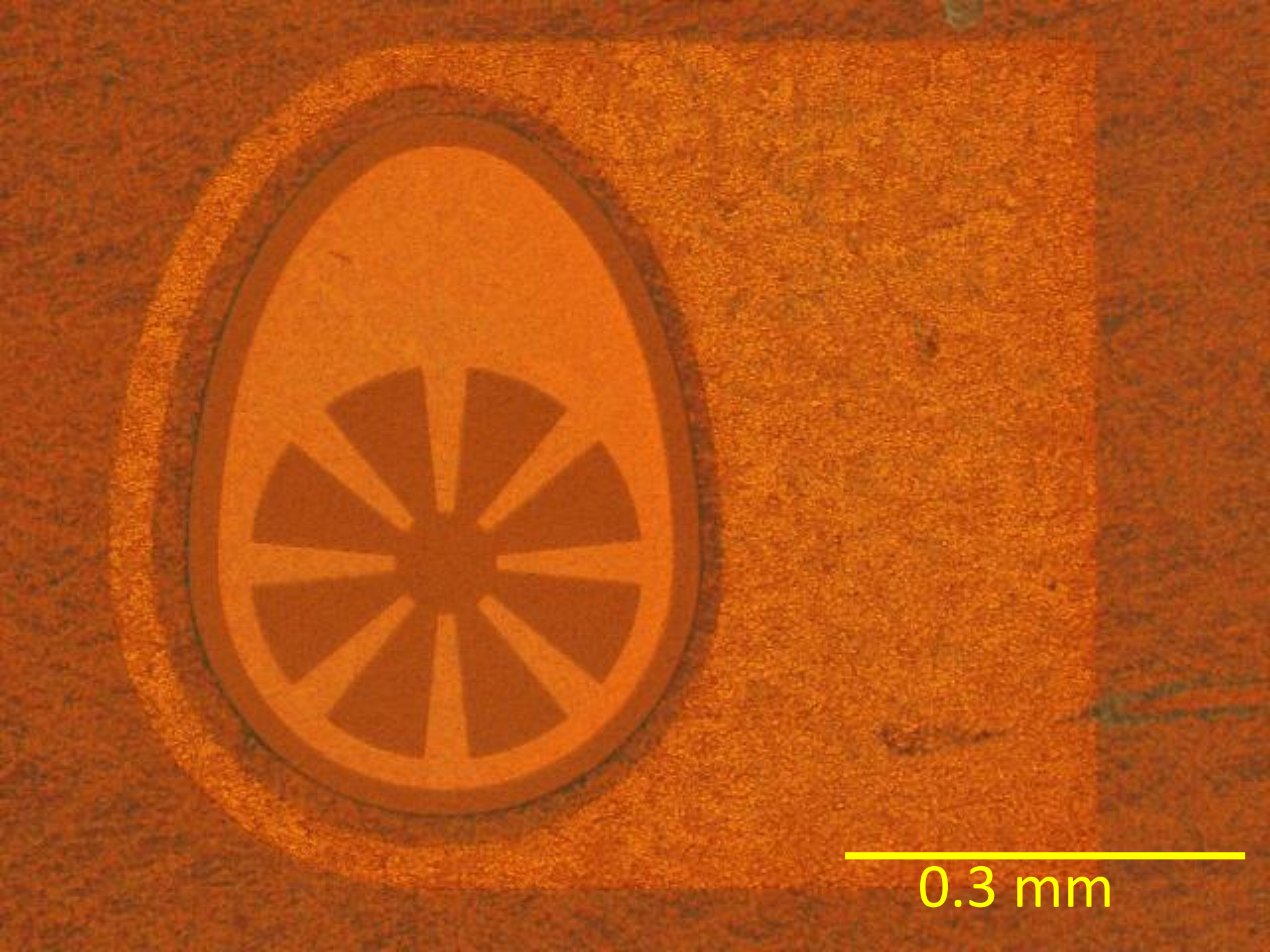
Mesa design and contact deposition



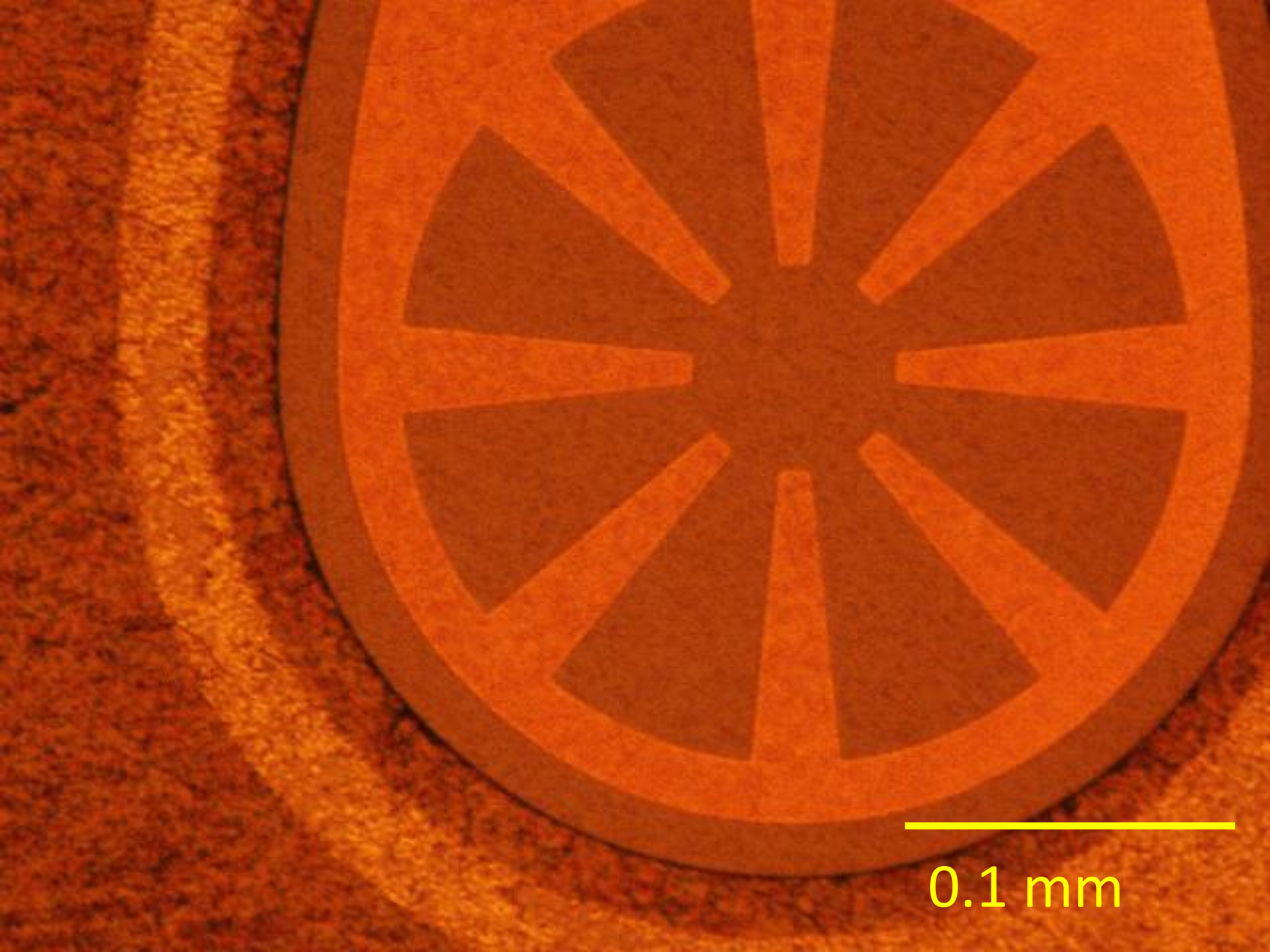
Mesa design and contact deposition



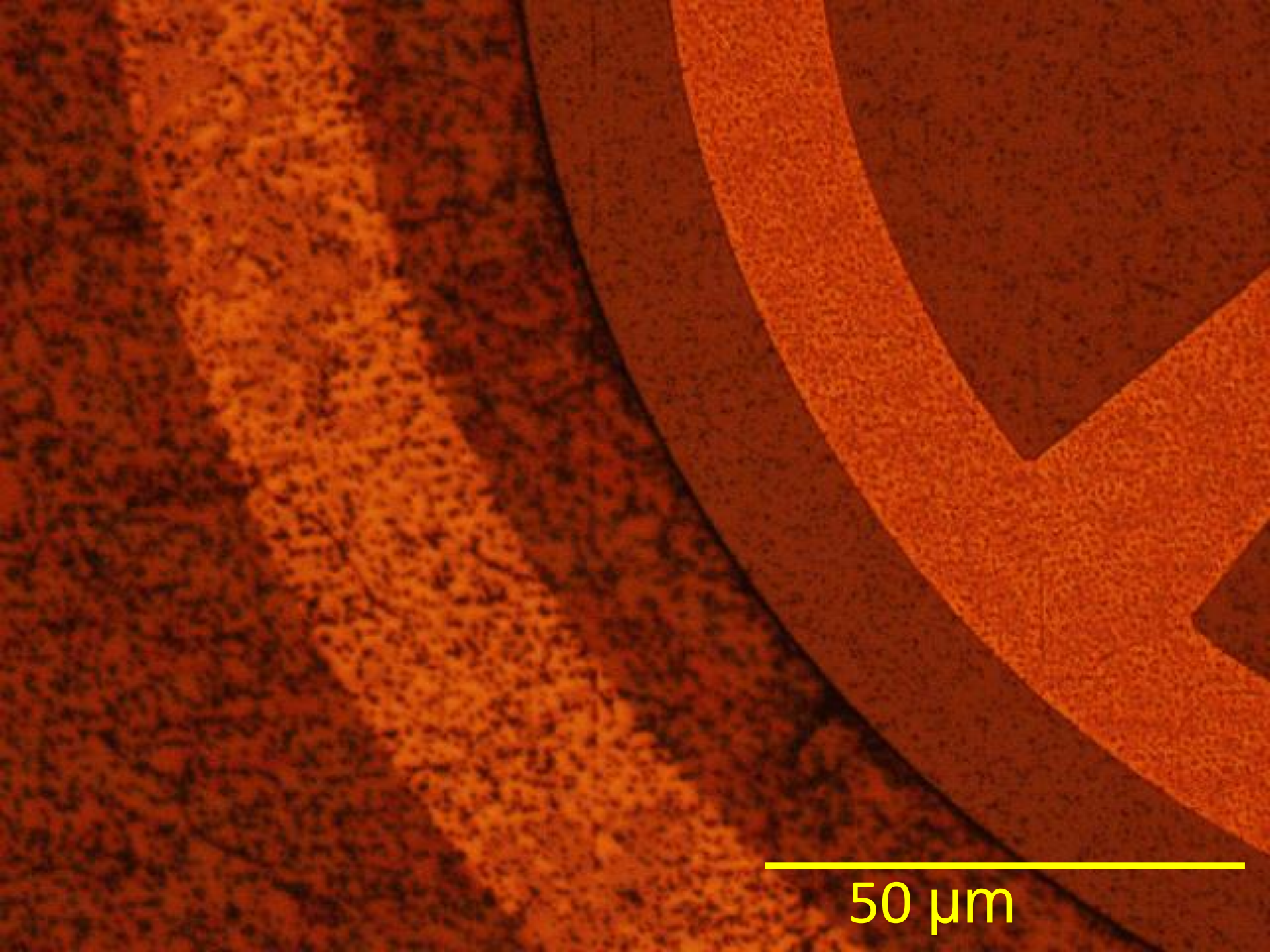




0.3 mm

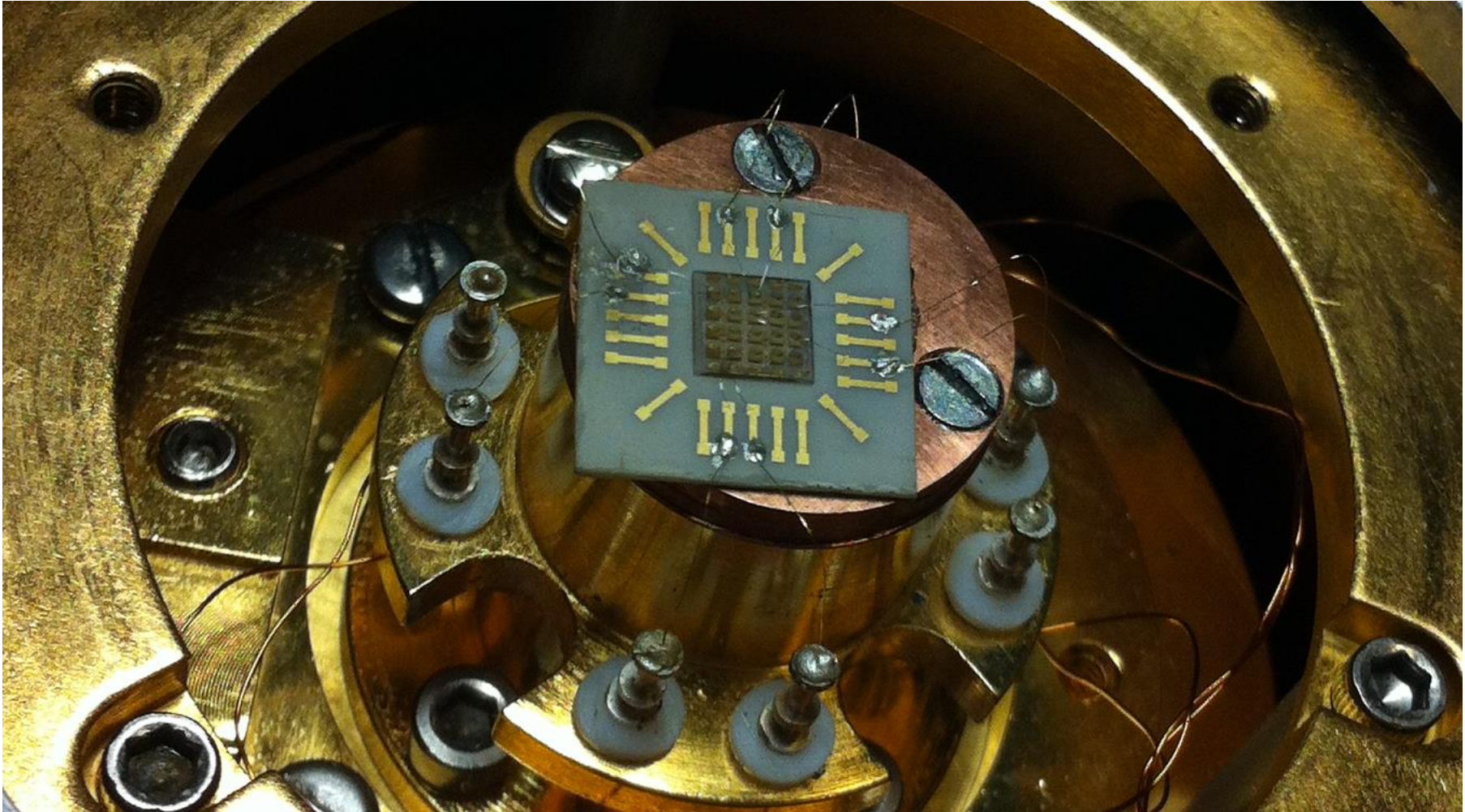


0.1 mm

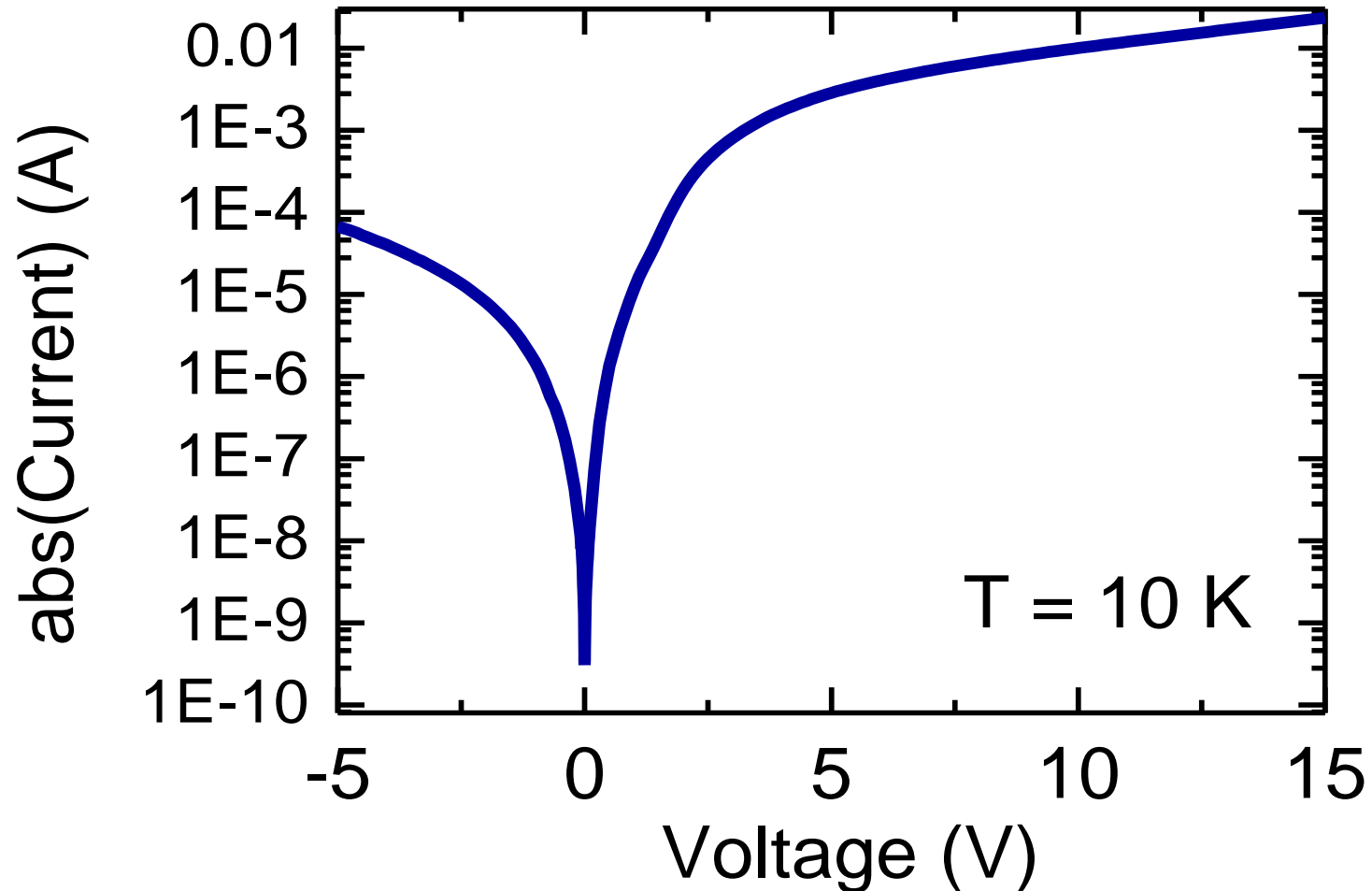


50 μm

Low temperature I-V and spectroscopy measurements

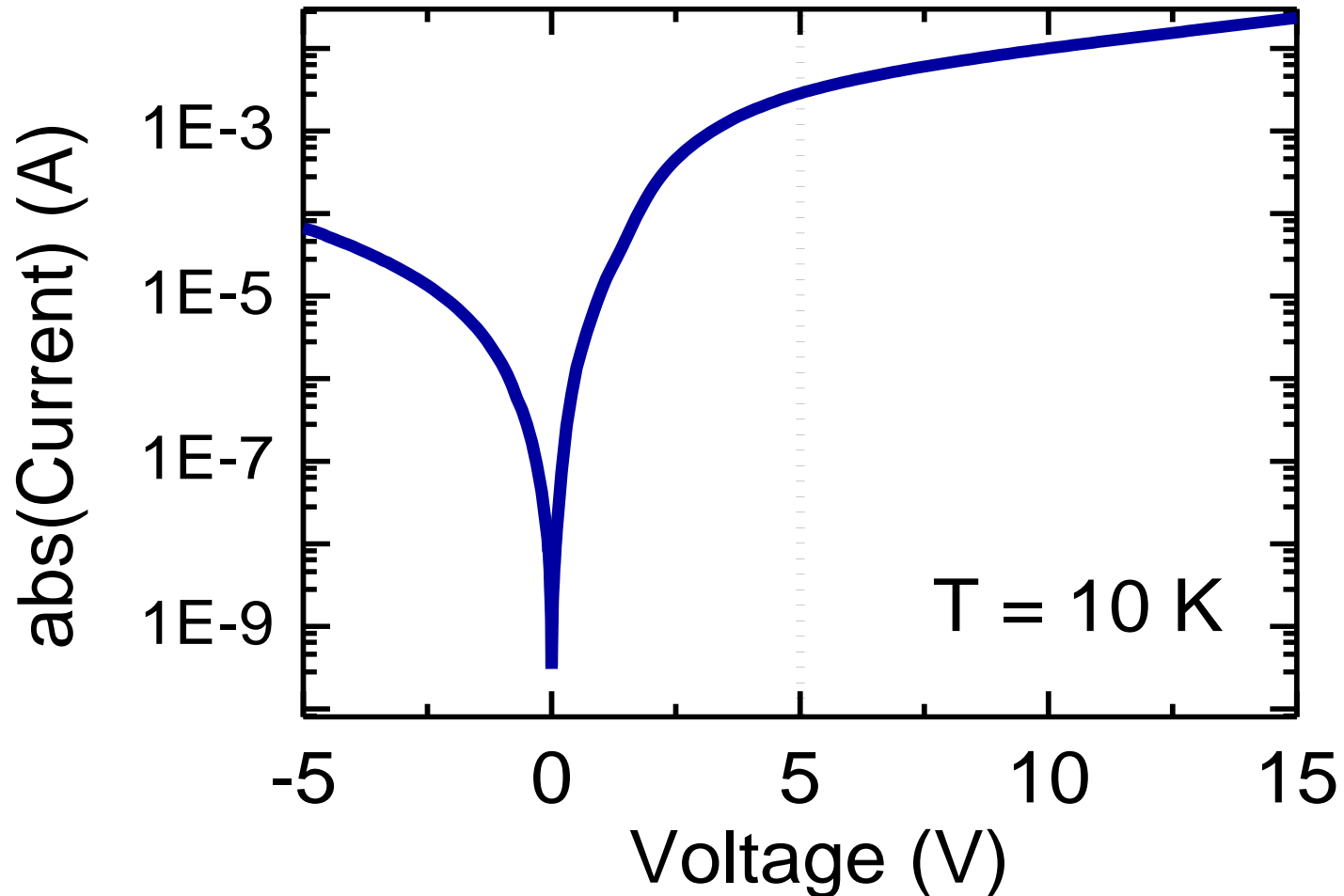


I-V characteristics



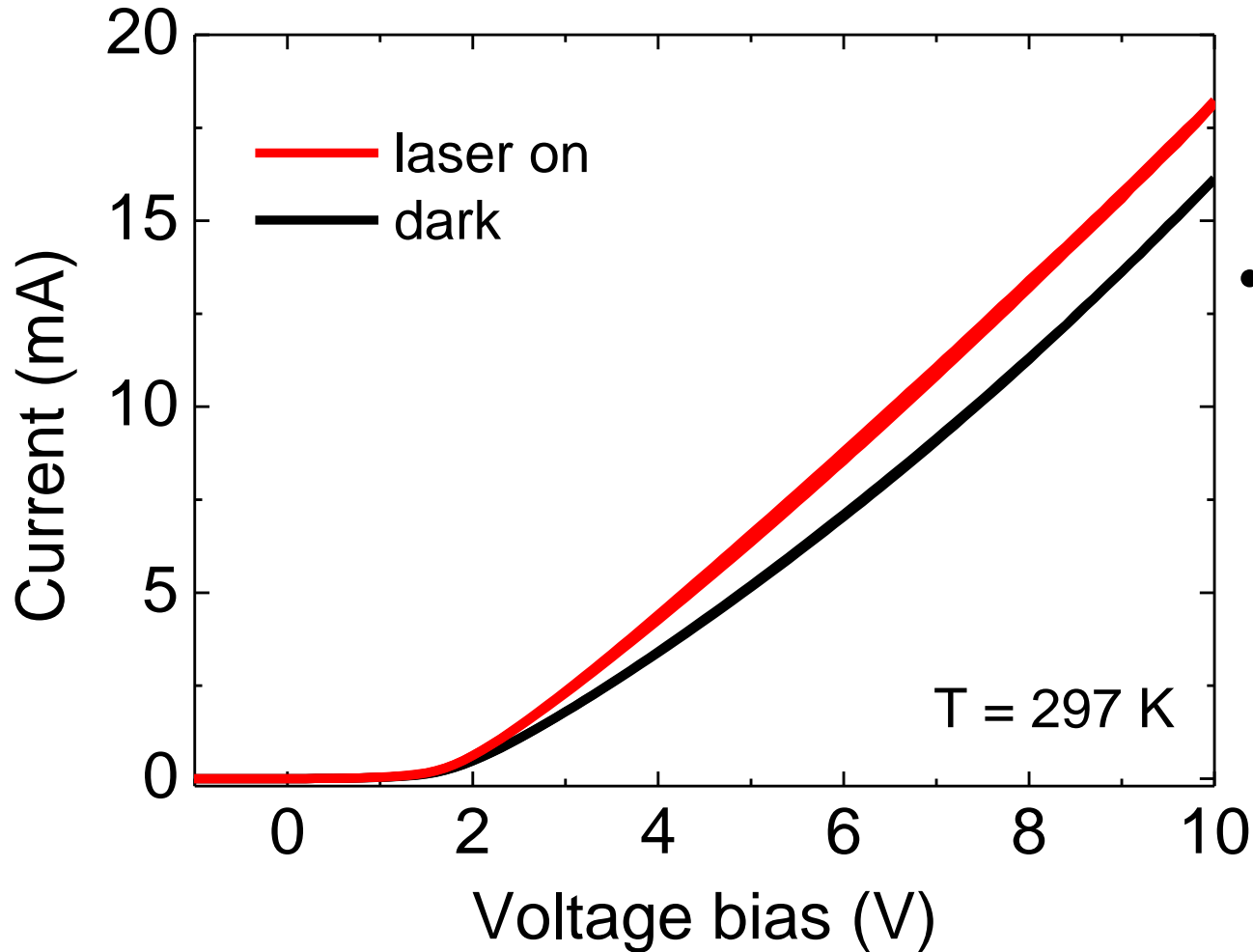
- Operation of junctions in a wide voltage range
- Current for a reverse voltage: 7×10^{-5} A at -5 V
- Current for a forward voltage: 3×10^{-2} A at 5 V

I-V characteristics



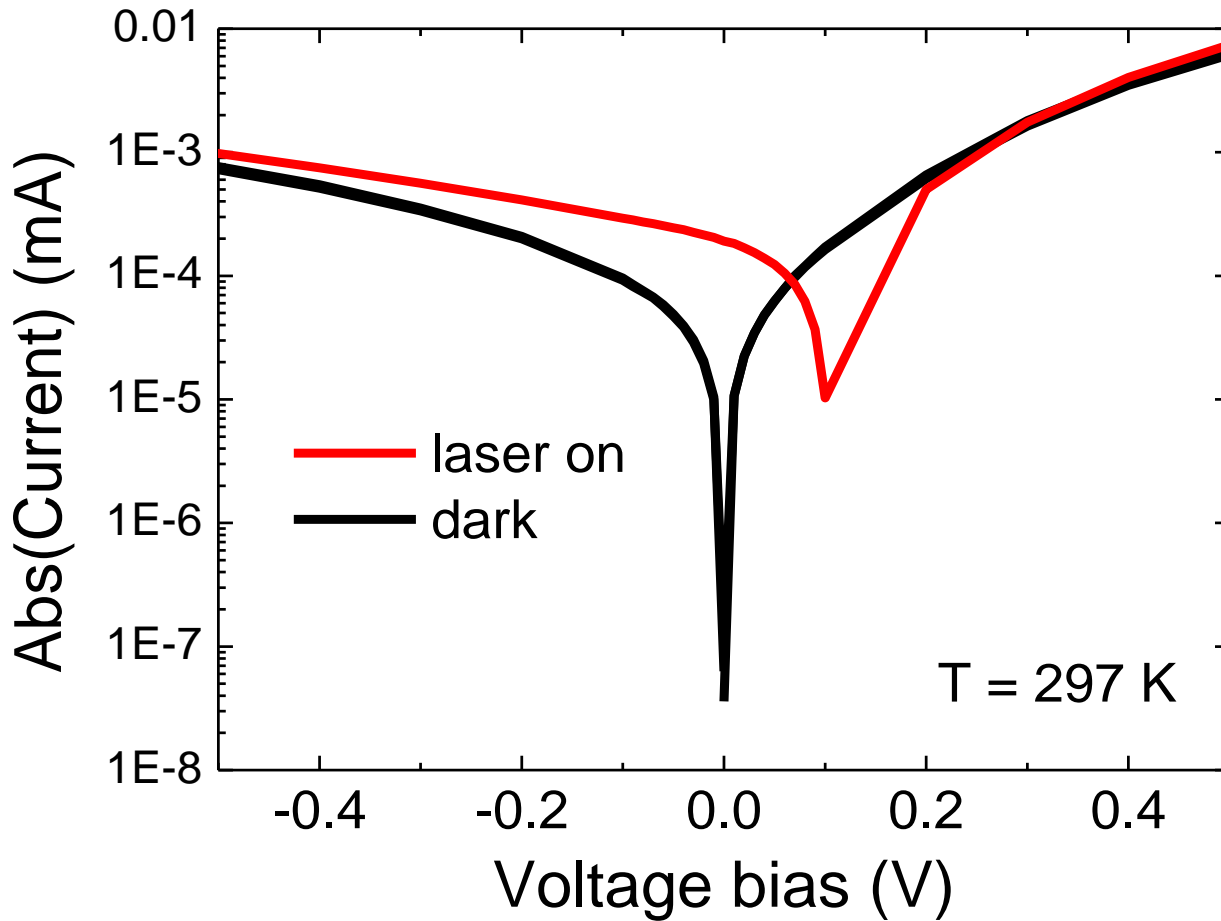
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I-V characteristics



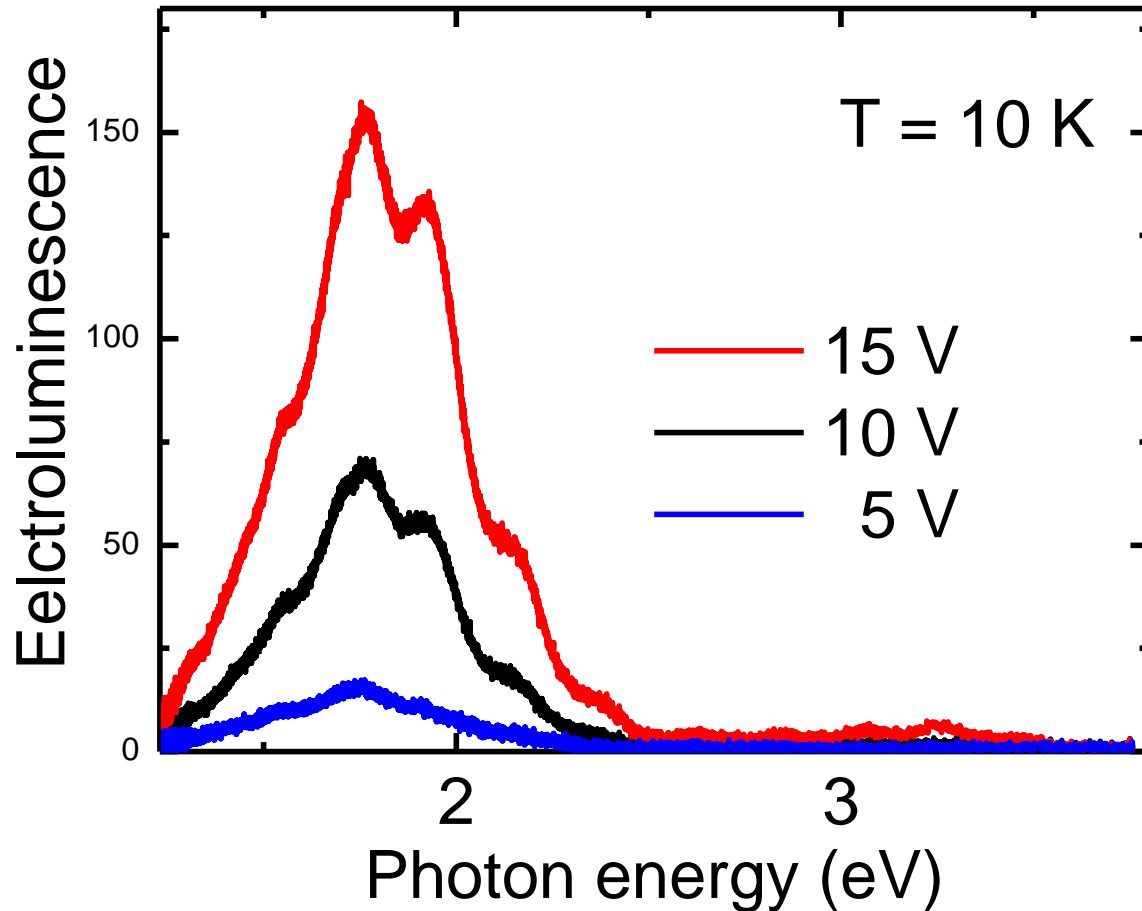
- photogenerated carriers contribute to the current

I-V characteristics



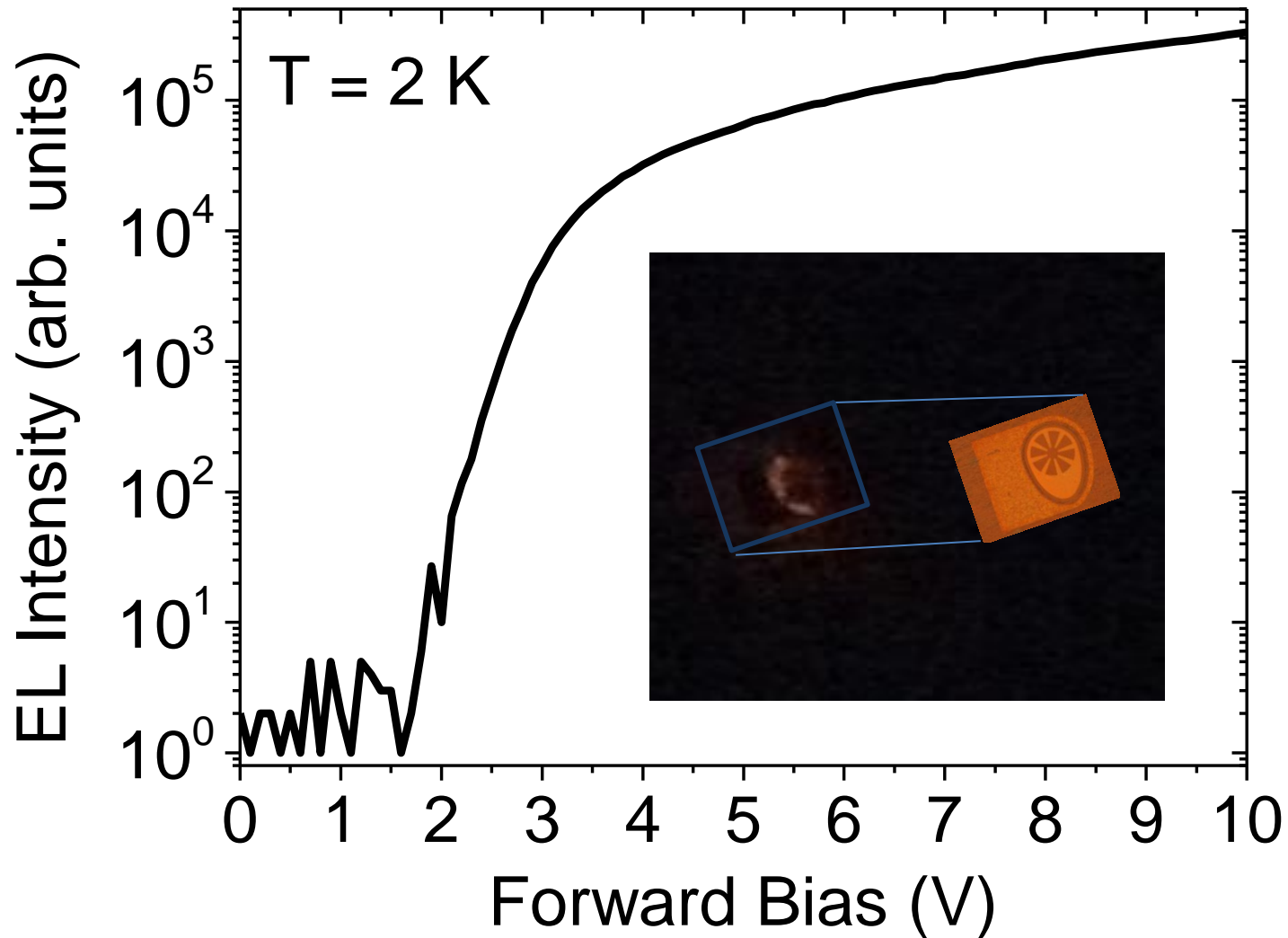
- detectable current originating from photogenerated carriers at zero voltage bias

Electroluminescence



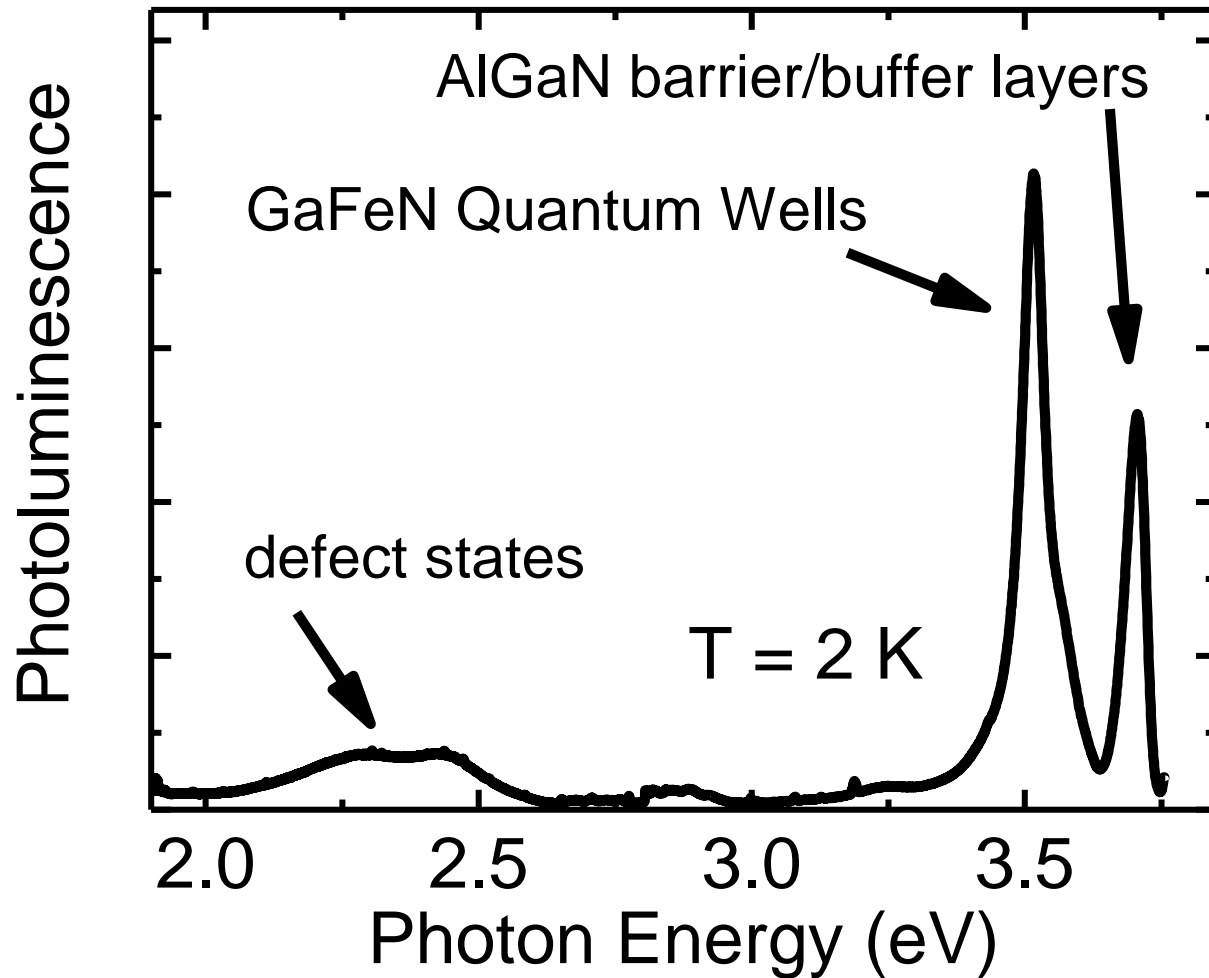
- Broad band electroluminescence in visible spectral range
- Defect states related emission

Electroluminescence



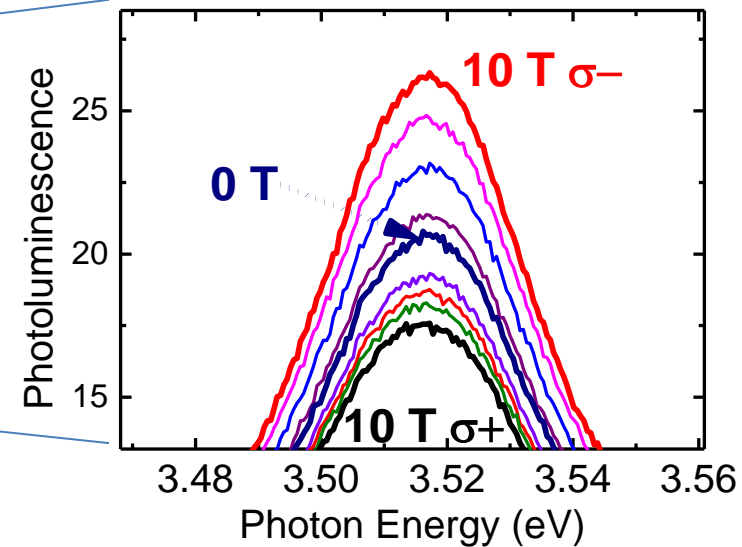
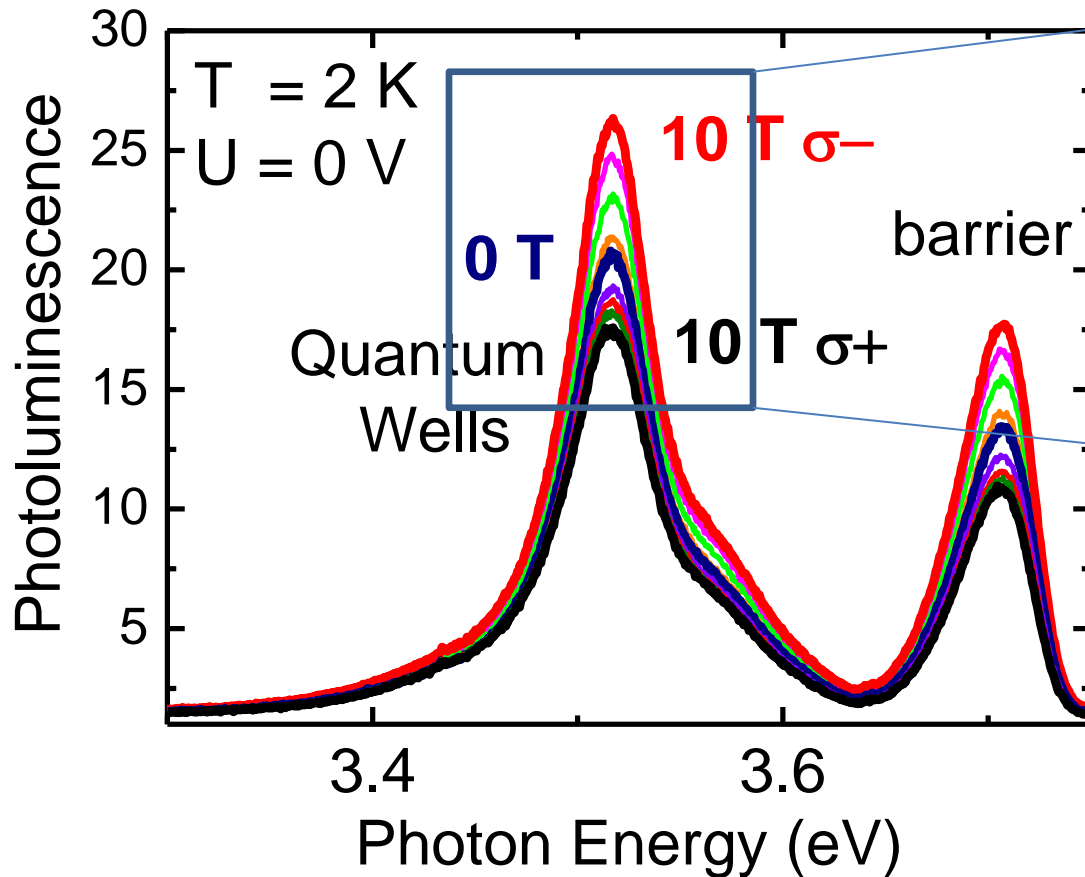
- Electroluminescence treshhold: 2 V (0.2 mA)

Photoluminescence



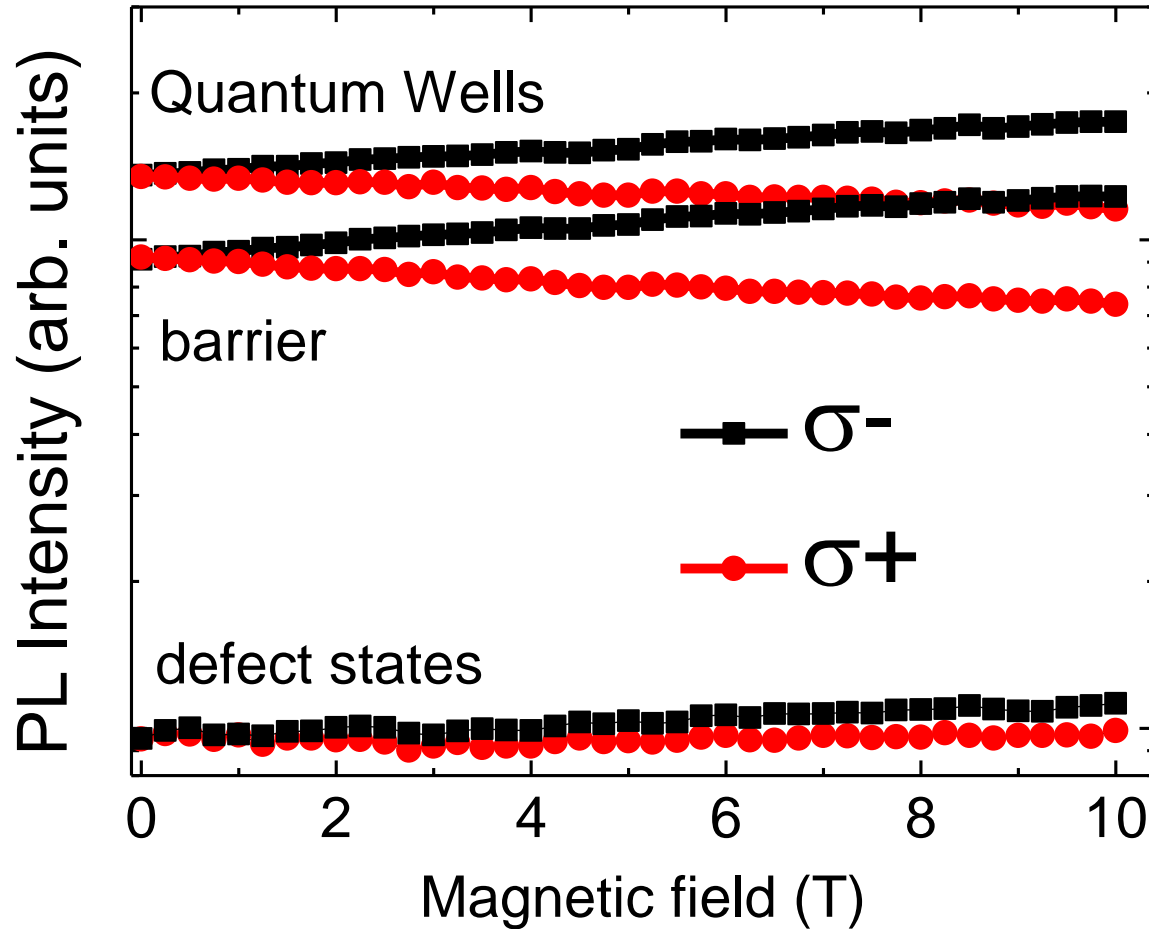
- the emission from the GaFeN Quantum Wells activated

Photoluminescence spectra in magnetic field



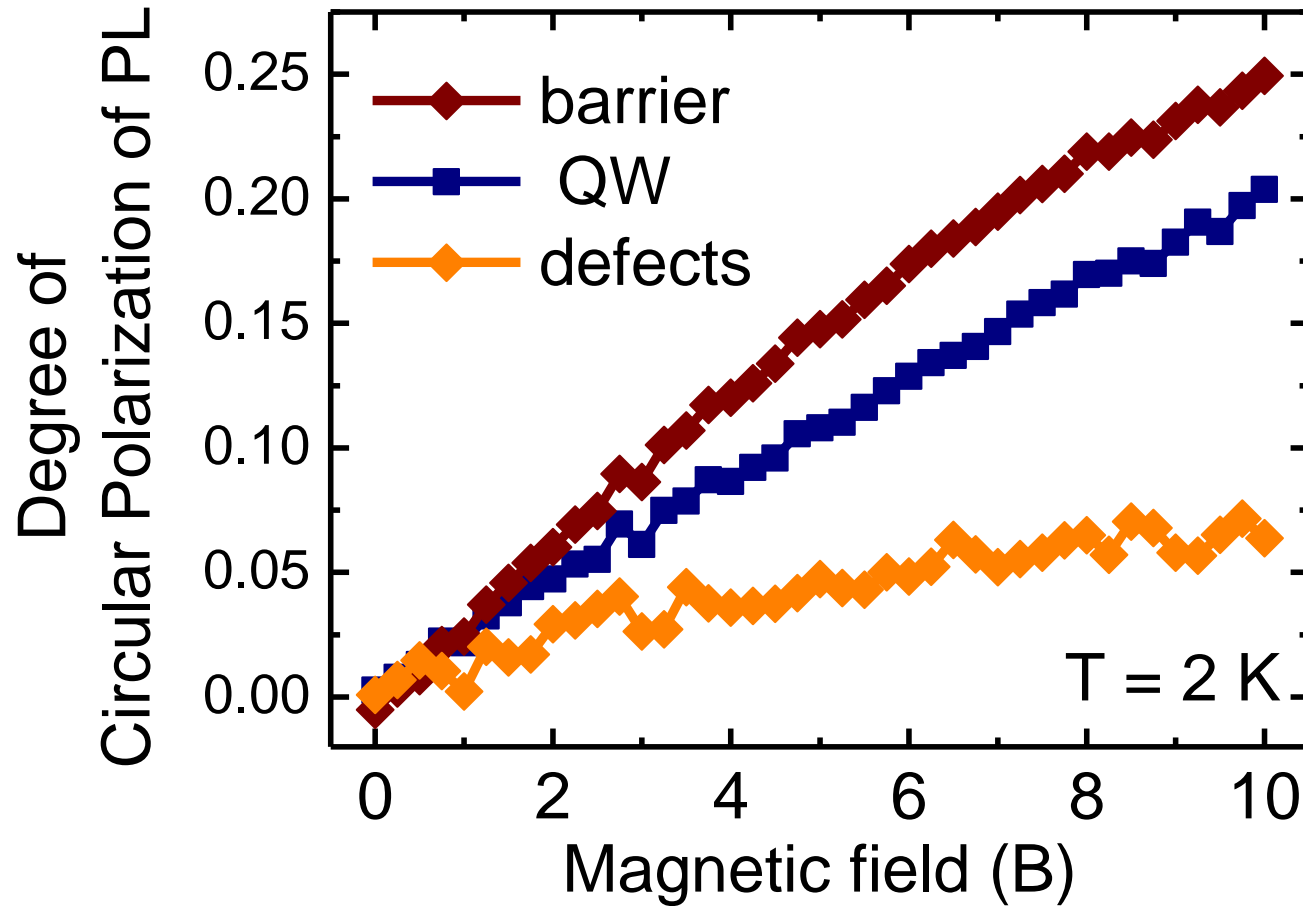
- Decrease of $\sigma+$ polarized signal
- Increase of $\sigma-$ polarized signal

Photoluminescence in magnetic field



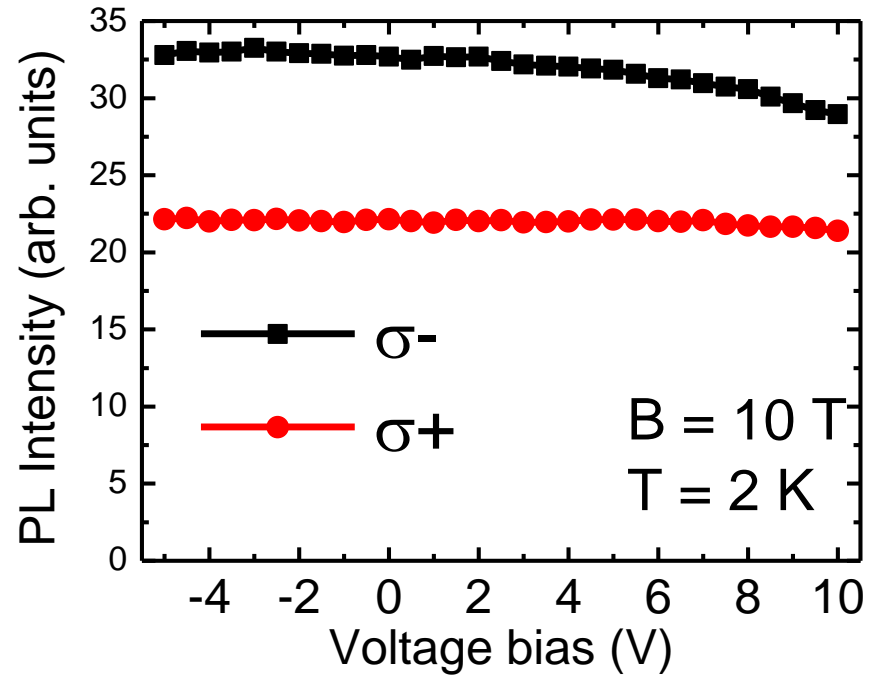
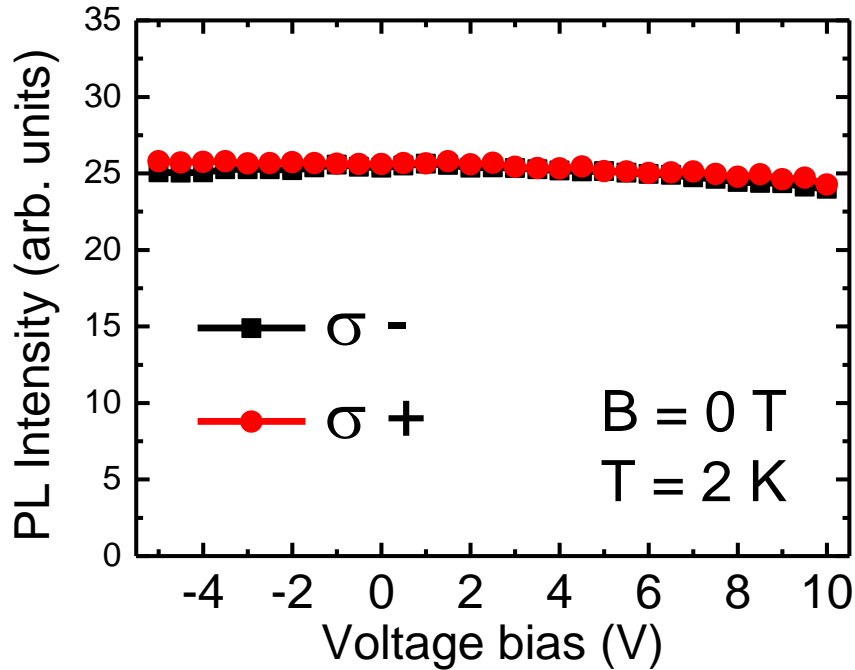
- Significant variation of σ^+ and σ^- polarized signal intensity
- Overall increase of the emission intensity

Circular polarization of the emission



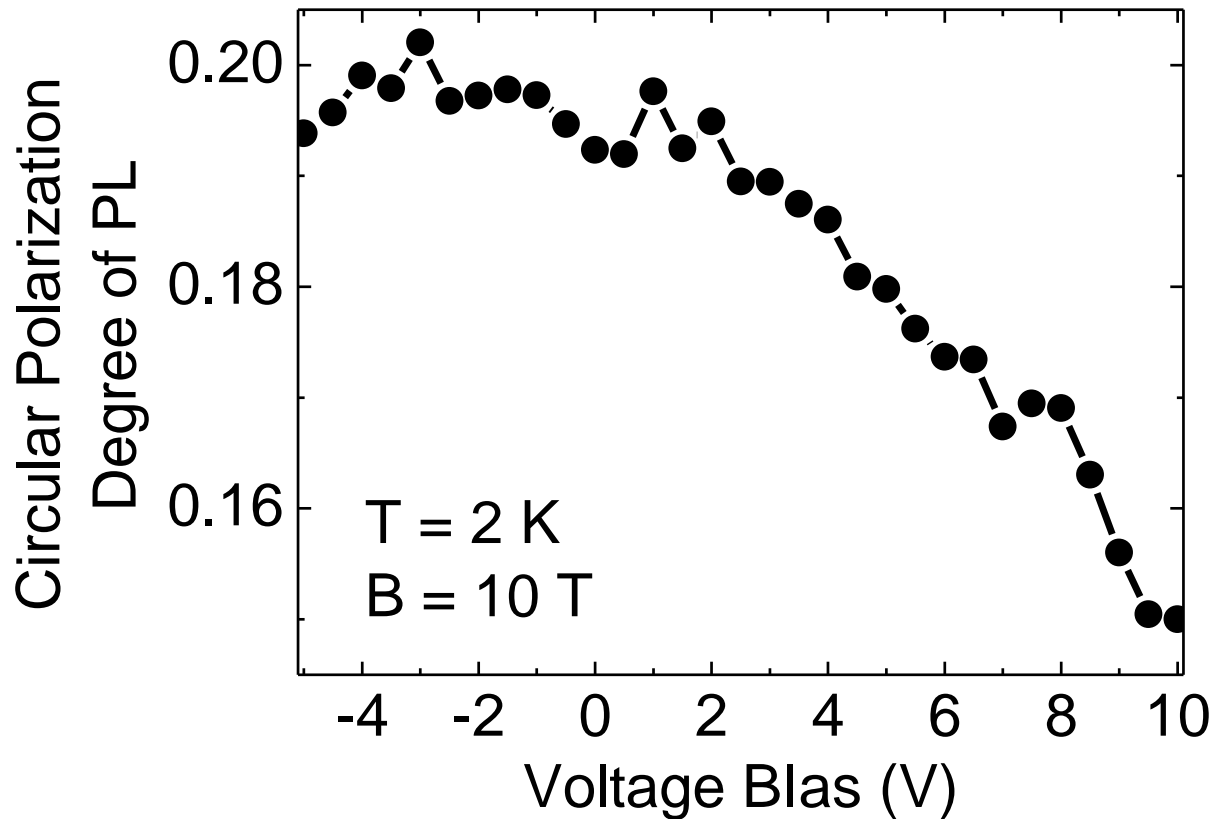
- Up to 25 % for barrier transition
- Up to 20 % for QW transition

Circular polarization of the QW emission vs voltage bias



- Decrease of PL intensity with increasing voltage
- Behavior of σ^+ and σ^- polarized signal vs voltage not equal

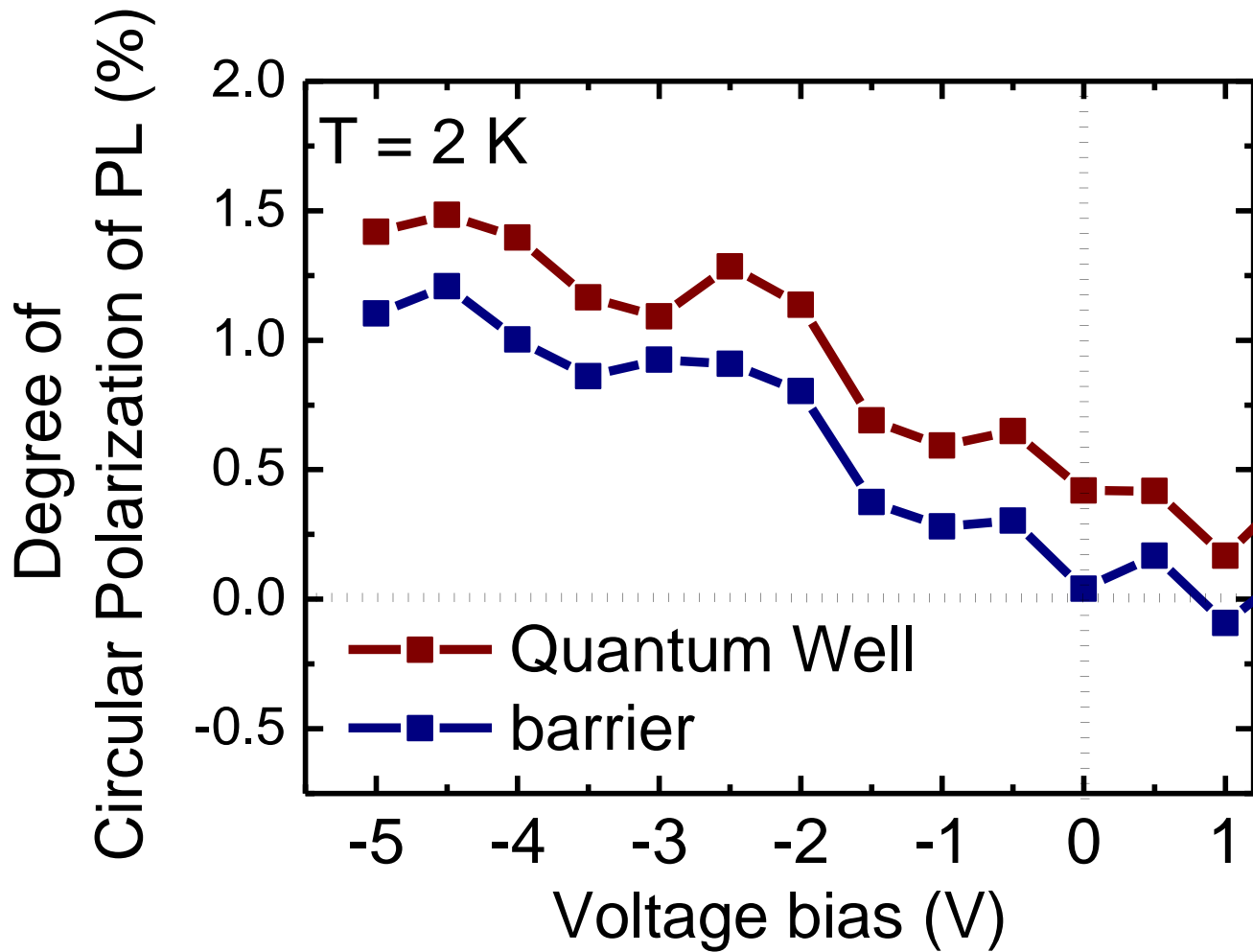
Degree of Circular Polarization of the QW emission vs voltage bias



- Decrease of DCP for the forward bias
- Slight increase of DCP for the reverse bias

→ A control of the circular polarization degree of the QW emission with applied voltage bias

Circular Polarization of emission at $B = 0$ T



- Nonzero degree of Circular Polarization at $B = 0$ T for a reverse voltage

Conclusions

- **Wide voltage range of the p-n junctions performance : -5 V to 15 V**
 - Forward current $3 \cdot 10^{-2}$ A at 5 V
 - Reverse current $7 \cdot 10^{-5}$ at -5 V
- **Up to 25% of circular polarization degree and its control with applied voltage bias**
- **Detection of the UV and visible light**
- **A broadband visible light source**