Mid-Infrared Single-Photon Detection with Tungsten Silicide Superconducting Nanowires

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[2]*National Institute of Standards and Technology, 325 Broadway, MC 815.04, Boulder, CO 80305, USA*
[3]*Department of Physics, Albion College, 611 E. Porter St., Albion, MI 49224, USA*
[4]*Max Planck Institute for Biophysical Chemistry, Göttingen, Germany*

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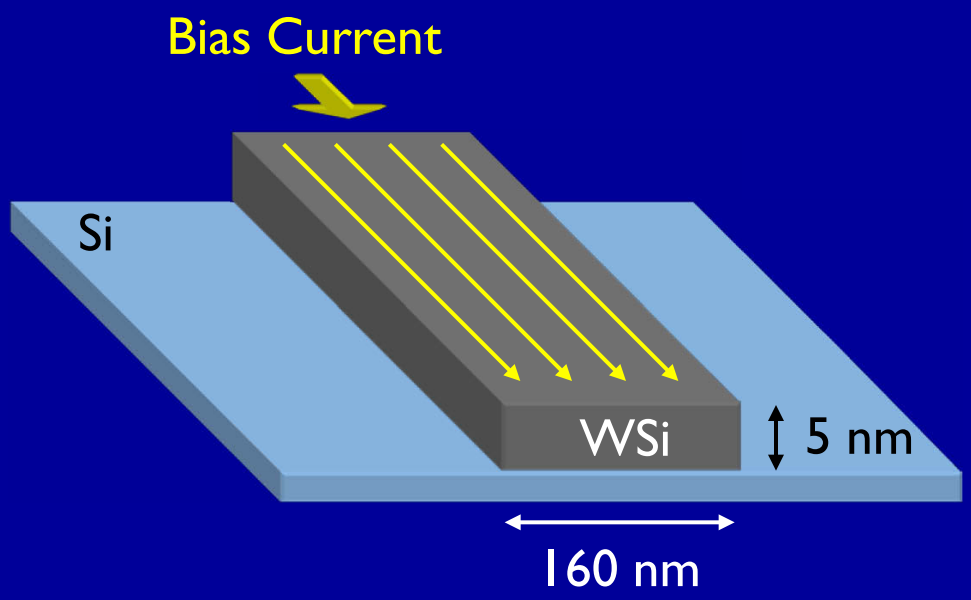
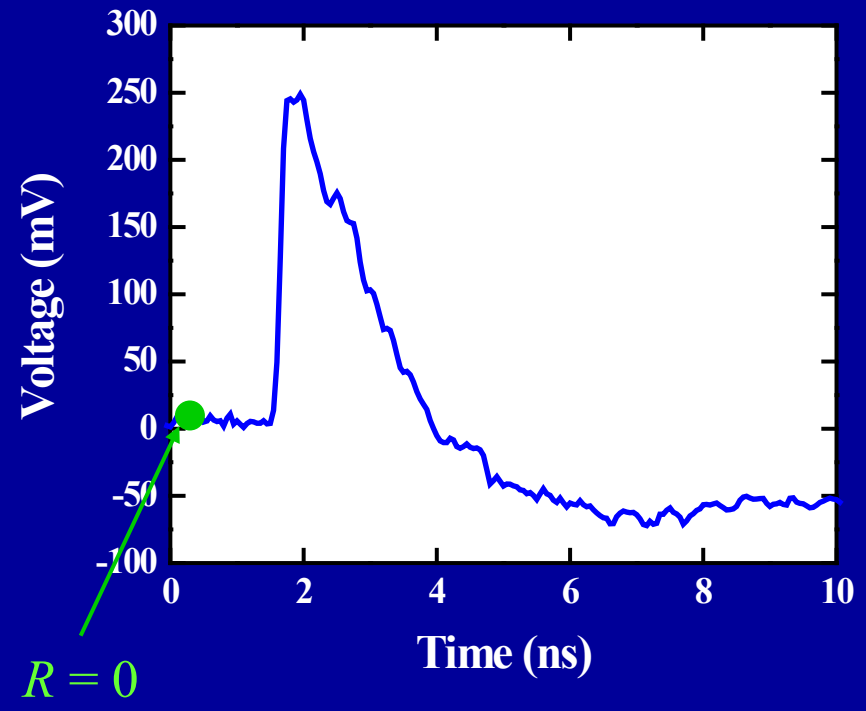
Working principle

Superconducting Nanowire Single-Photon Detector (SNSPD)



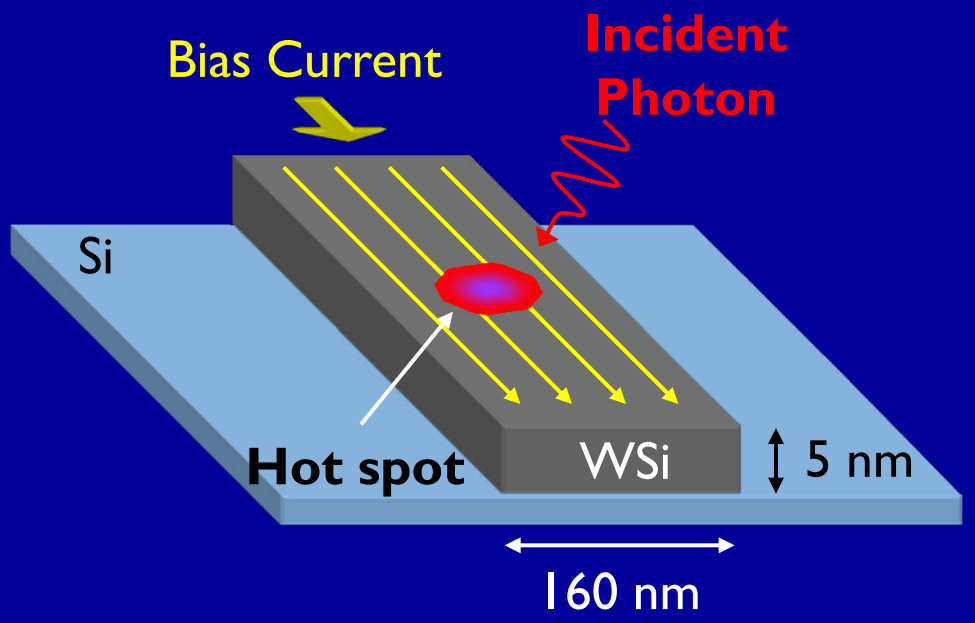


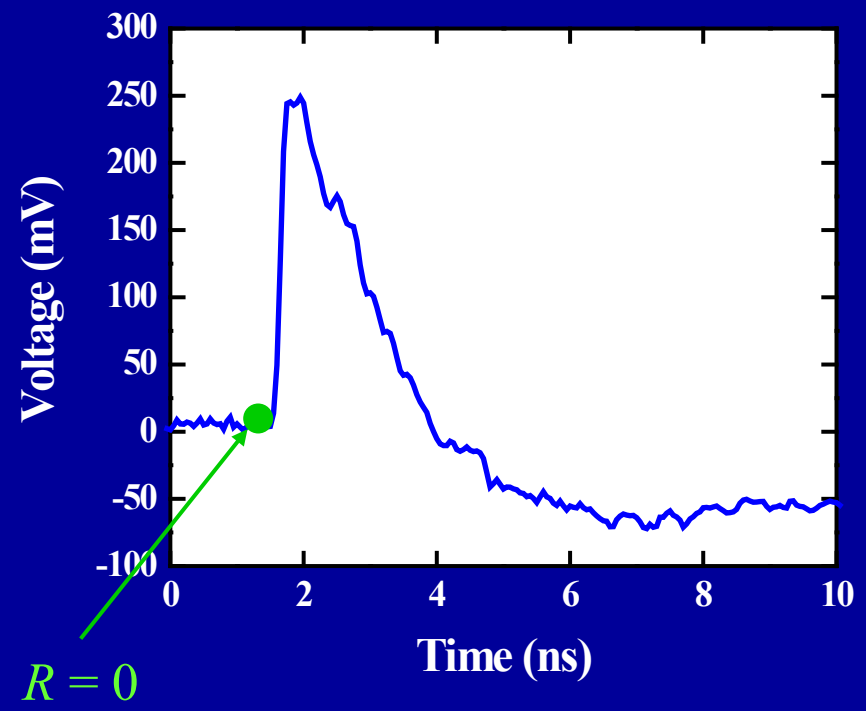
Superconducting WSi :

- Temperature < T_C (~ 4.5 K)
- Current density < J_C

Gol'tsman *et al.*, APL 79, 705 (2001)

Superconducting Nanowire Single-Photon Detector (SNSPD)





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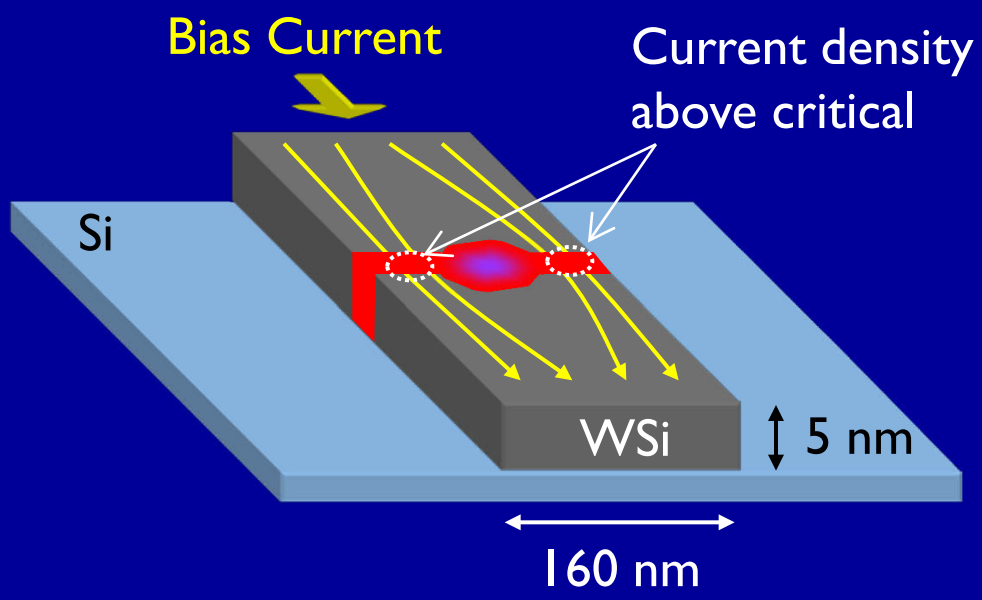

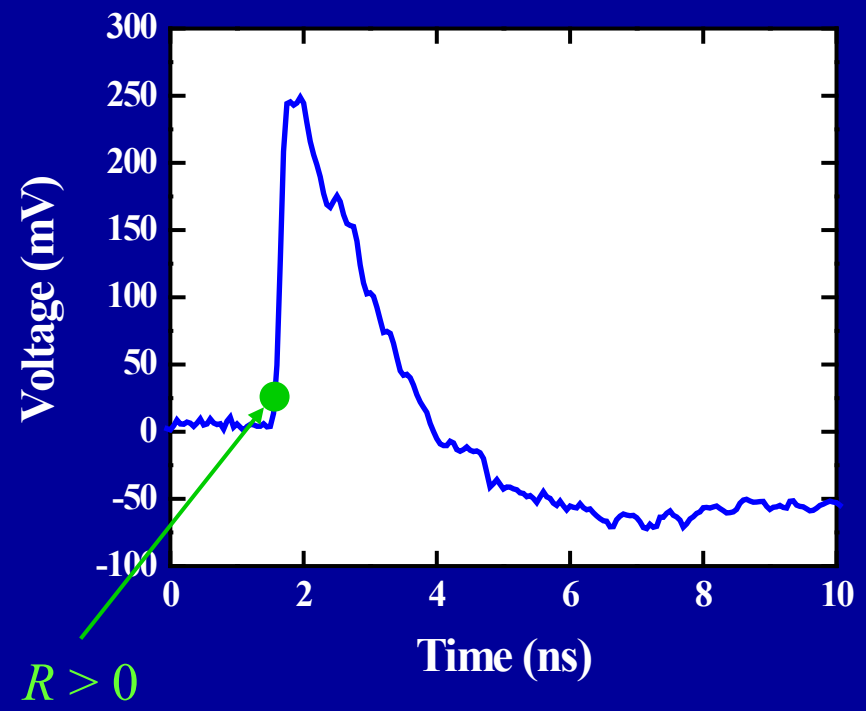

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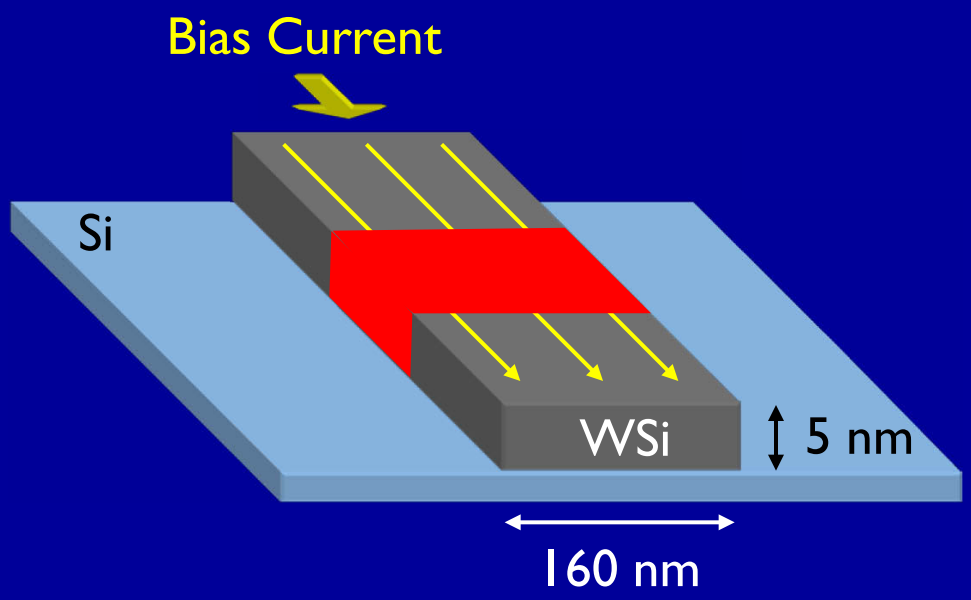

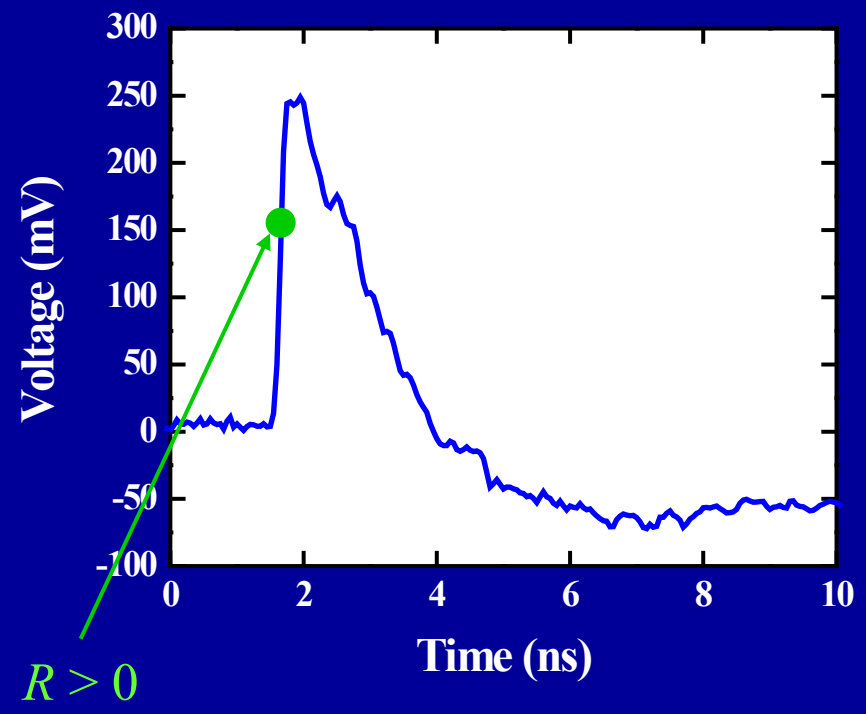

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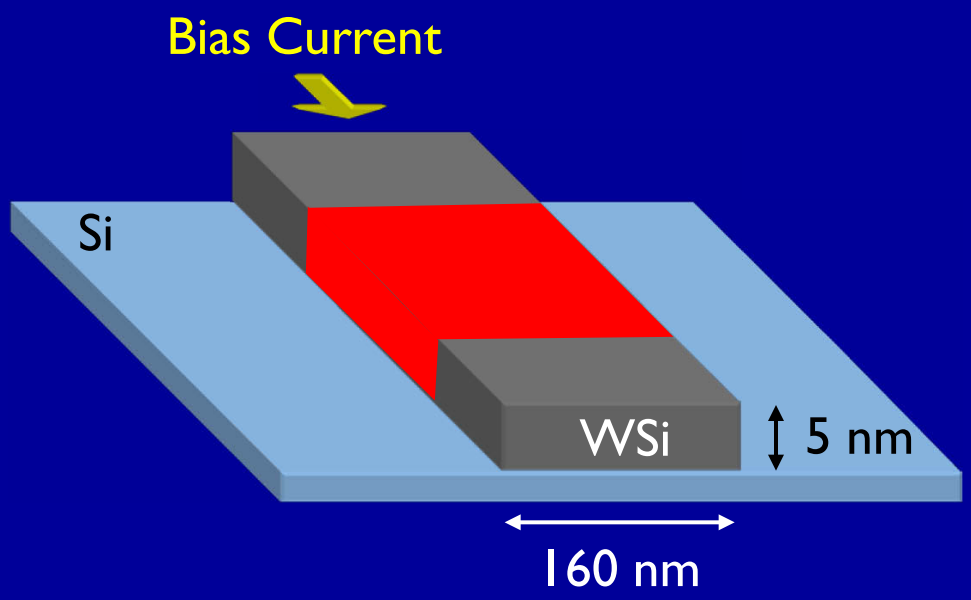
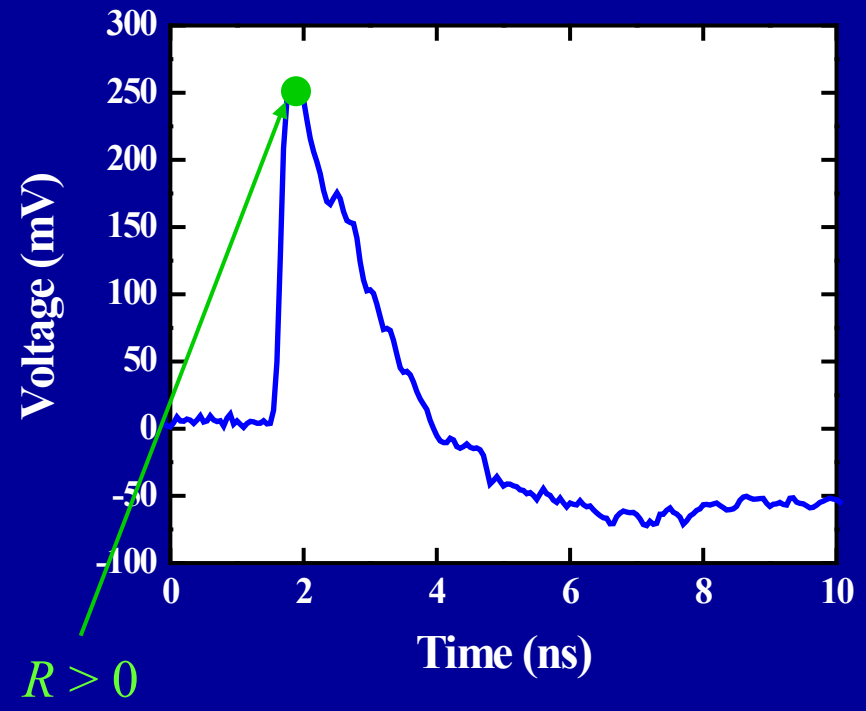
Superconducting Nanowire Single-Photon Detector (SNSPD)





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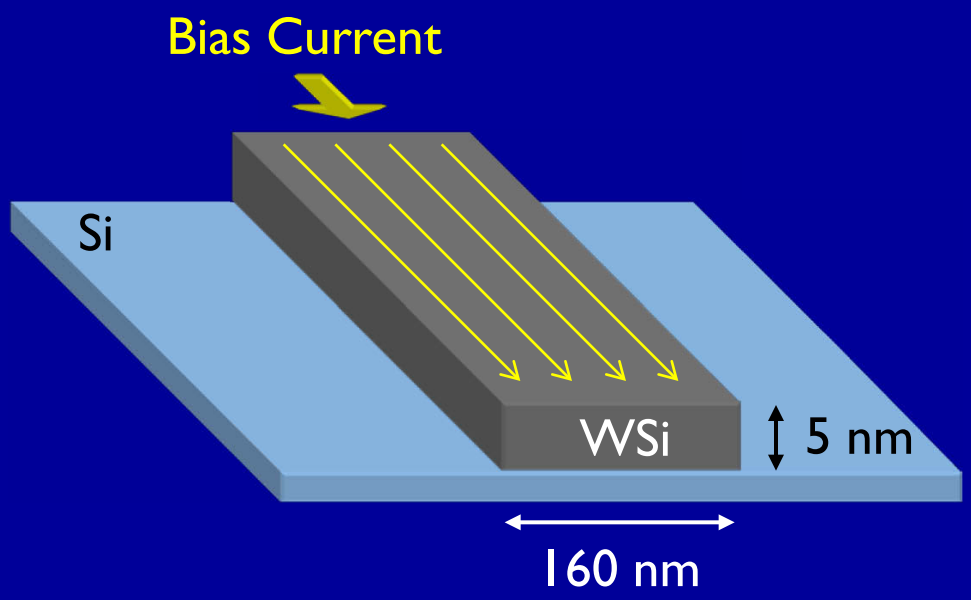
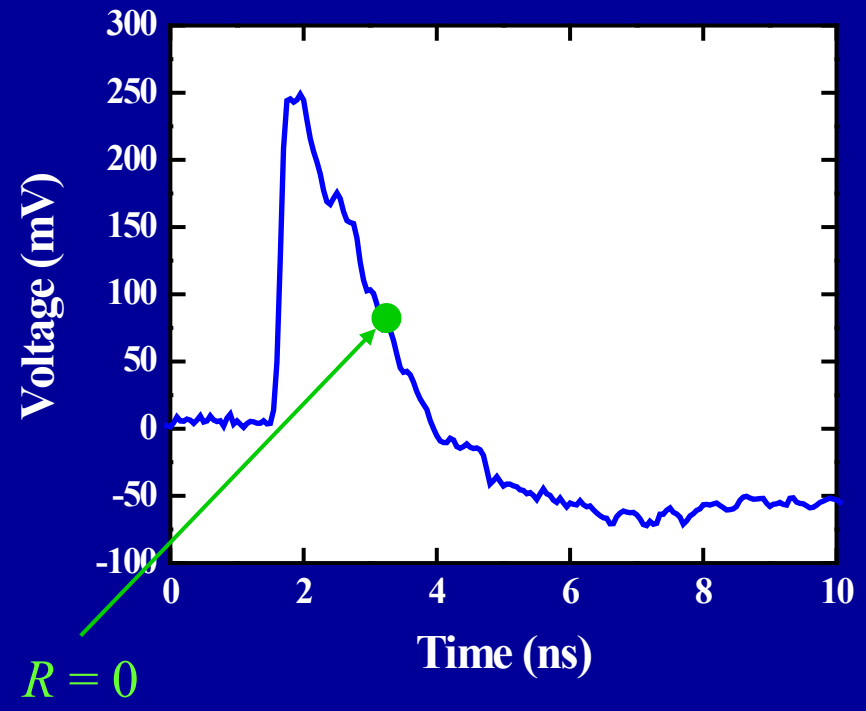
Superconducting Nanowire Single-Photon Detector (SNSPD)





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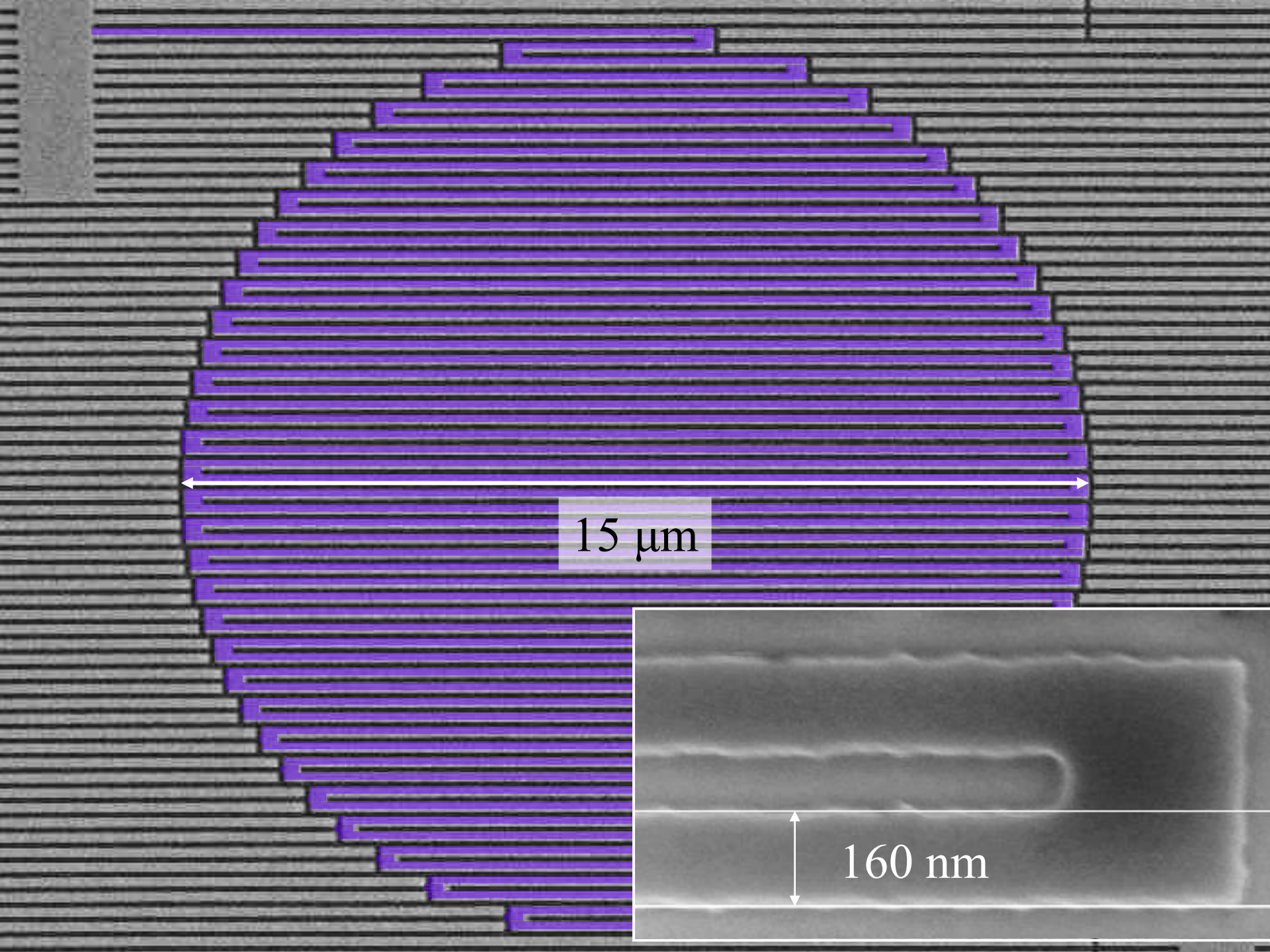
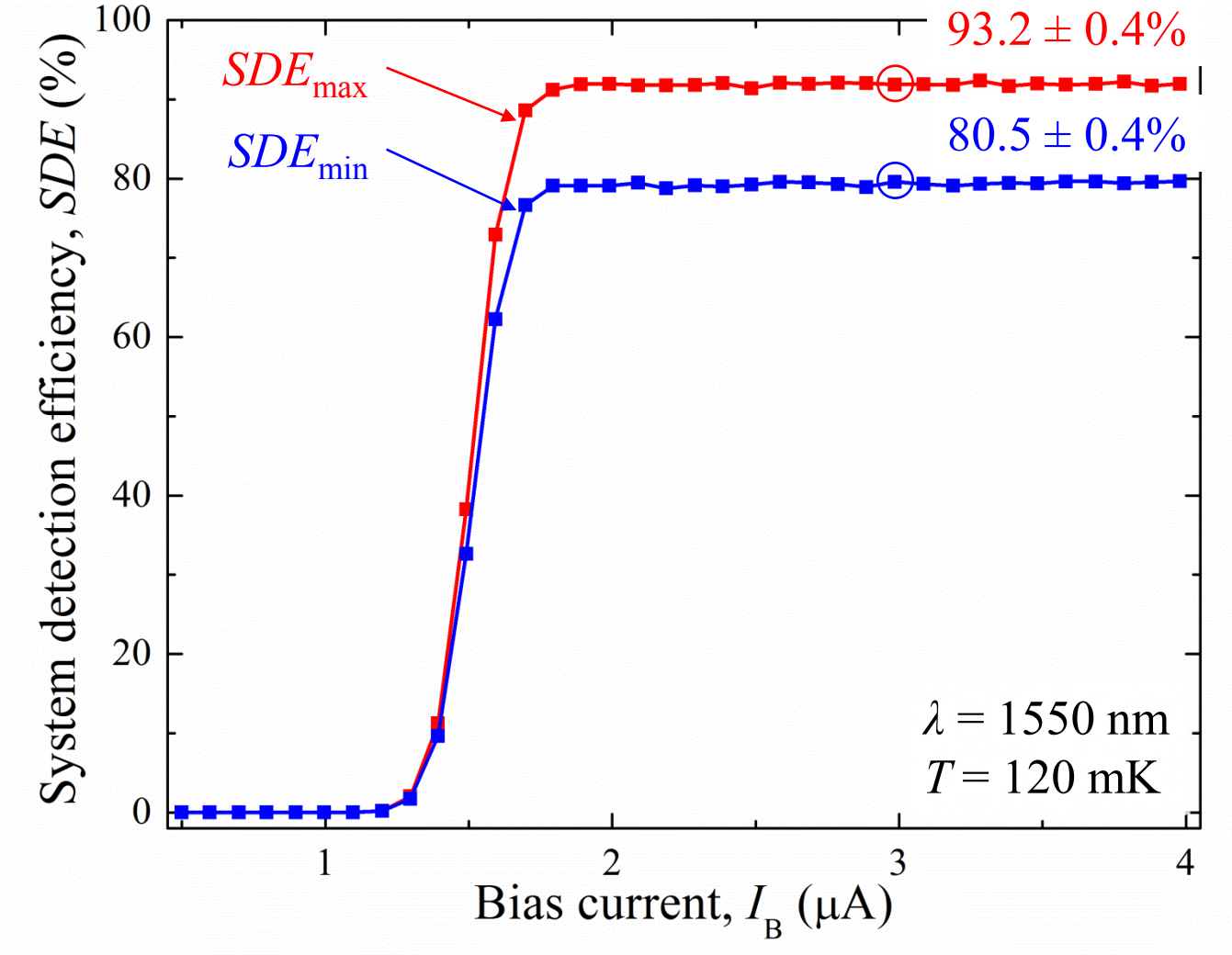
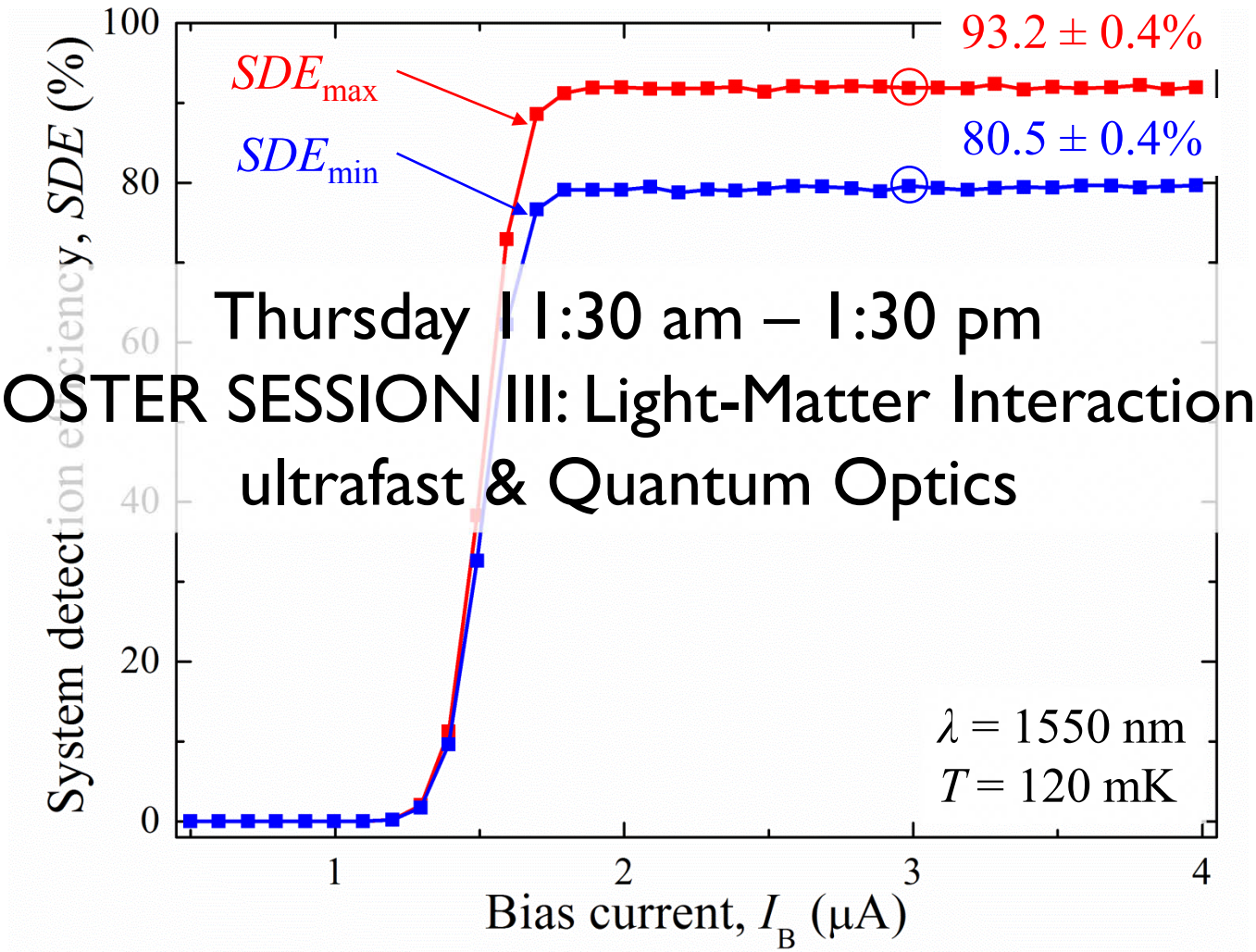

15 μm
160 nm

93% System Detection Efficiency



Marsili et al., Nature Photonics 7, 210 (2013)

93% System Detection Efficiency



Thursday 11:30 am – 1:30 pm
POSTER SESSION III: Light-Matter Interactions, ultrafast & Quantum Optics

Marsili et al., Nature Photonics 7, 210 (2013)

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California Institute of Technology

National Institute of Standards and Technology
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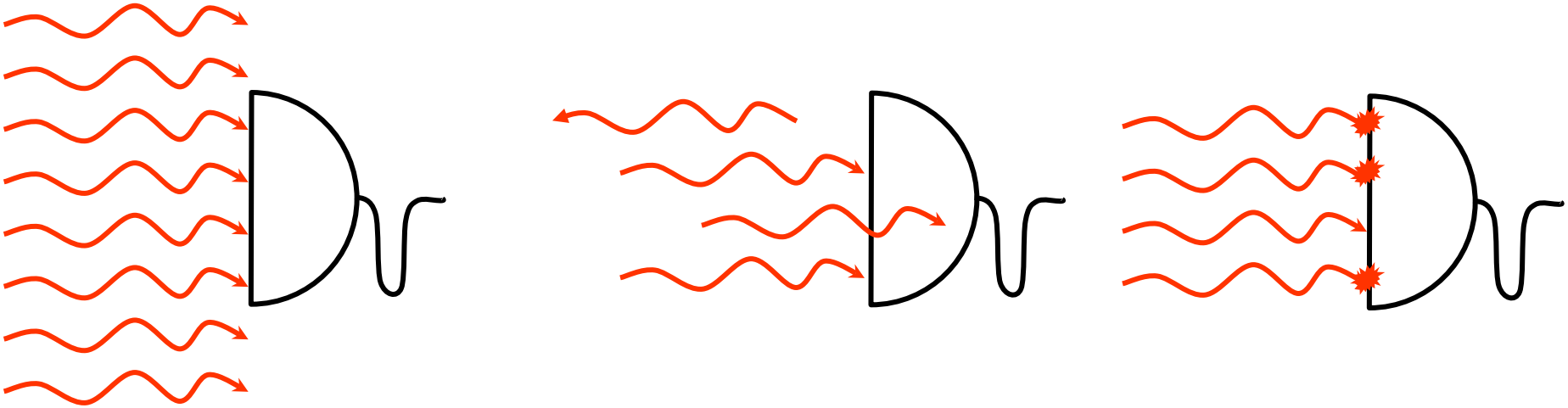
Can we achieve high SDE in the mid-IR?

How to never miss a photon

Coupling Efficiency × Absorption × Internal Efficiency



How to never miss a photon

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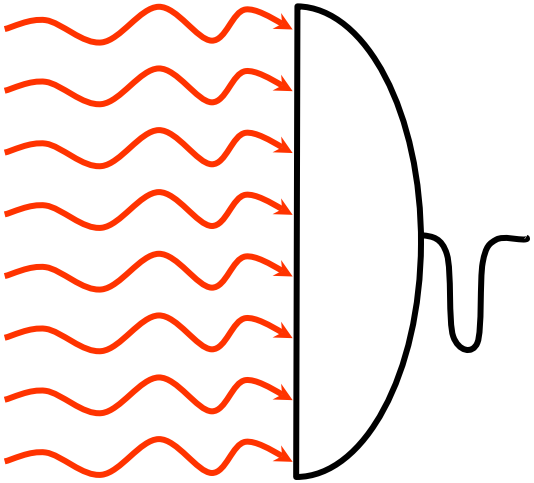
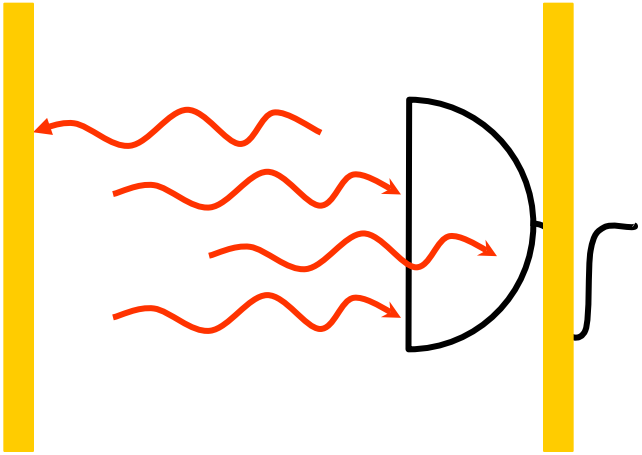
Coupling Efficiency



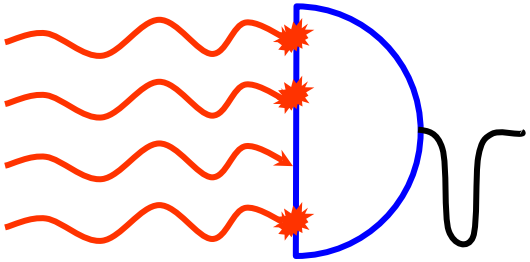
Optical Alignment
Detector Active Area

Absorption



Resonant absorption

Internal Efficiency



Device Design

How to never miss a photon

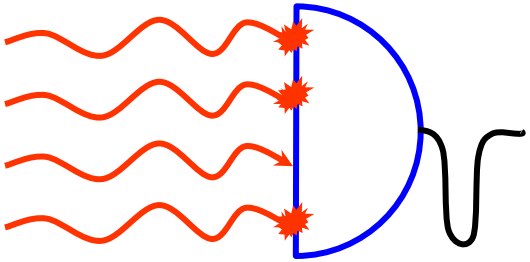
Coupling Efficiency

Optical Alignment
Detector Active Area

Absorption

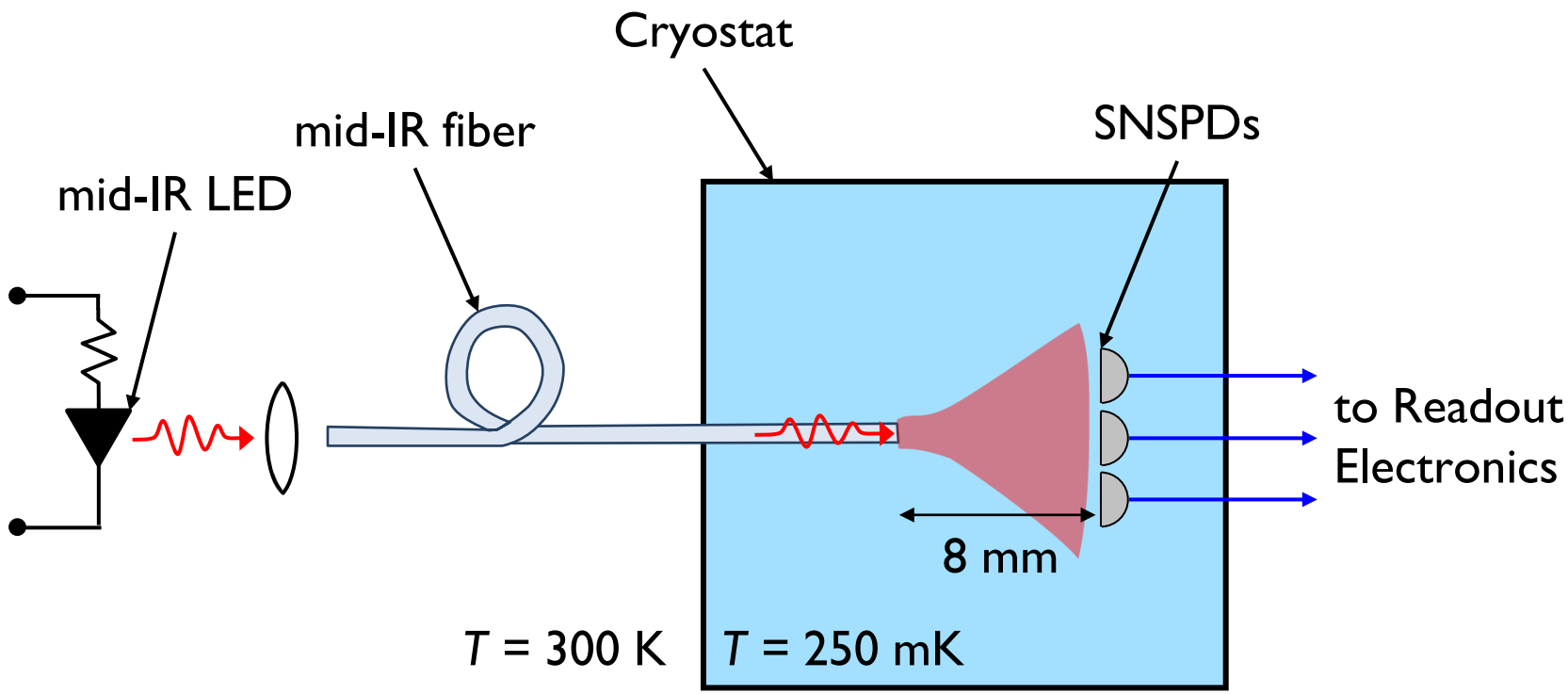
Resonant absorption

Internal Efficiency

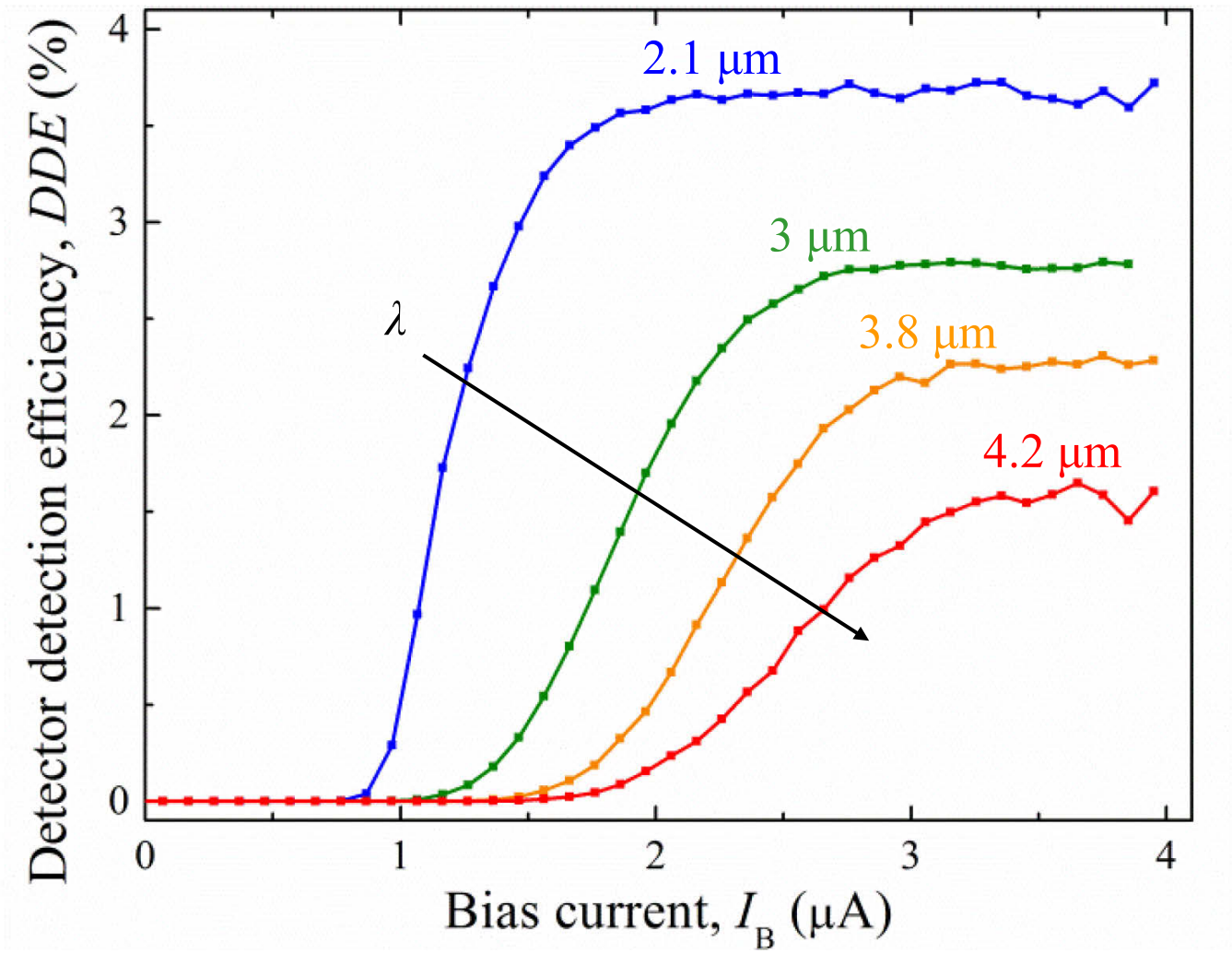


Device Design

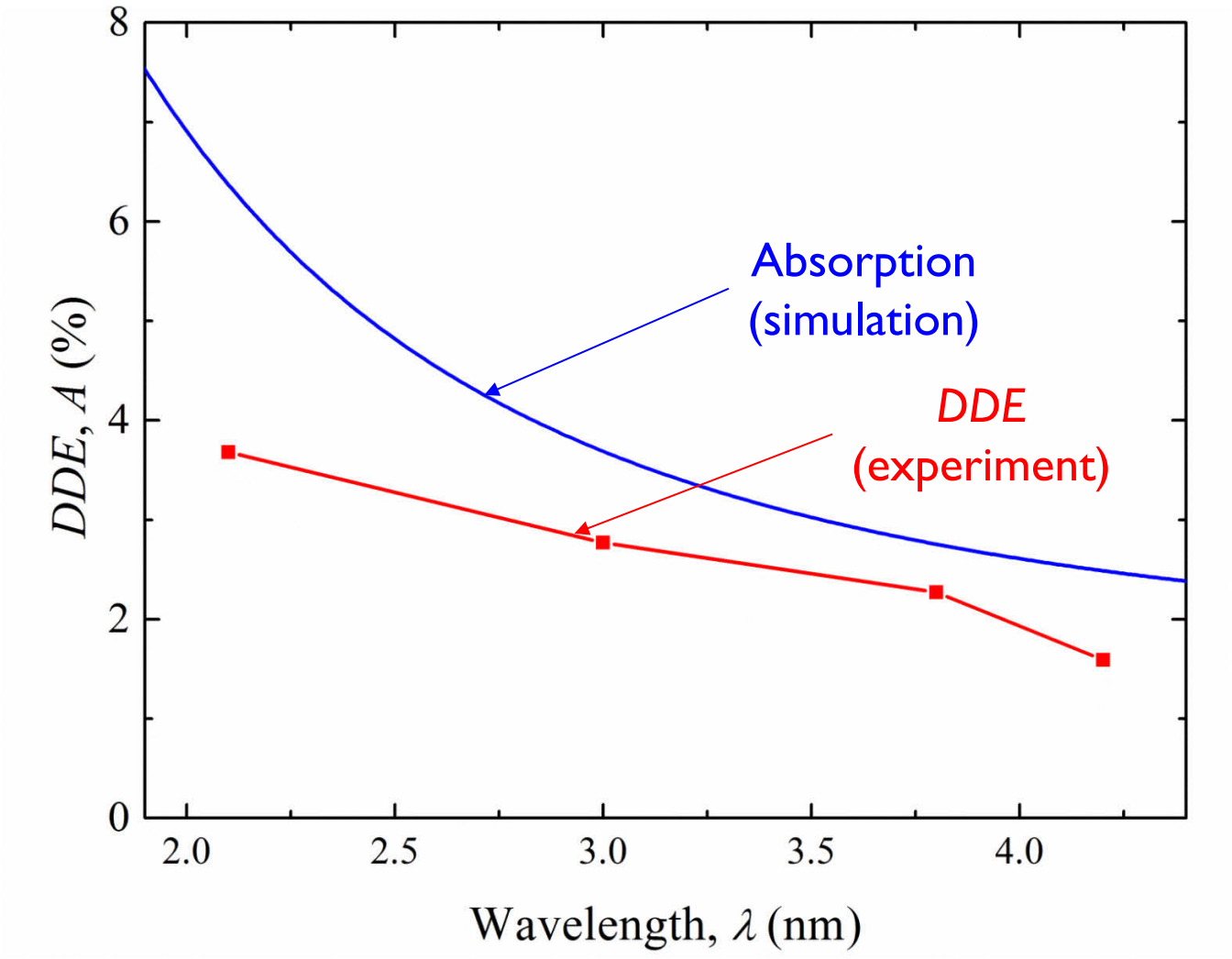
Characterization set up



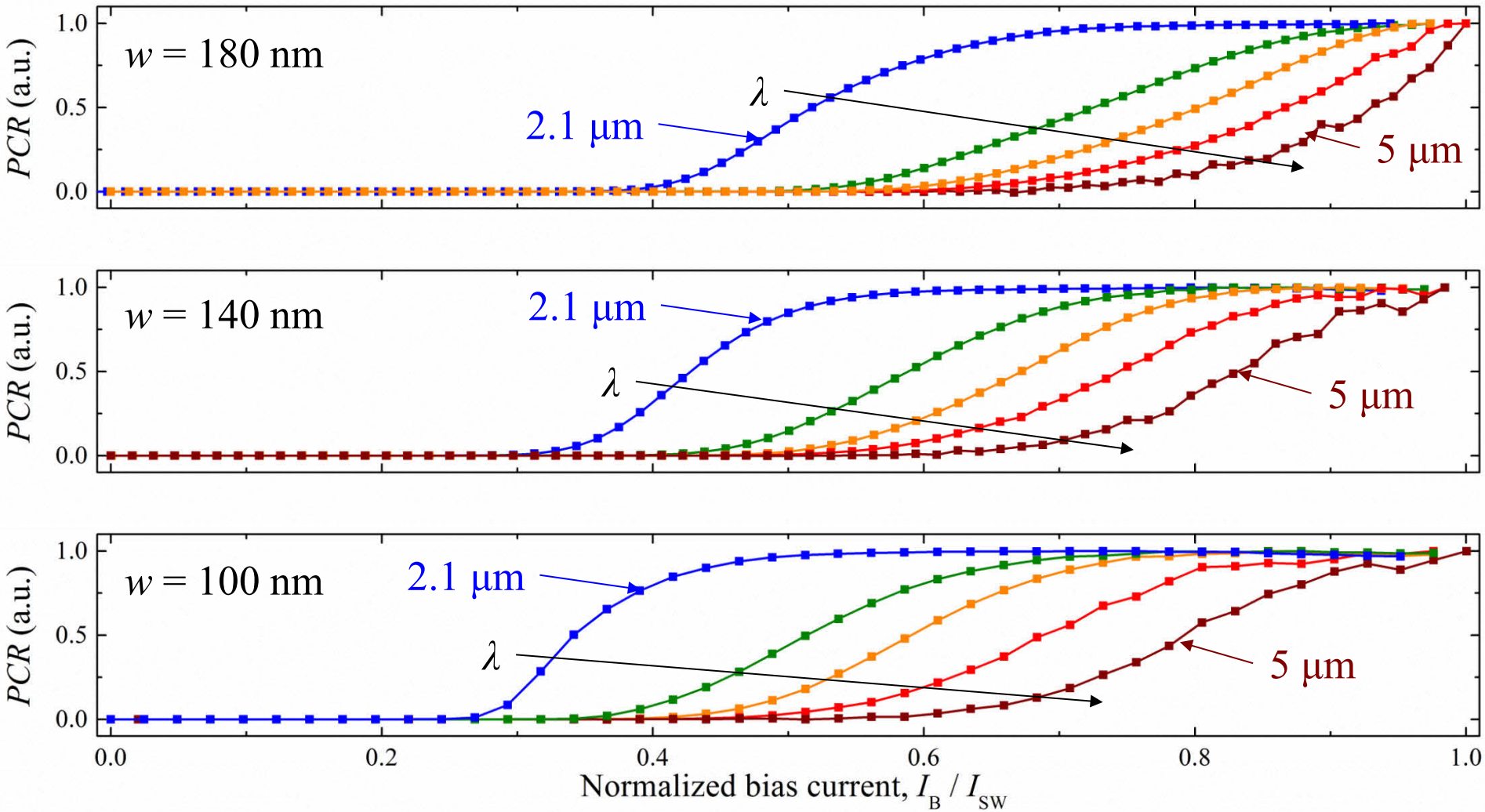
Detector Detection Efficiency *(DDE)*



Wavelength Dependence of Absorption



Dependence on Nanowire Width

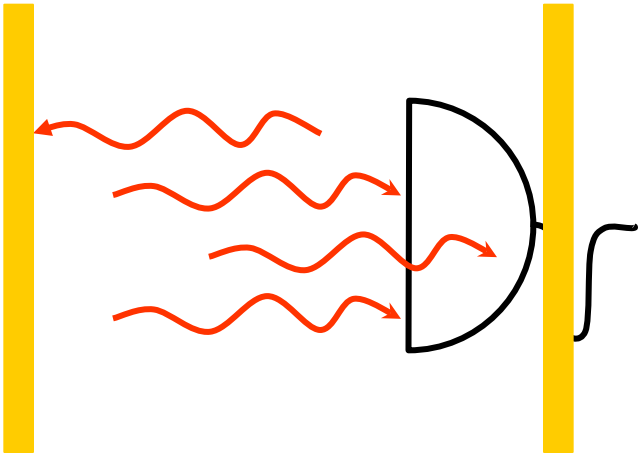


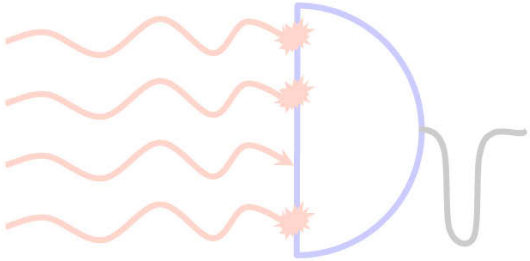
How to never miss a photon

Coupling Efficiency

Absorption

Internal Efficiency



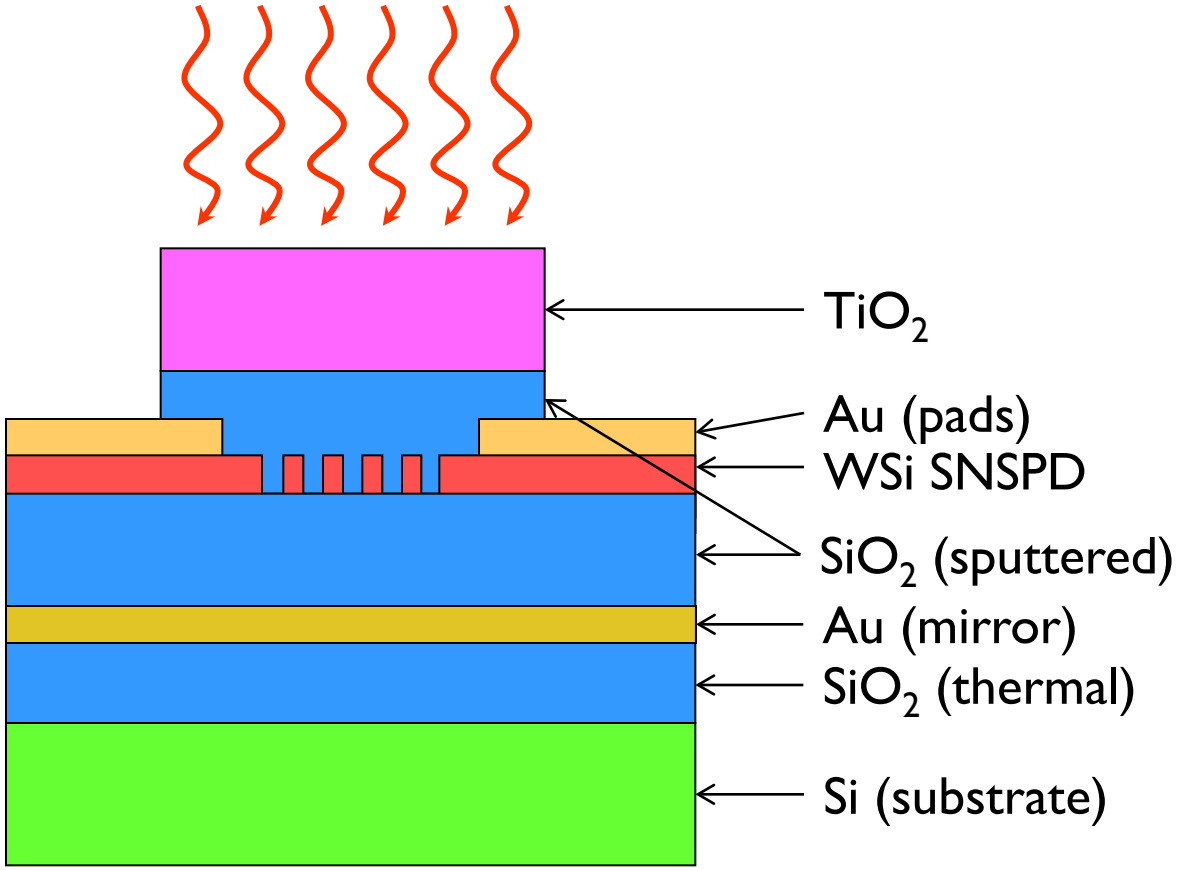


Optical Alignment
Detector Active Area

Resonant absorption

Device Design

Absorption: Optical Stack



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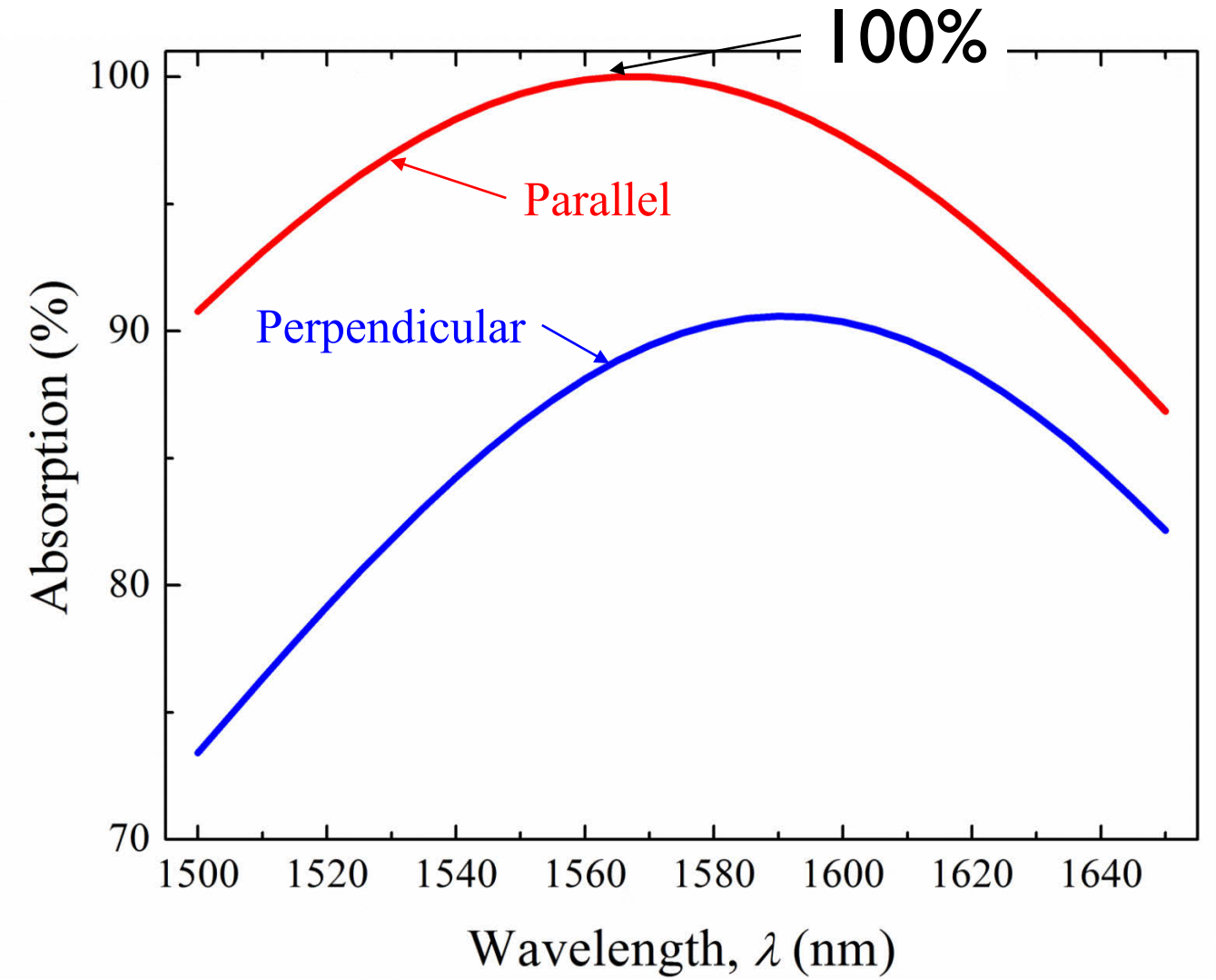
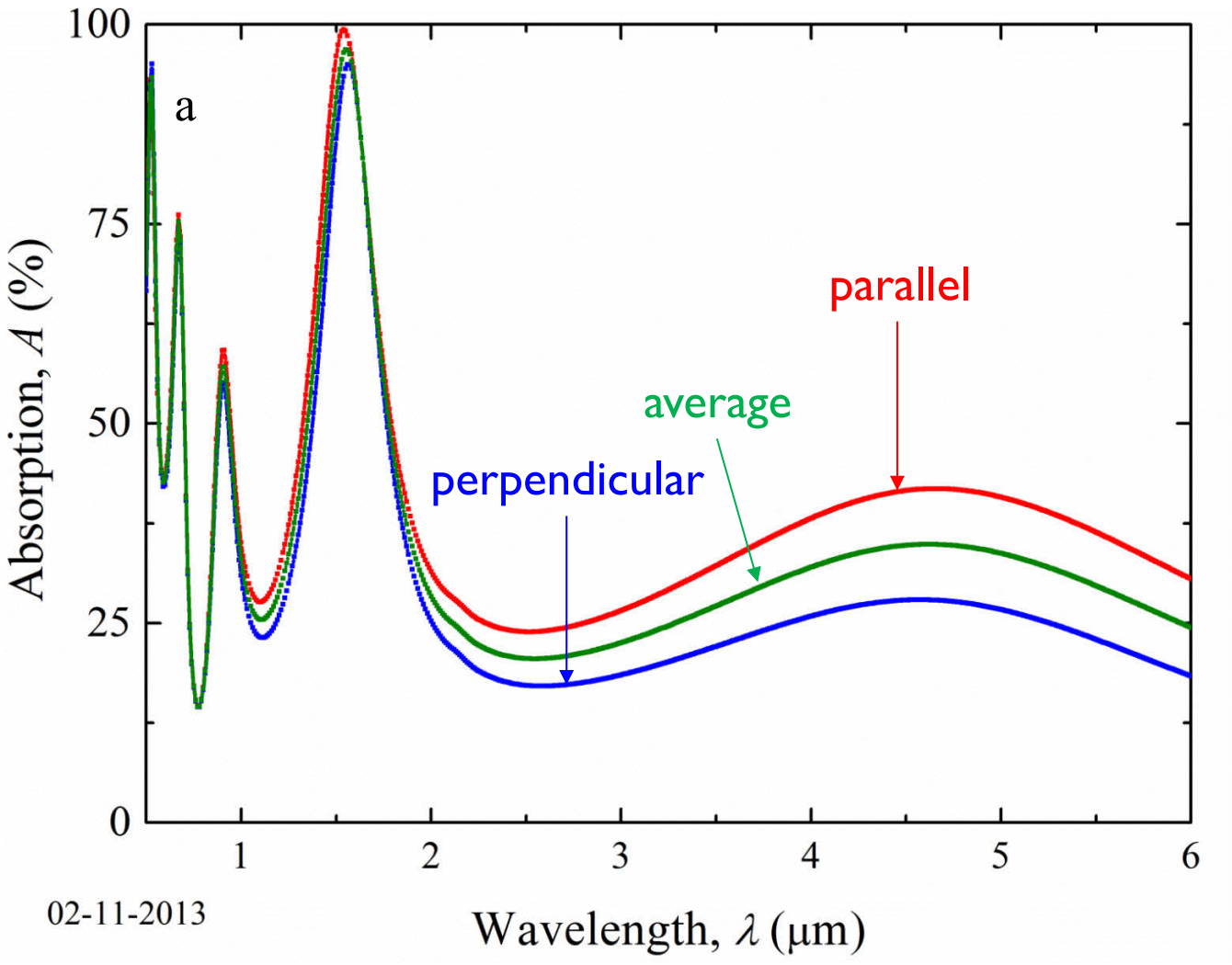


Absorption of cavity devices



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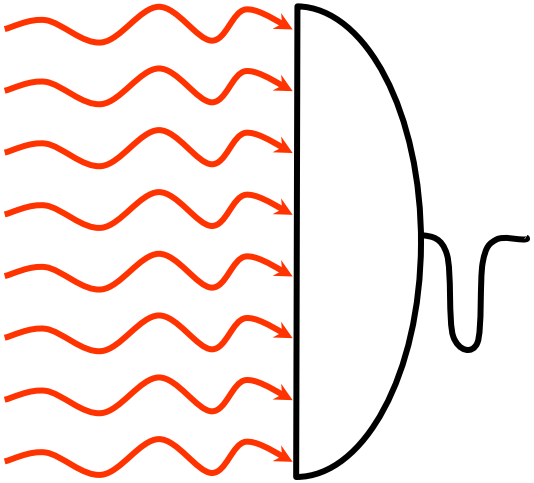
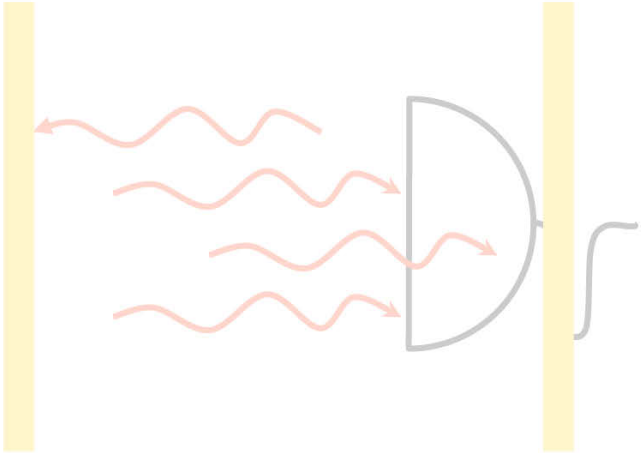
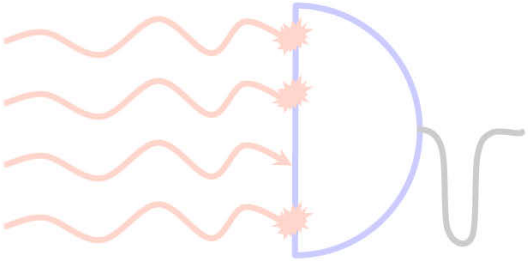
Coupling Efficiency

Absorption

Internal Efficiency







Optical Alignment
Detector Active Area

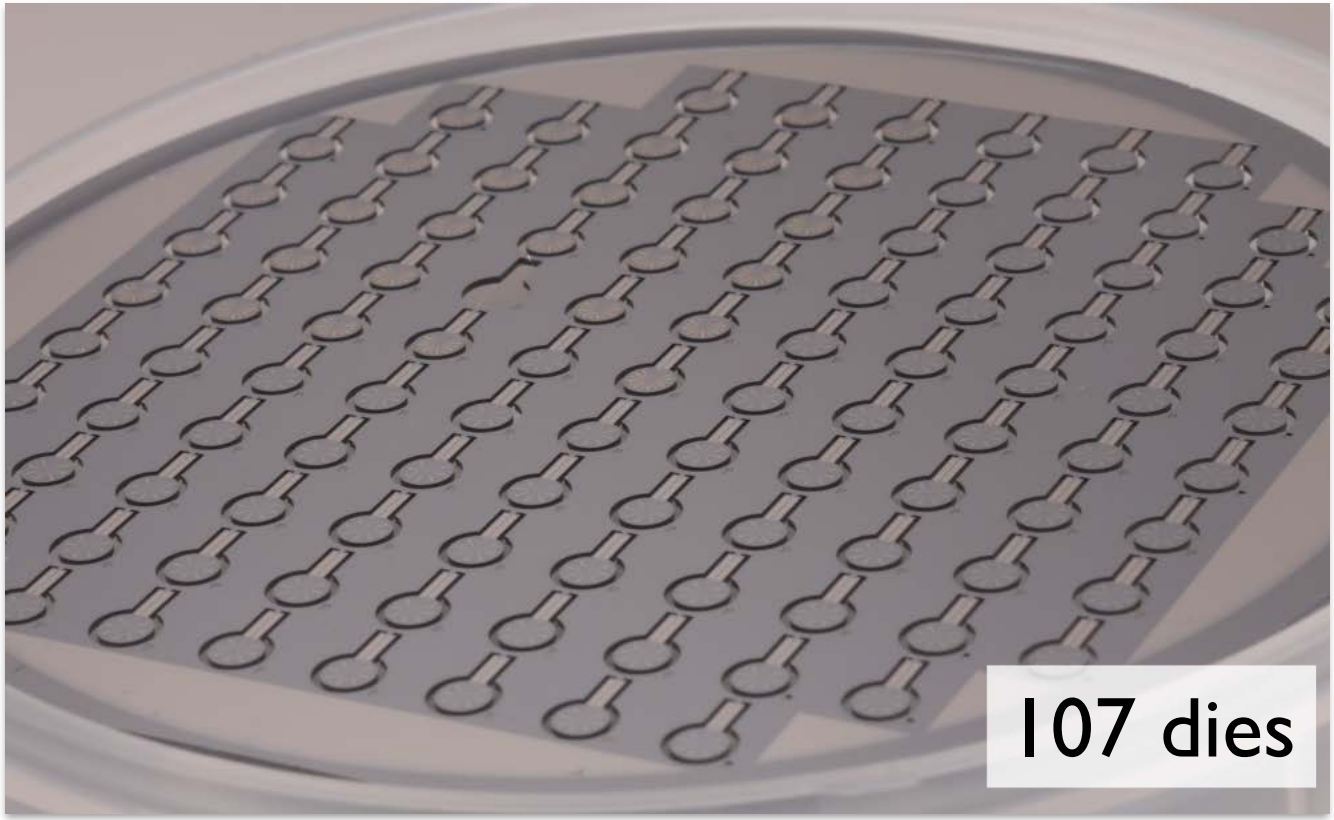
Resonant absorption

Device Design

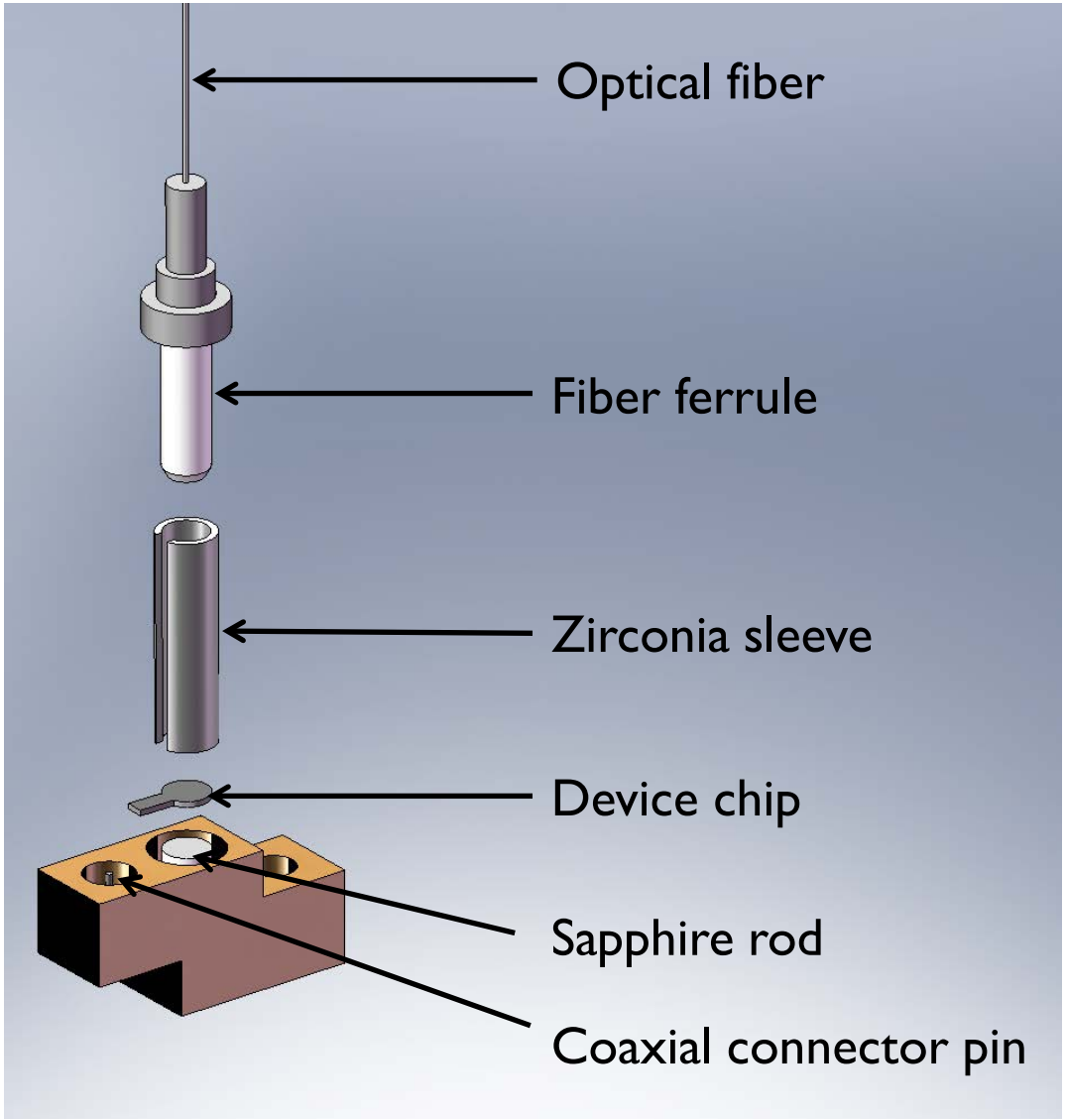
Marsili CLEO 2013

Coupling efficiency: Optical Alignment

Room temperature deposition of WSi on 3 in Si wafers



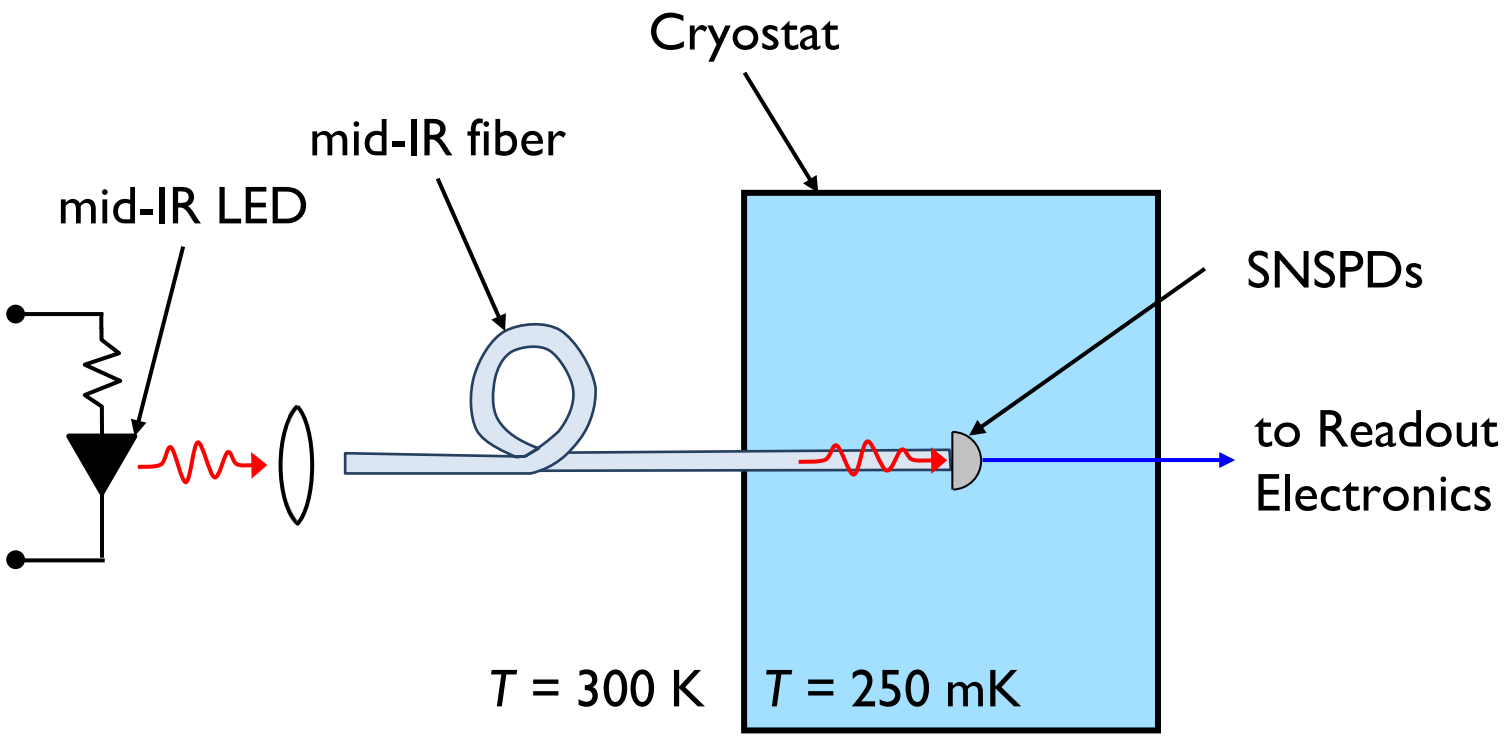
Coupling efficiency: Optical Alignment



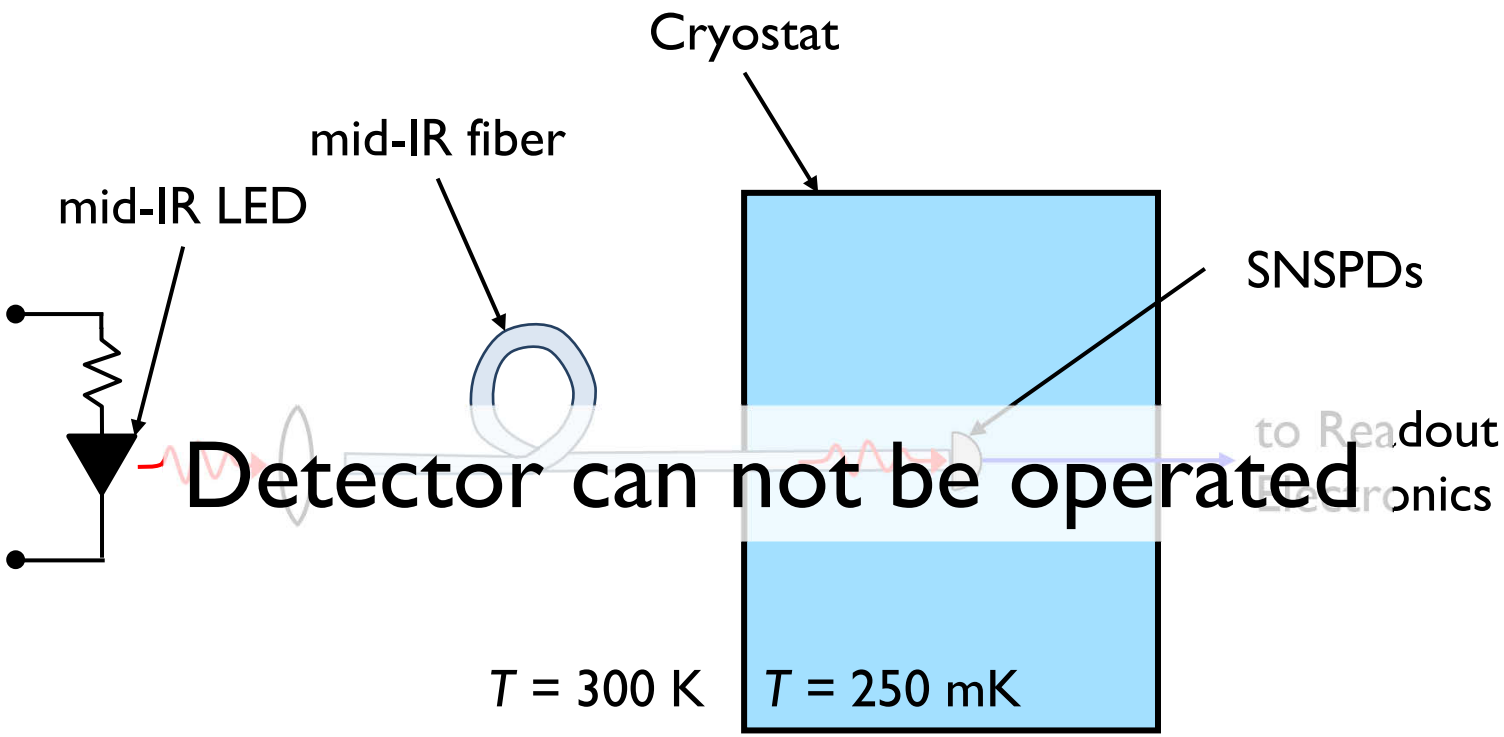
Miller et al., Opt. Express 19 (10), 9102 (2011)

Experimental Results

Characterization set up

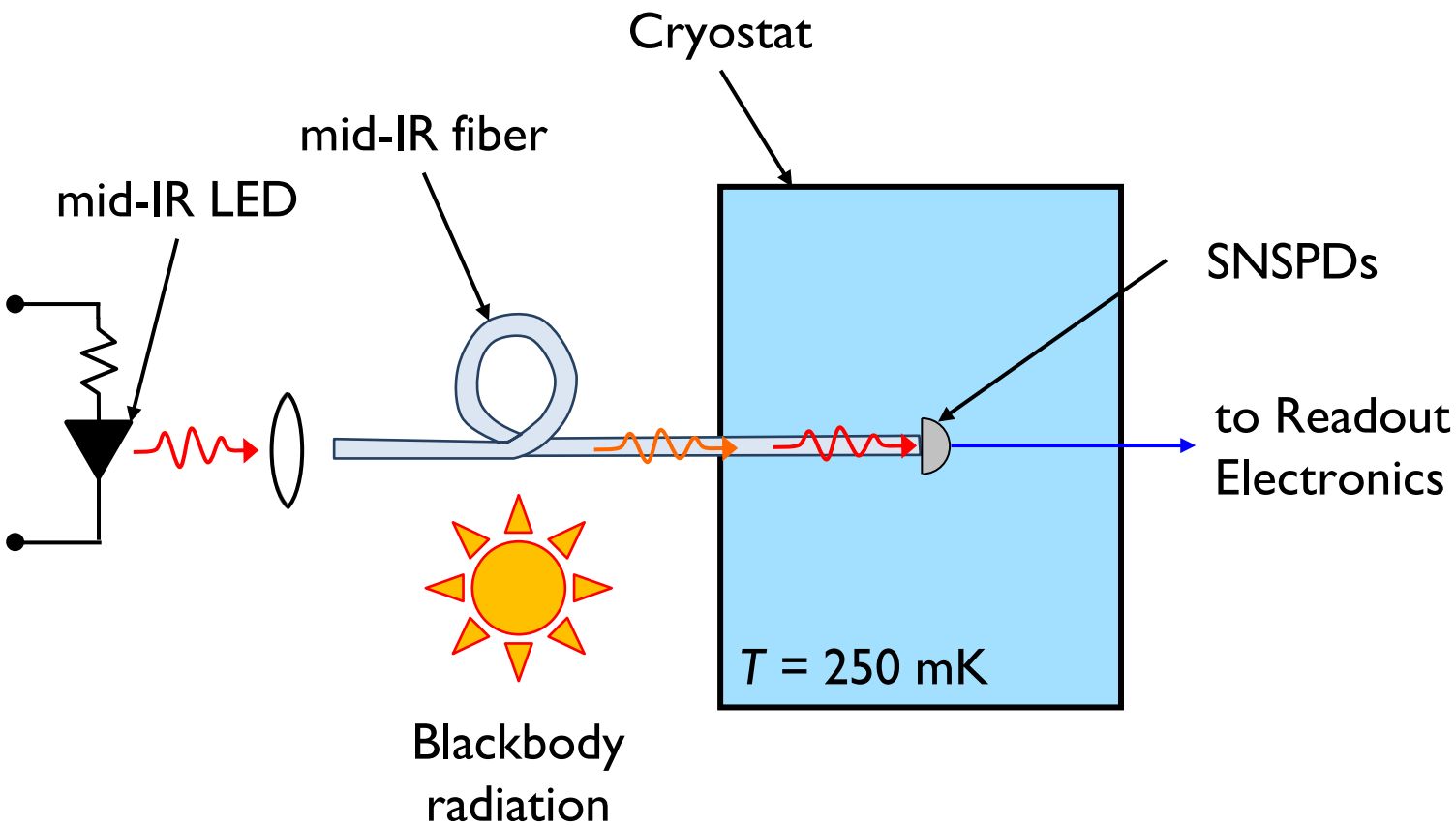


Characterization set up



Detector can not be operated

Characterization set up



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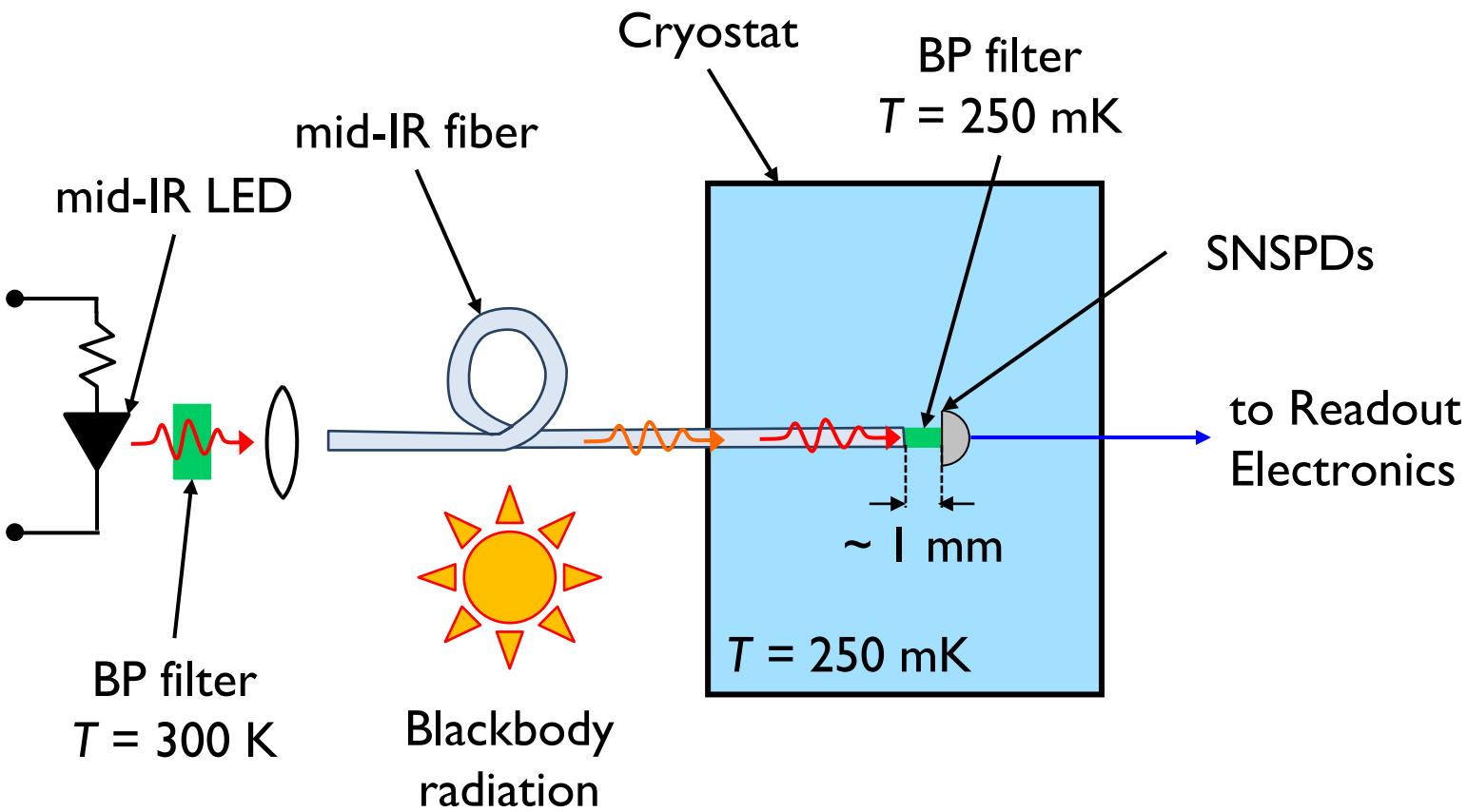
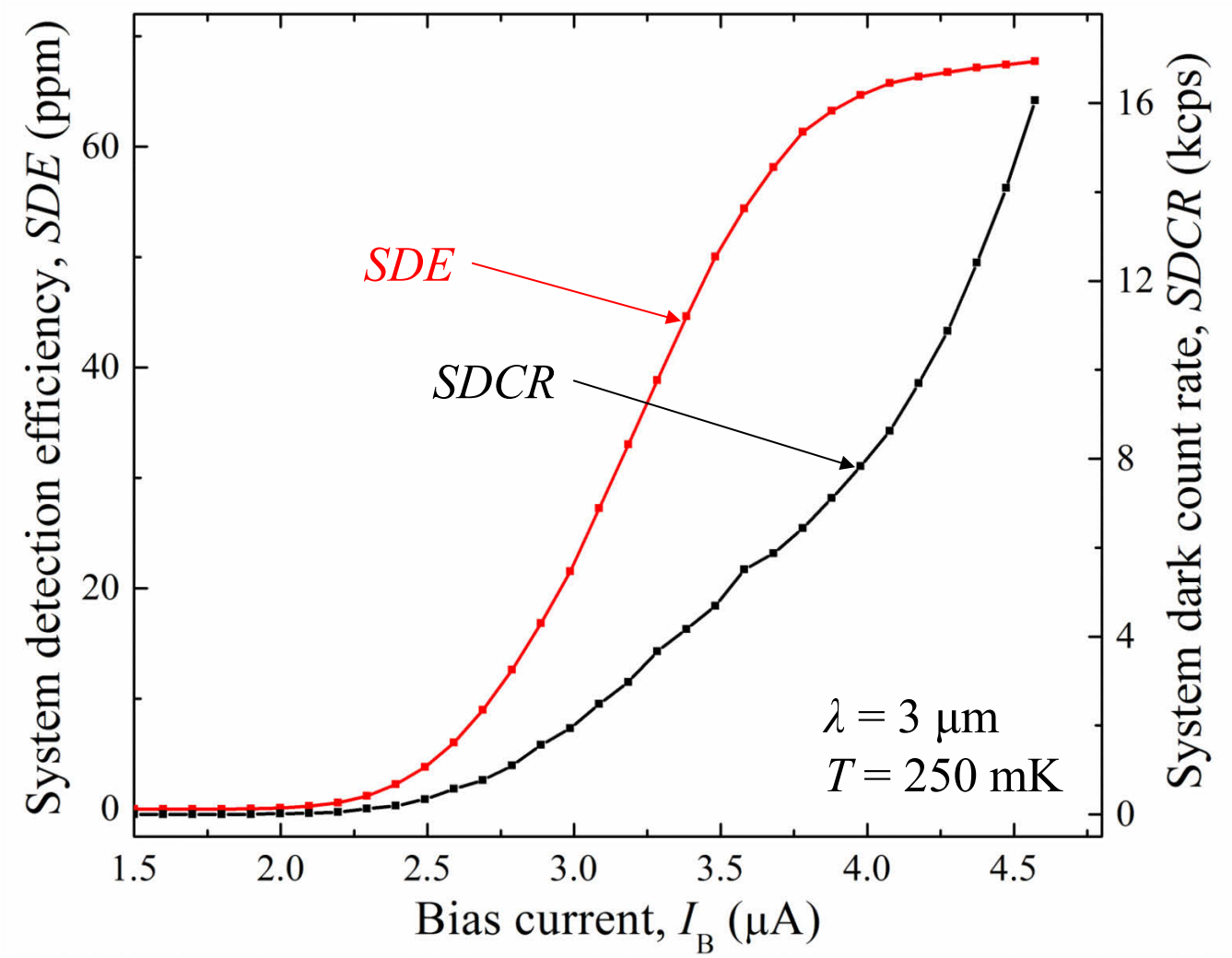
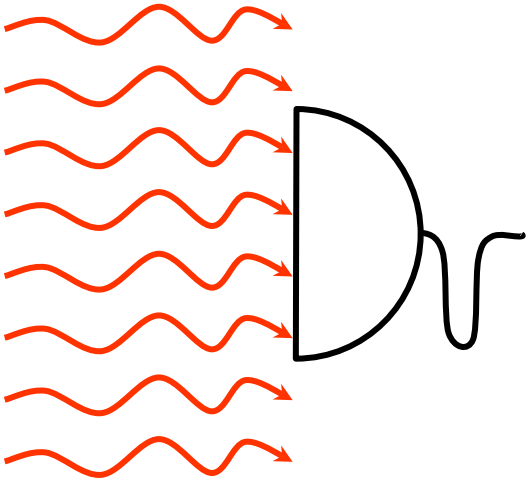


System detection efficiency at λ = 3 μm



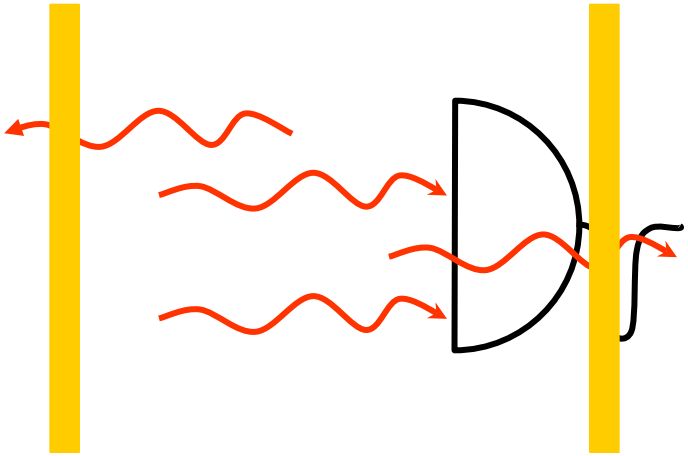
Summary

Coupling Efficiency ✗



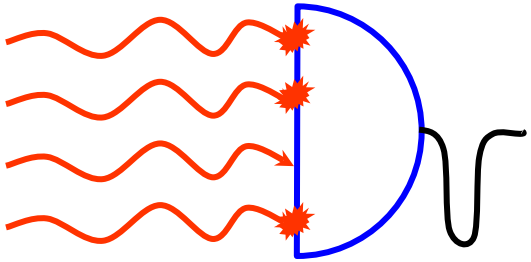
Mismatch between the mode field diameter and the active area of the detector

Absorption ✗



Cavity not optimized for the mid-IR

Internal Efficiency ✓

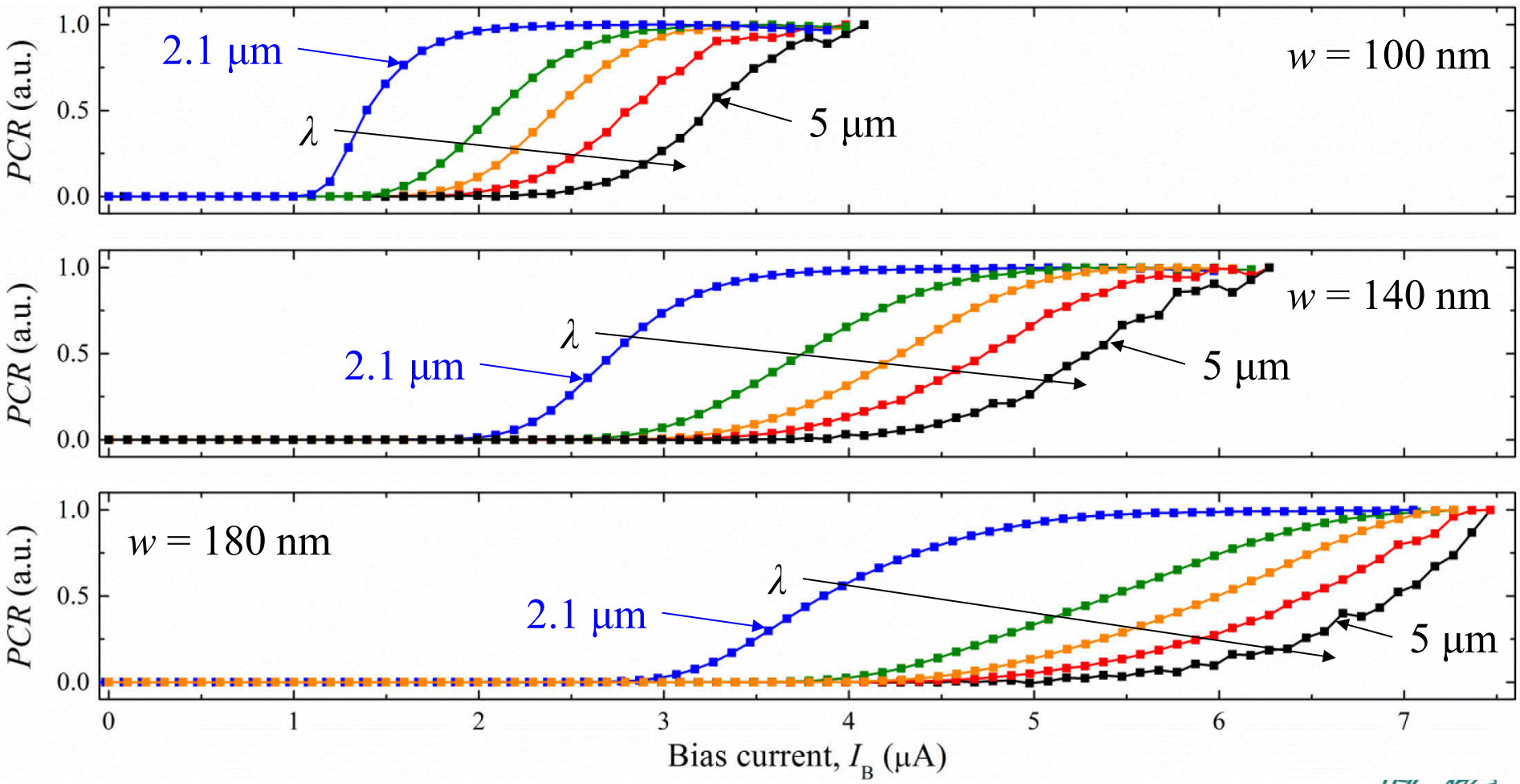


Saturated internal efficiency up to 5 μm wavelength

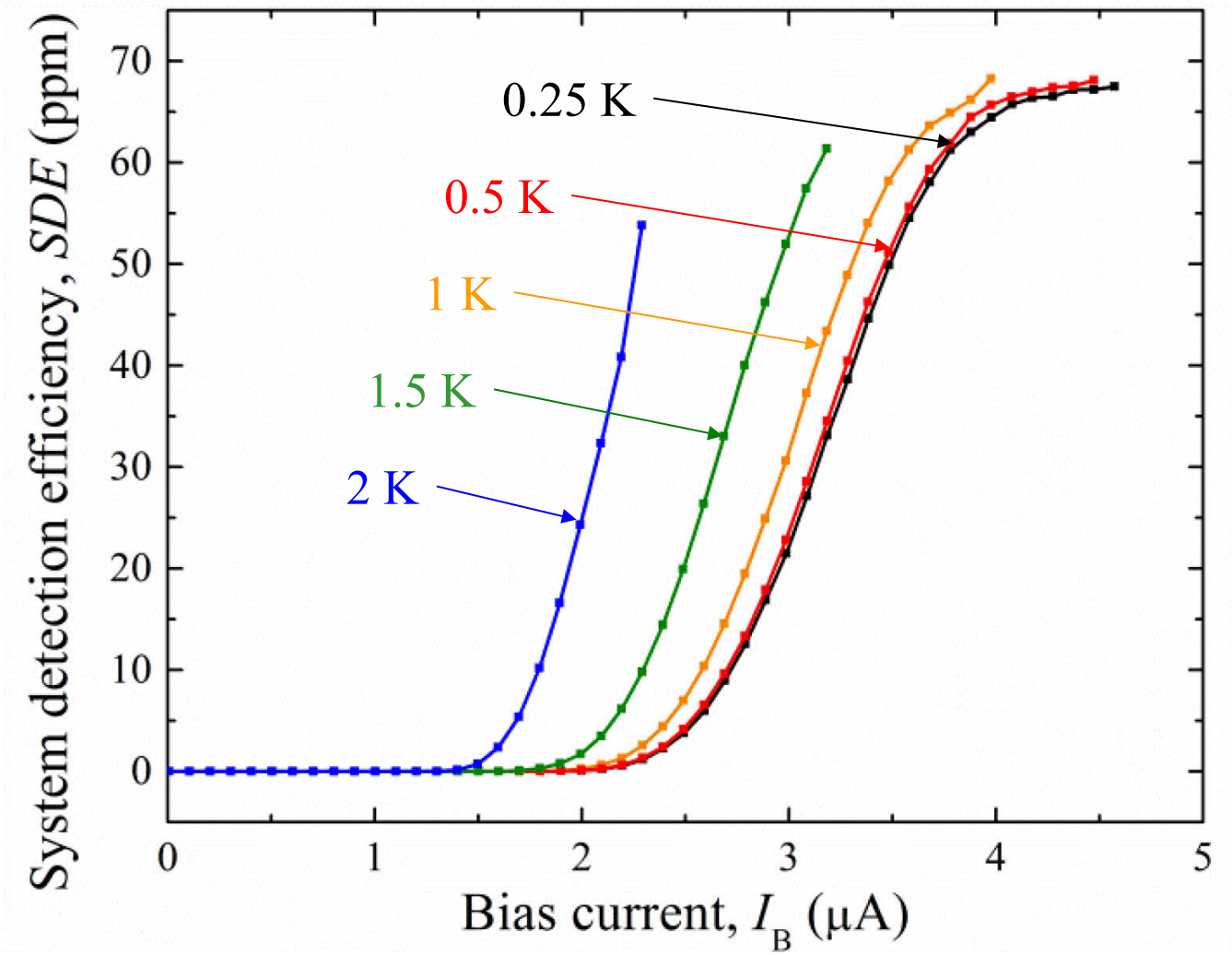
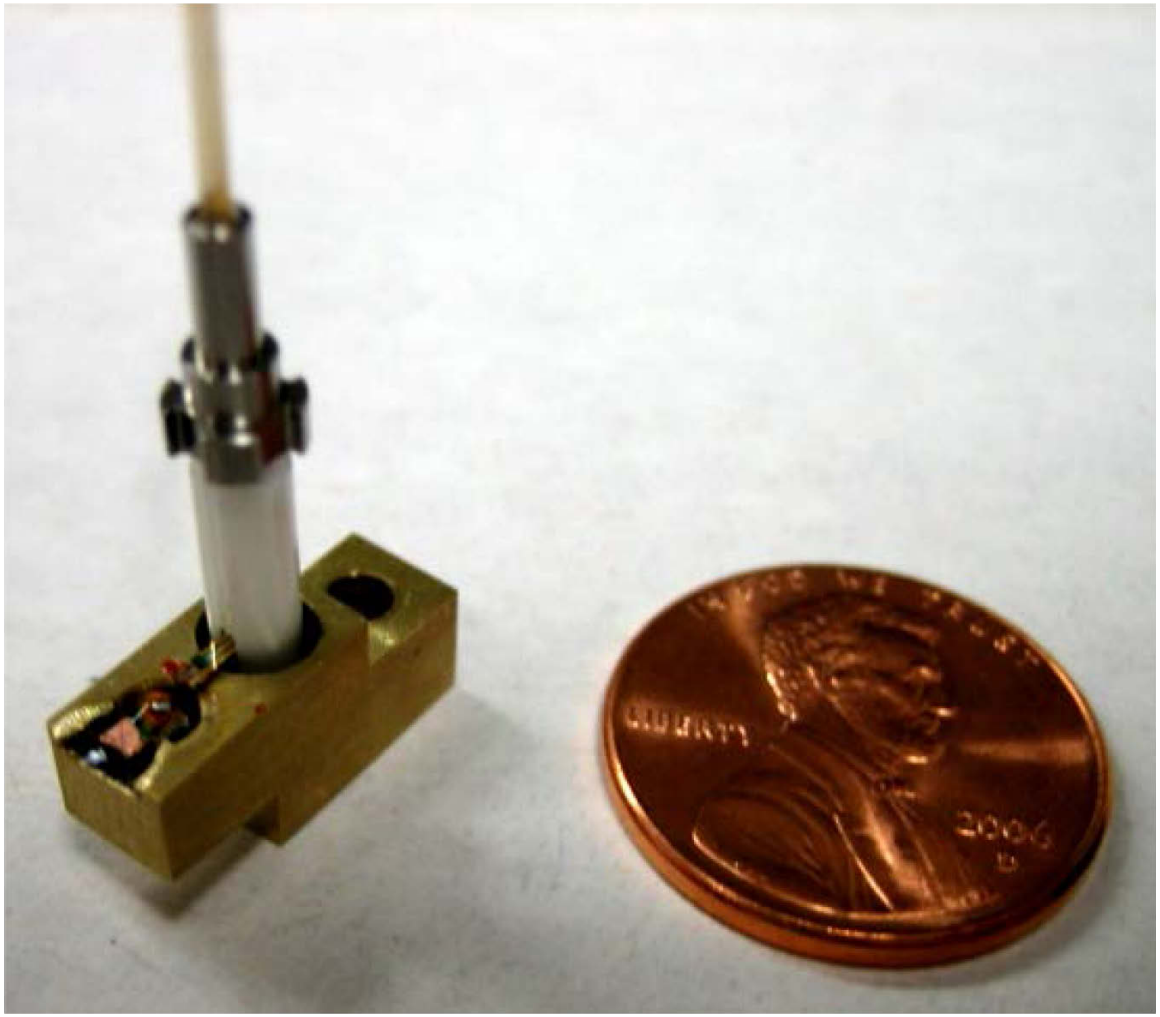
End of Presentation

Backup slides

Dependence on Nanowire Width



Temperature Dependence



Coupling efficiency: Optical Alignment