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Near-unity quantum efficiency of broadband black silicon photodiodes with an induced junction

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Dr. Mikko Juntunen

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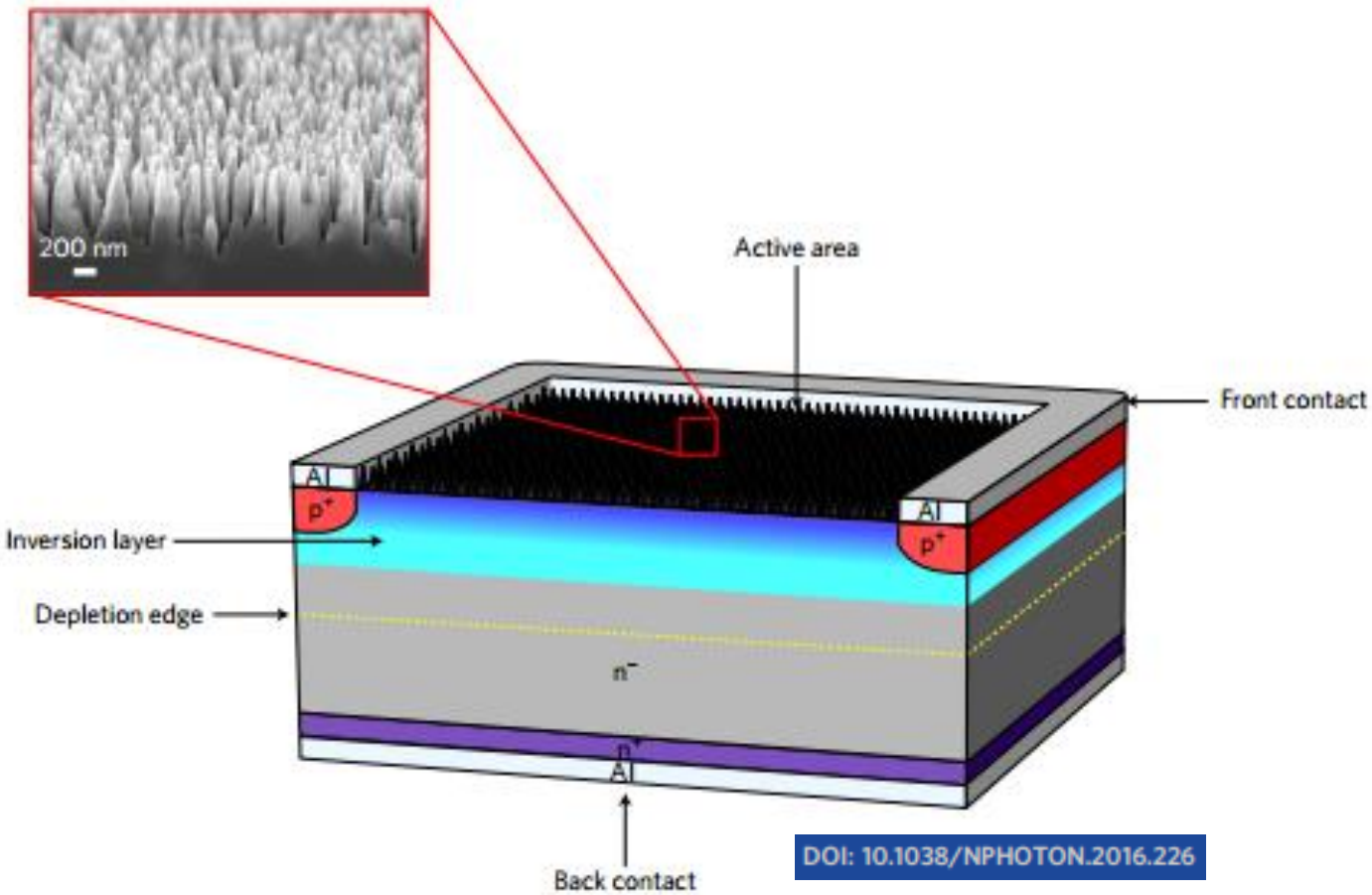
Black silicon n-type photodiodes with induced junction



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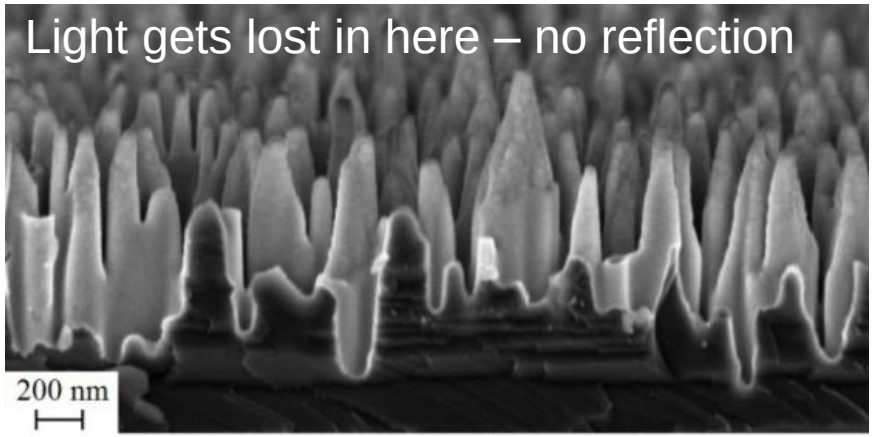
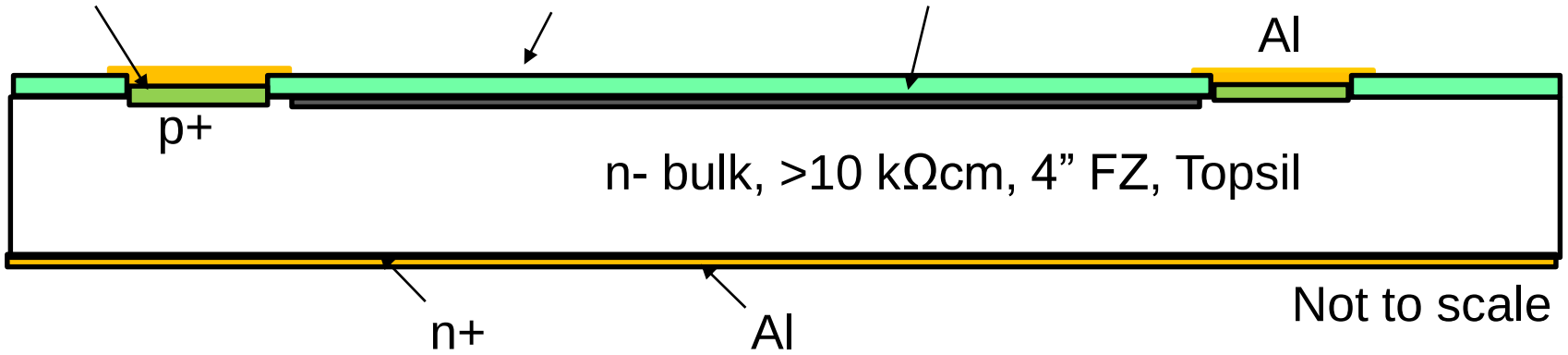


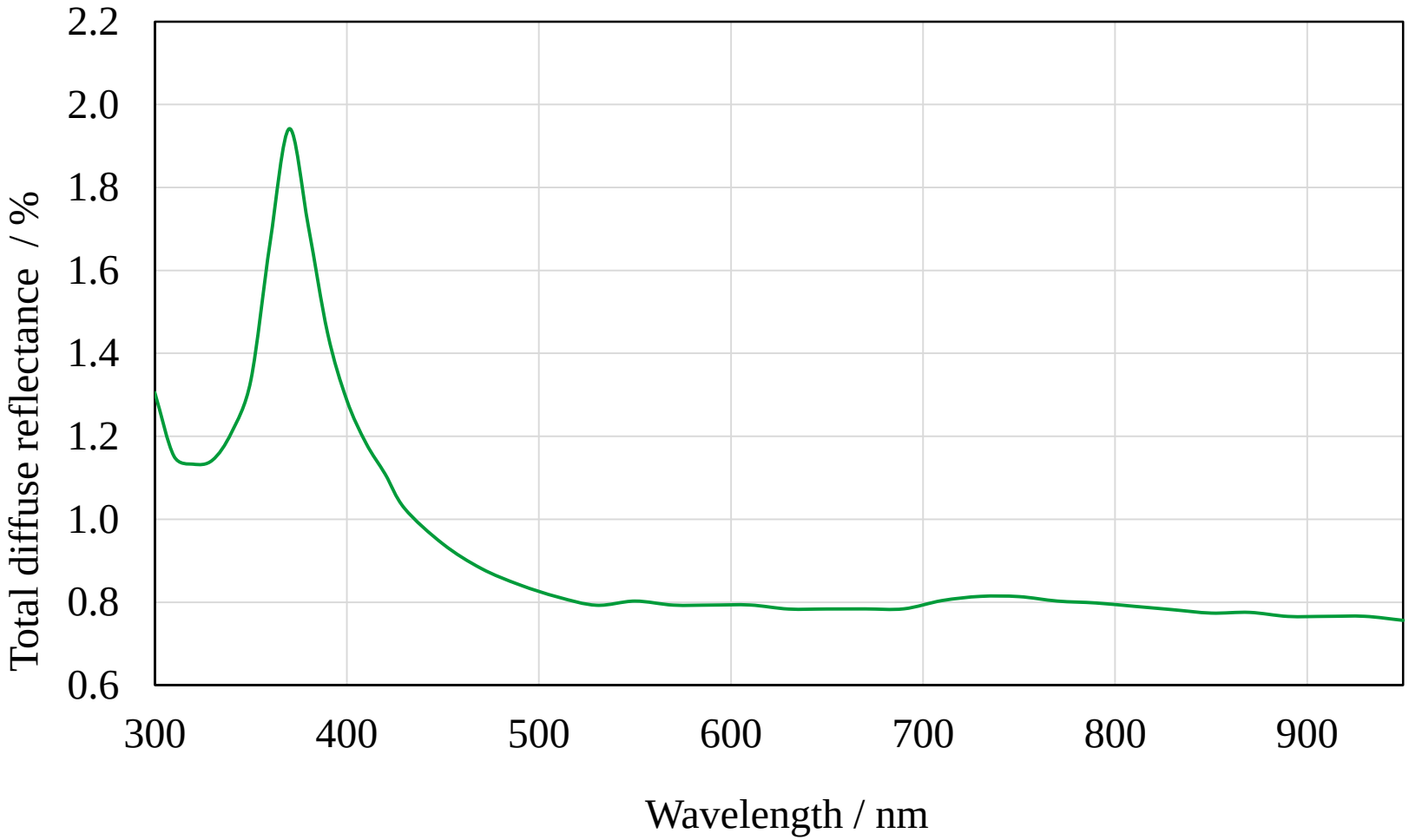
Black Silicon

~20 nm ALD Al_2O_3
Nanostructuring increases surface area and charge ~6-fold => deep inversion

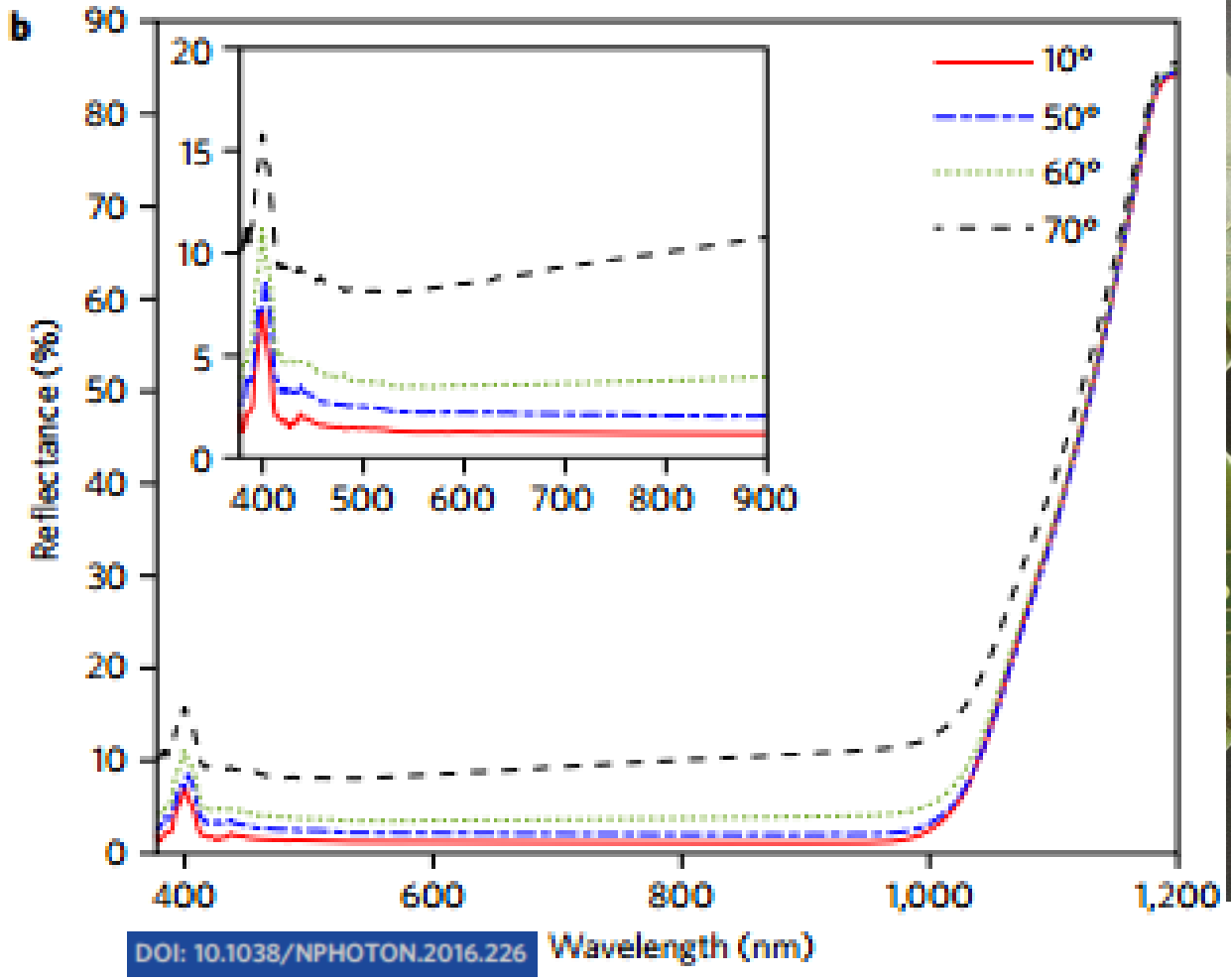
p implantation for contacts only, no junction doping

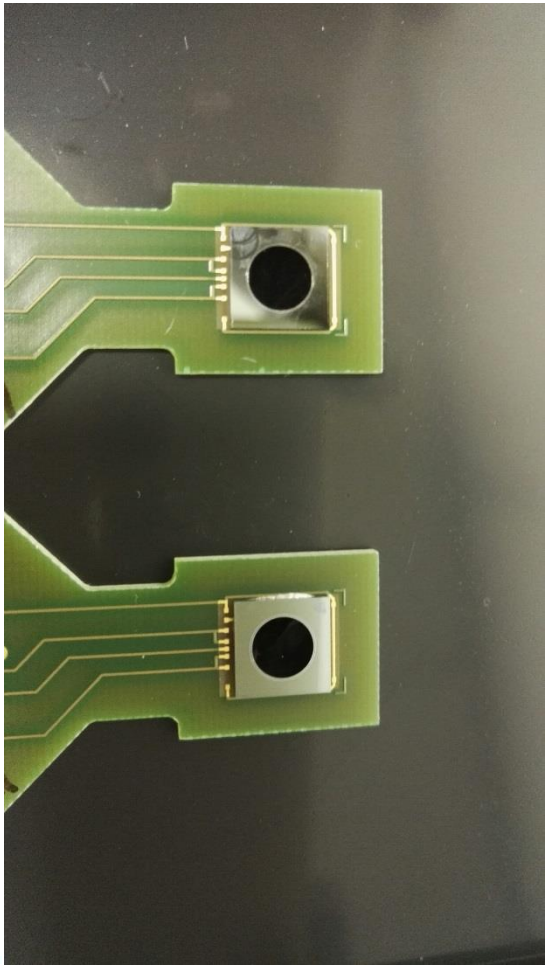


Total reflectance (perpendicular)

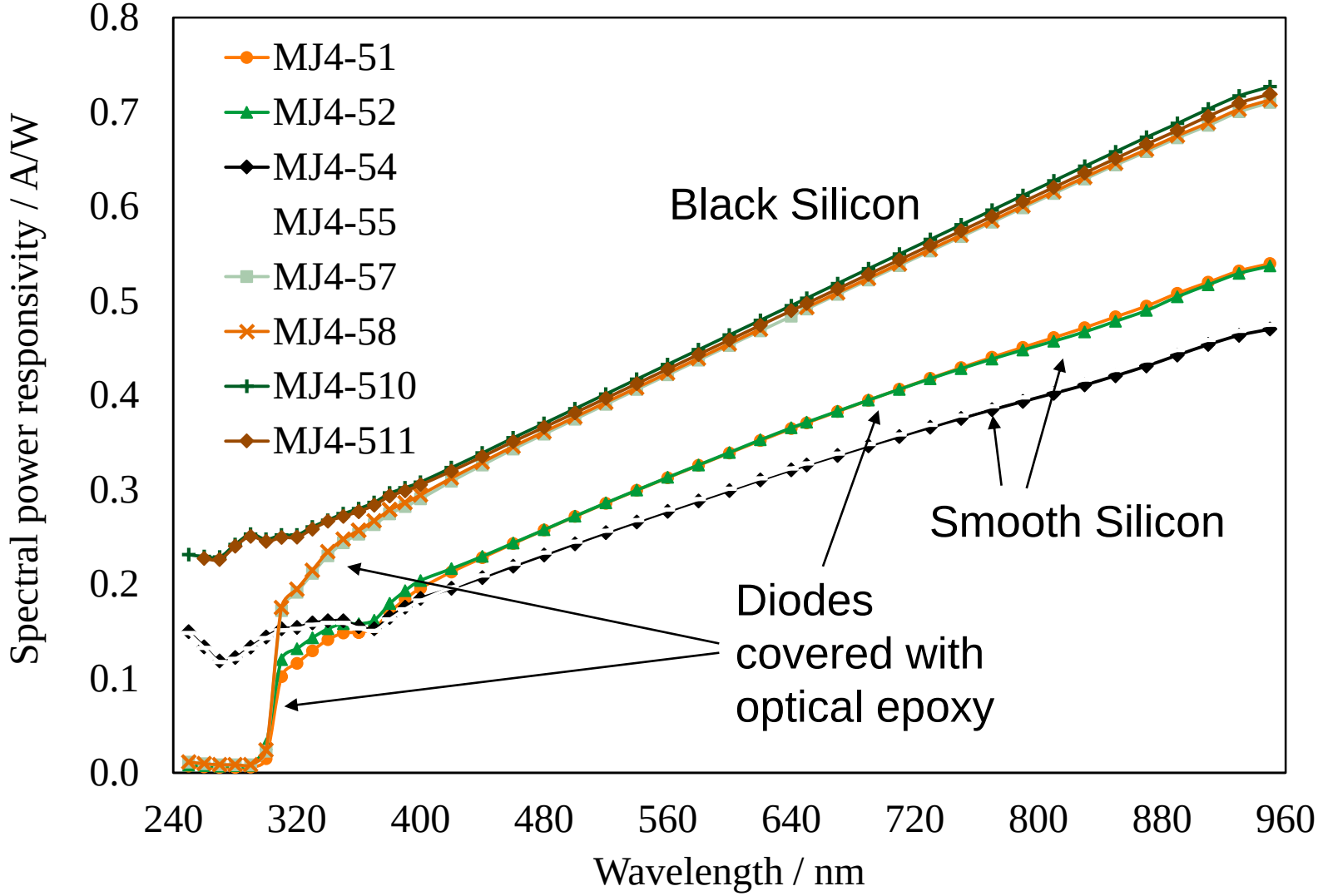


Total reflectance





Spectral Response



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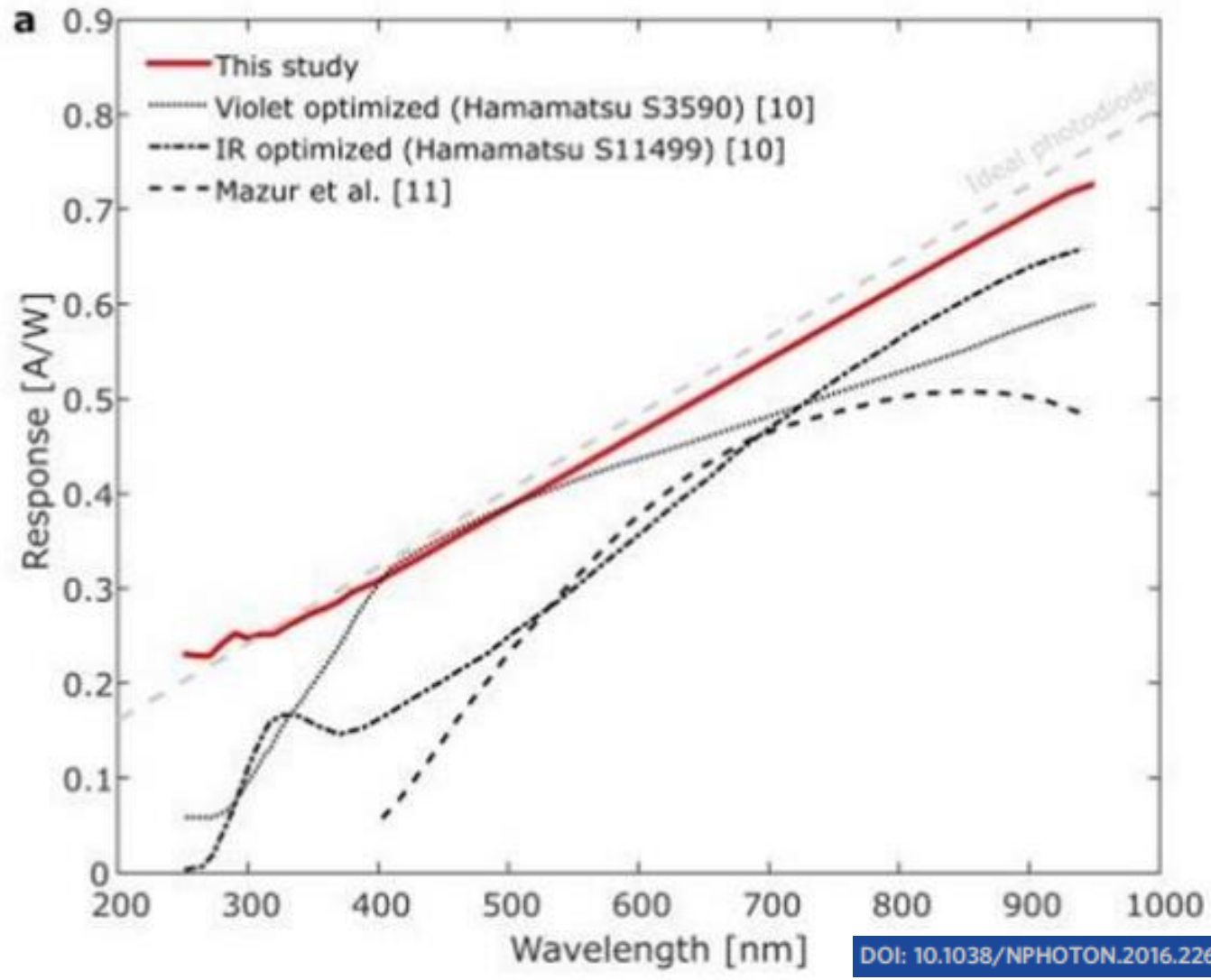
Measurements:
Anna Vaskuri and Farshid Manoocheri of MIKES

Comparison to some other diodes



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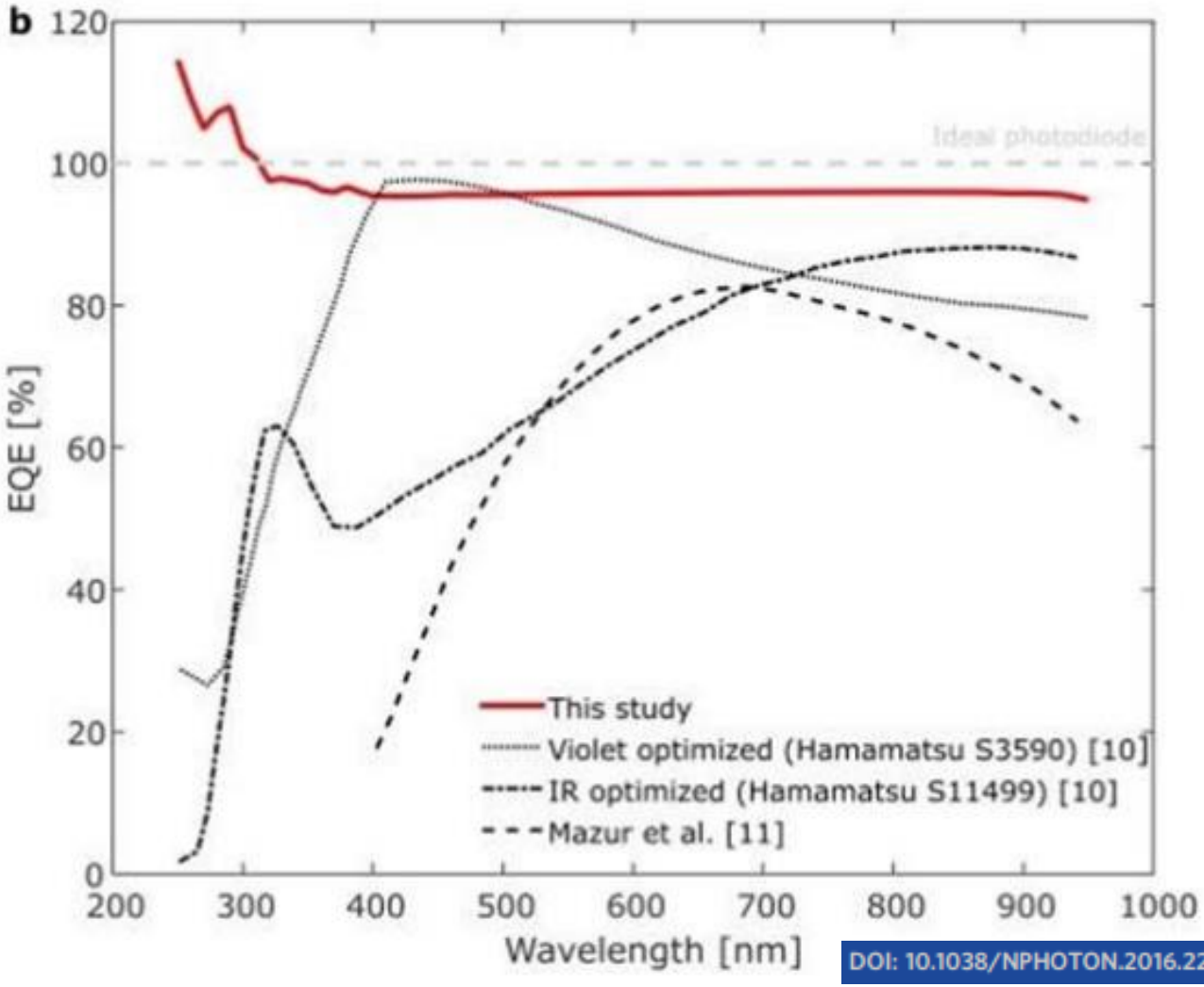
Secondary ionization

- Can occur if photon energy ≥ 3.3 eV (λ ≤ 375 nm)
- With increasing energy probability of impact ionization increases in comparison to phonon excitation
- One photon may create >1 electron-hole pairs
- → IQE > 100 %

External Quantum Efficiency >96%



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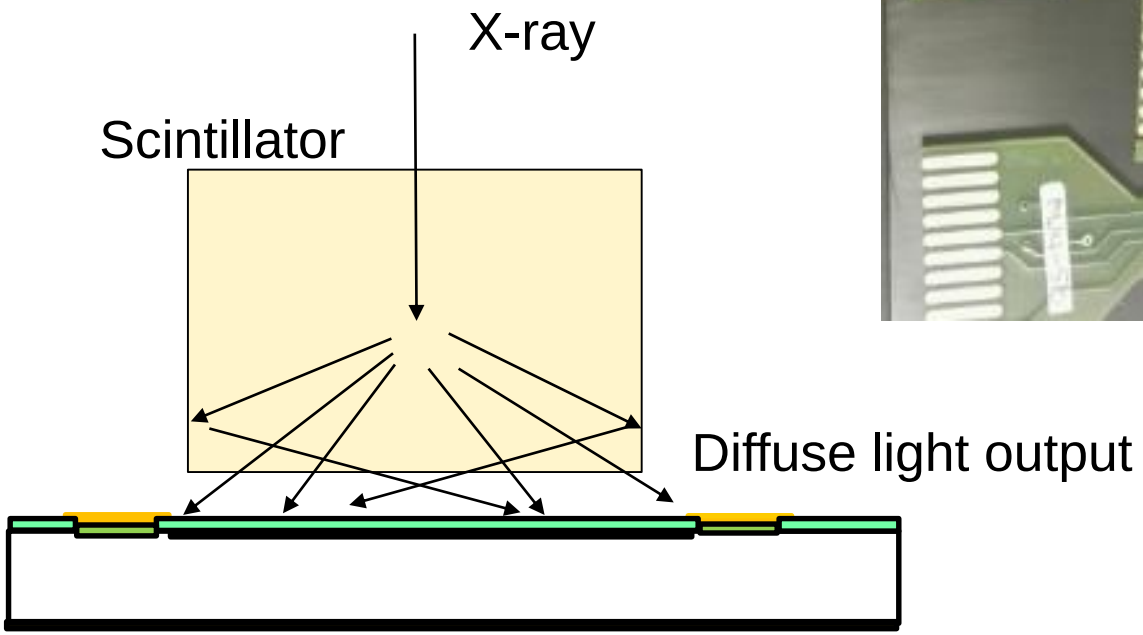
Application example



- Very low reflectance up to 70 degrees incident angle => improved collection of diffuse light.
- Initial X-ray test results comparing to commercial photodiodes indicate >20% improvement.

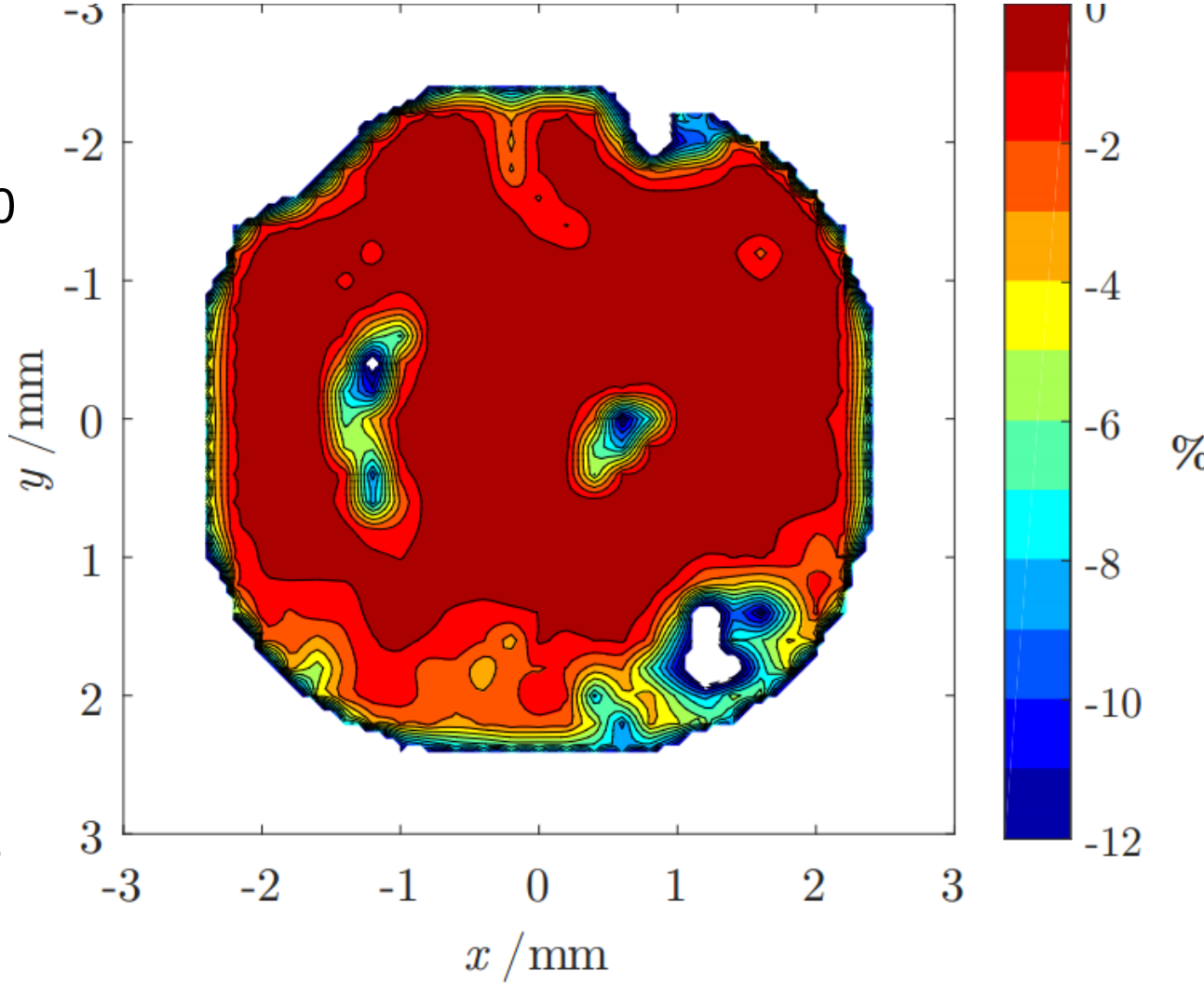
Why not 100% QE

MJ4-510 was scanned with 325nm focused beam with about 200-300 µm diameter

Scratches, dust, vacuum pen mark?

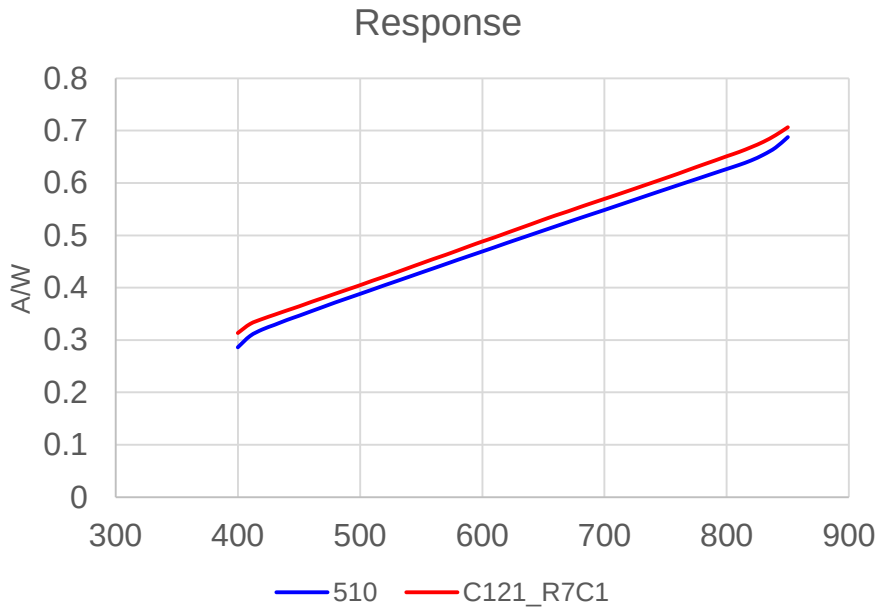
Spectral response was measured with larger beam, bad areas included.

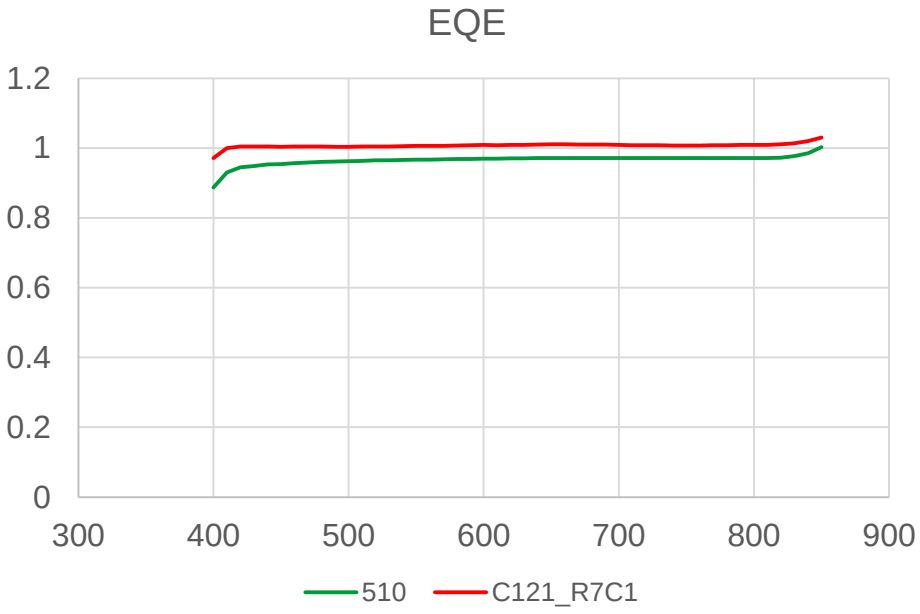
Better handling => better response



Preliminary results – clear improvement

To be confirmed in calibration laboratory





Yeah, why not 100%..

Acknowledgements

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- Mr. Juottonen of Detection Technology, Inc. assembled sample diodes to substrates for measurements
- F. Manoocheri and A. Vaskuri of VTT Technical Research Centre of Finland, Centre for Metrology MIKES measured the response and reflectance
- V. Kübler measured the angle-dependent reflectance measurements