CMOS-compatible Si short wavelength infrared Schottky photodetectors

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Short wavelength infrared spectrum

Extending the spectral range to short wavelength infrared (SWIR) radiation allows to access manifold information hidden to the optical range.

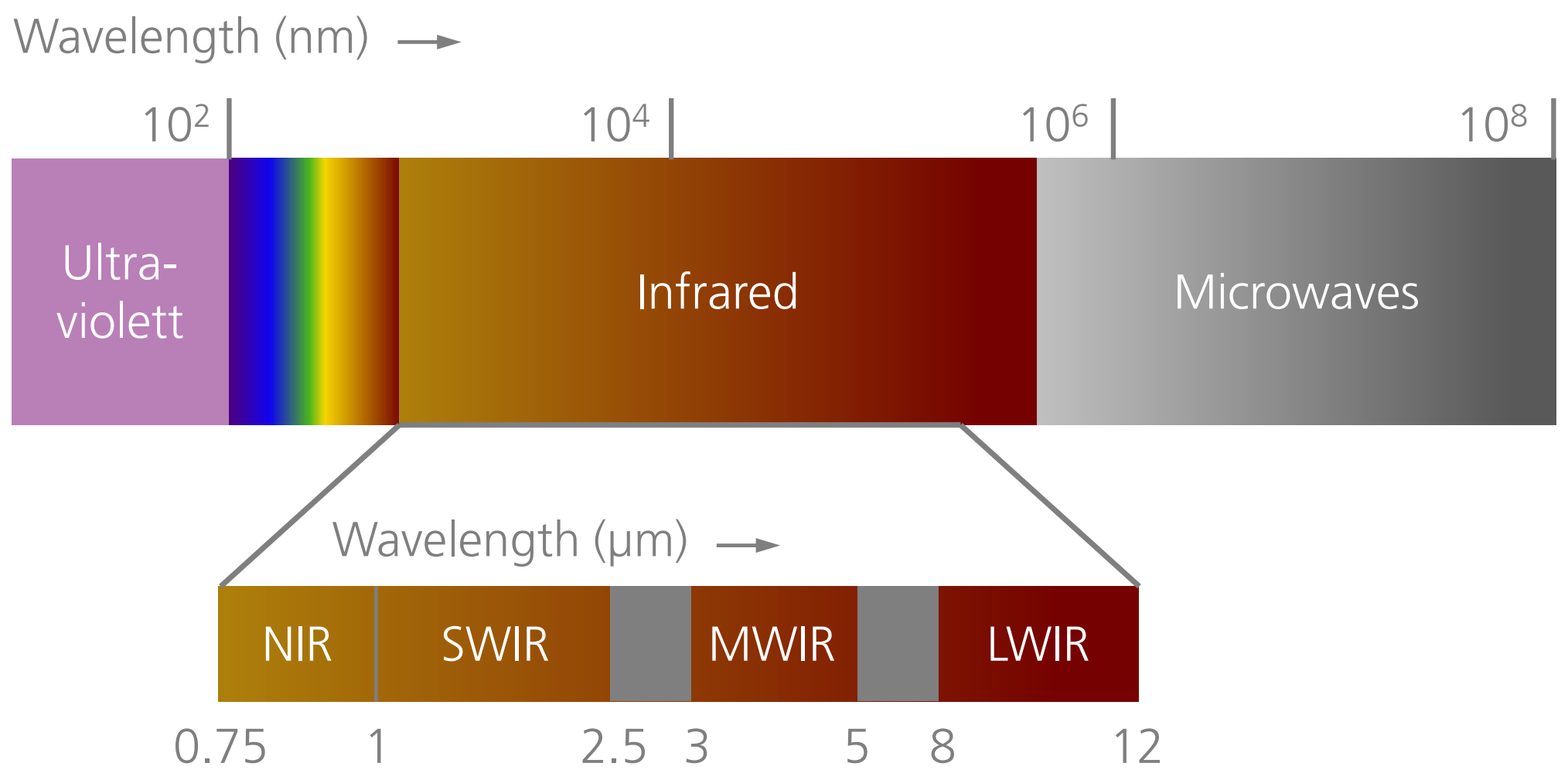

Figure 1 – Electromagnetic spectrum.

SWIR applications

The extended penetration depth and the reduced scattering makes the SWIR spectral range an interesting candidate for enhanced detection in the fields of quality assurance, autonomous vehicles and safety.

Figure 2 – SWIR application example, images of the same apples in different spectral ranges.[1]

Si SWIR detection

SWIR radiation can not be detected in Si by interband absorption processes. Schottky interfaces provide adjustable barriers by choosing metal and doping concentration appropriately.

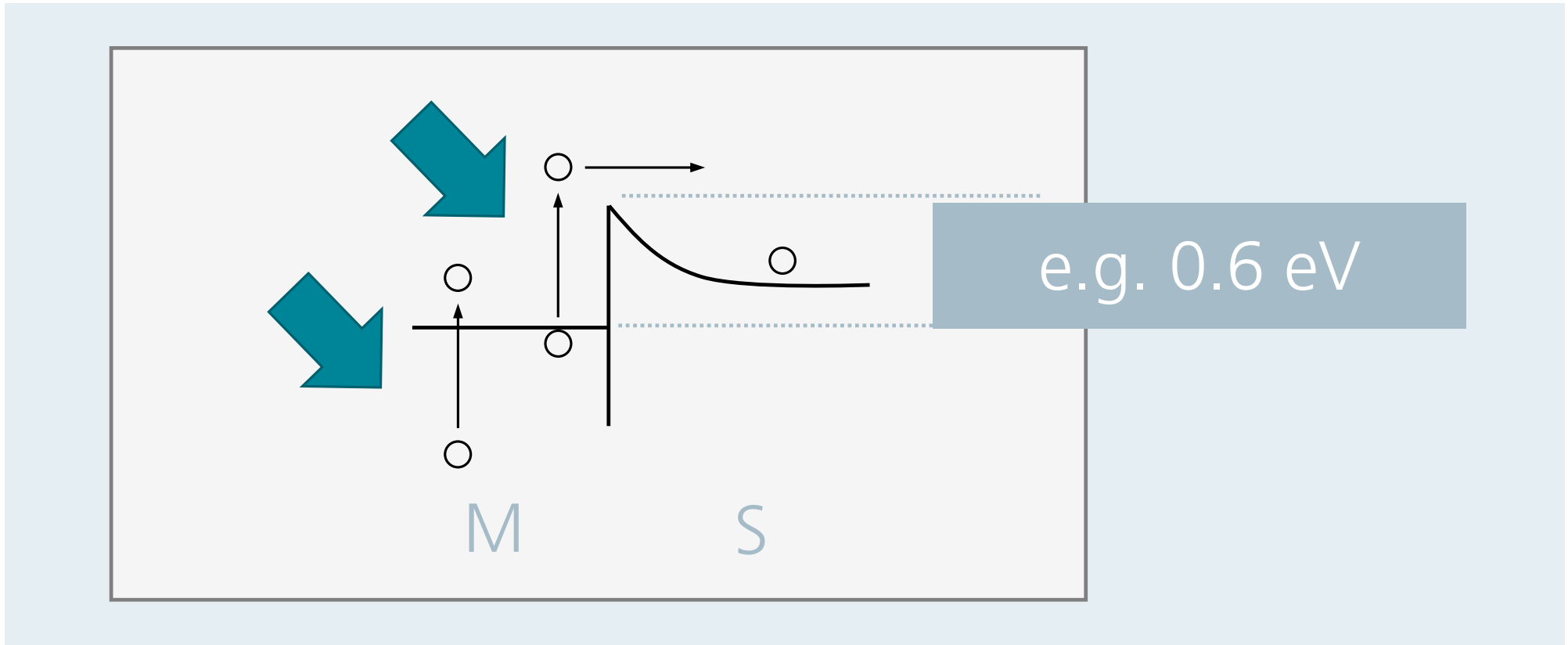

Figure 3 – Schematic of a Schottky barrier with photogenerated charge carriers.

Si Detector design

Typically, Schottky detectors suffer from low external quantum efficiency originating from a low internal quantum efficiency and high reflection at the internal metal-semiconductor interface.

Reduction of reflection

Matrices of pyramidal shaped nanostructures act as absorbing structure increasing the interaction length of incoming radiation with the interface.

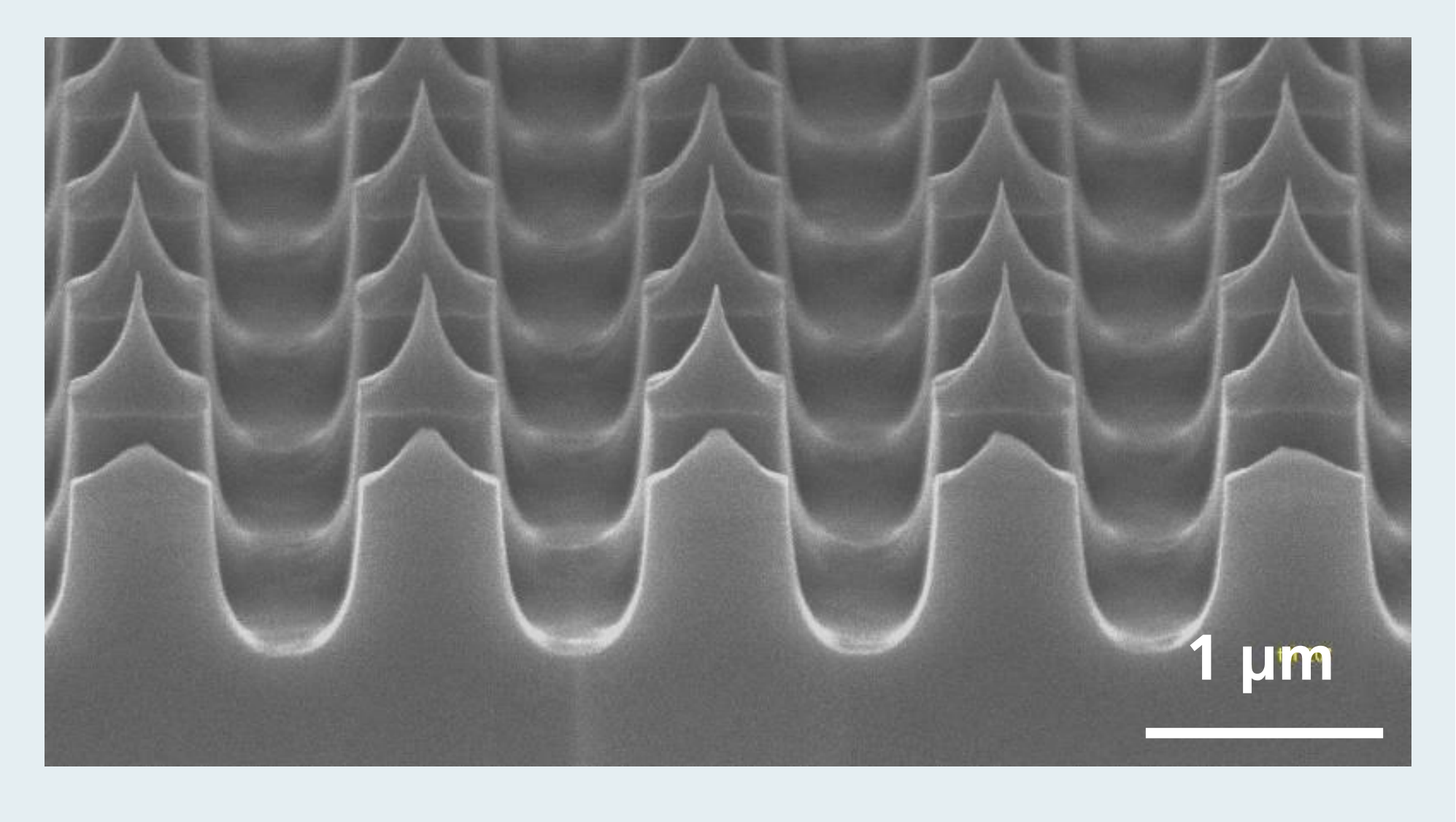

Figure 4 – Si nanostructures fabricated by a two-step anisotropic and isotropic dry etching process.

Increasing internal quantum efficiency

Khurgin[2] suggests an improvement in internal quantum efficiency by intermediate TiN based on an optimized charge carrier distribution along the interface.

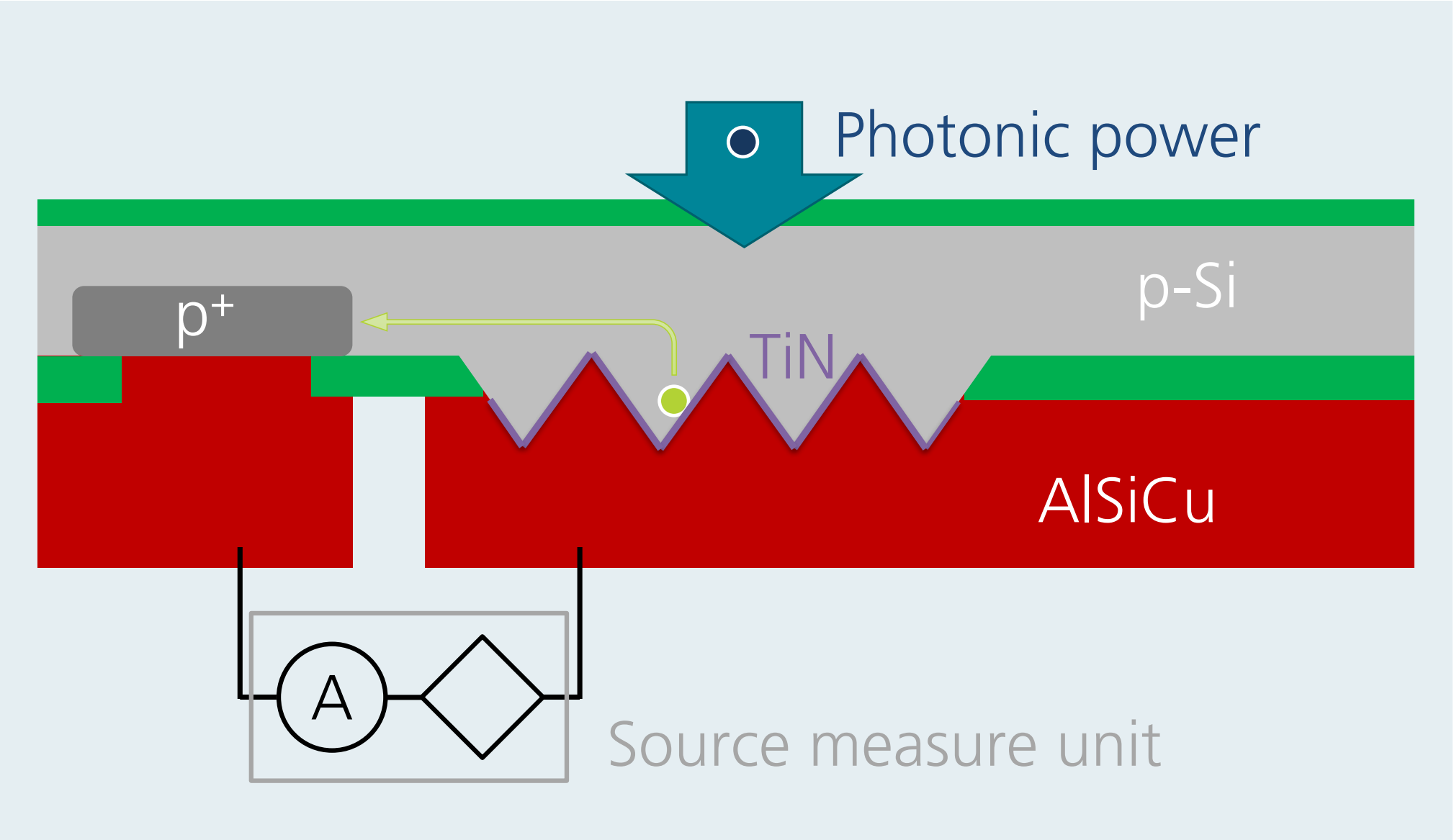

Figure 5 – Schematic crosscut through the detector with the TiN interface.

Device characterization

Devices are characterized by electrical and photonic measurement techniques. By relating photocurrent and photonic power from a tunable light source the optical responsivity was determined.

Effective barrier height

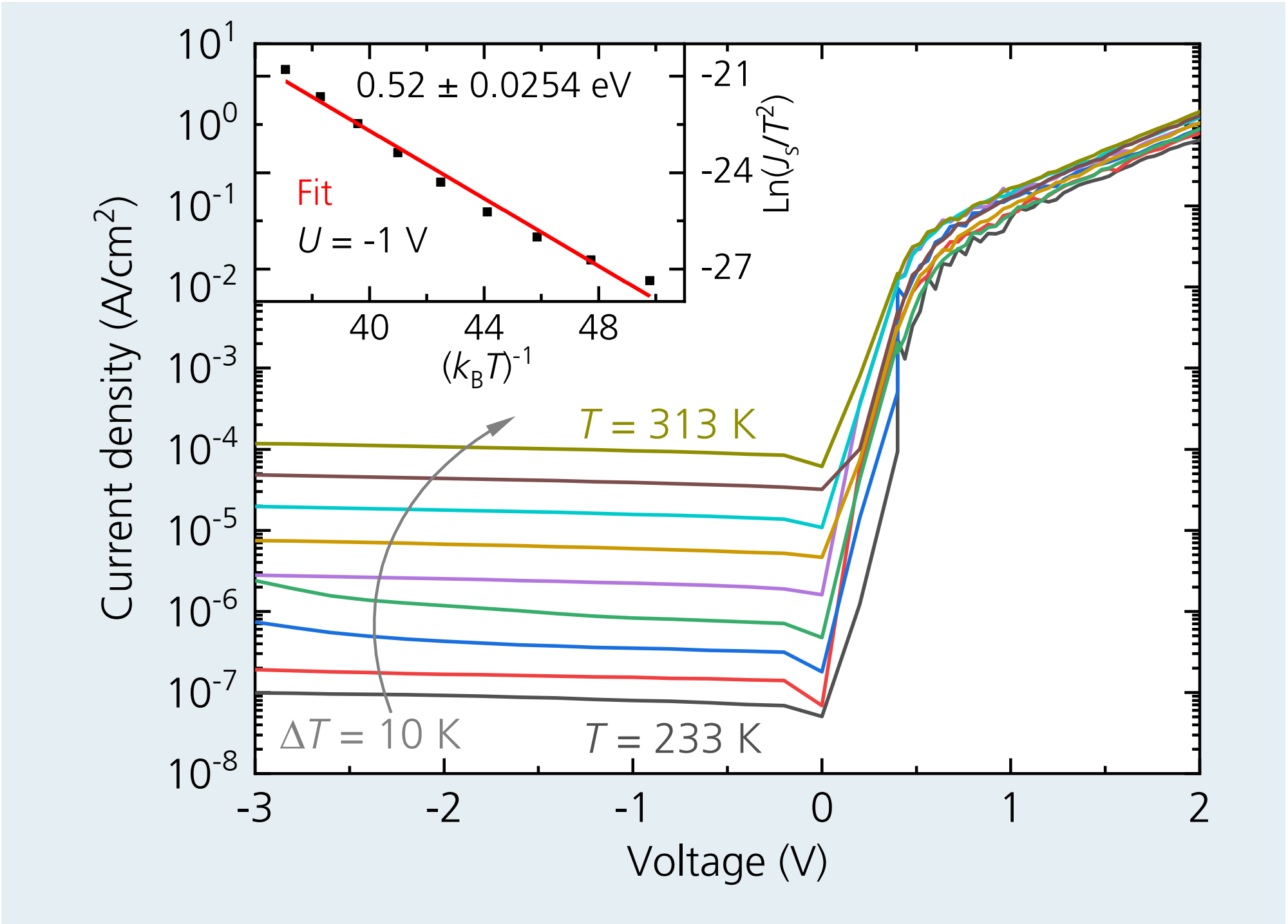

Figure 6 – Temperature depended current densities and inset with Richardson plot.

Optical responsivity

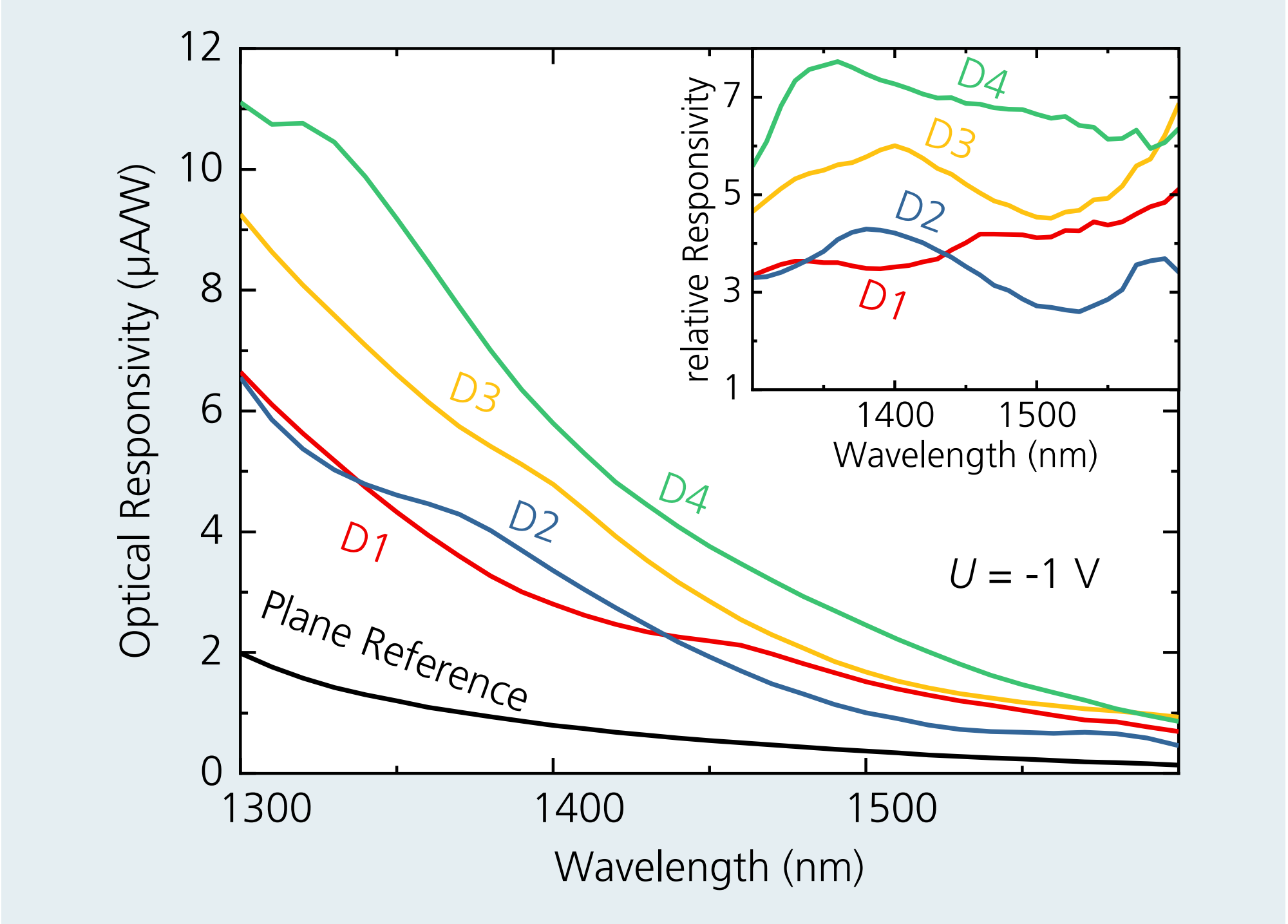

Figure 7 – Responsivity of devices with different pyramidal nanostructures.

Conclusion

In summary we found that

- Si nanostructures enhance the optical responsivity,
- TiN creates a Schottky barrier of required height and reasonable saturation current.

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[1] Stemmer Imaging

[2] Khurgin, J. B. "Fundamental limits of hot carrier injection from metal in nanoplasmonics" Nanophotonics, vol. 9, no. 2, 2020, pp. 453-471

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