Nano-Black anti-reflection layer for improved QE in CMOS image sensors

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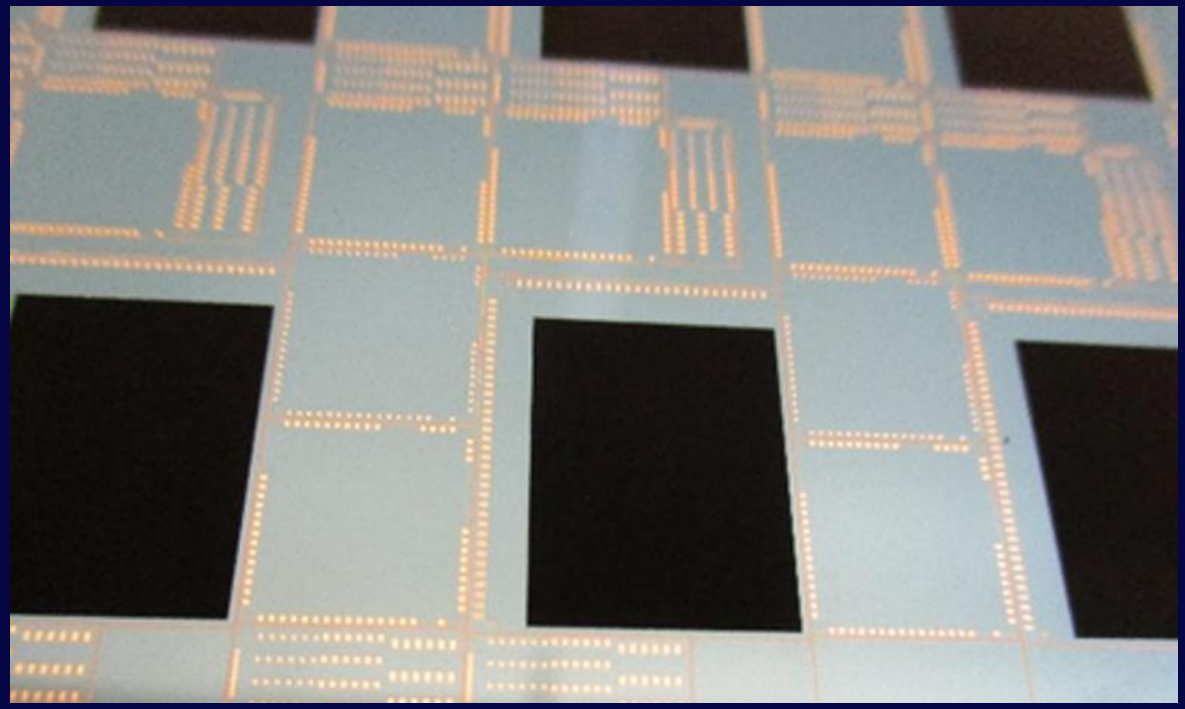

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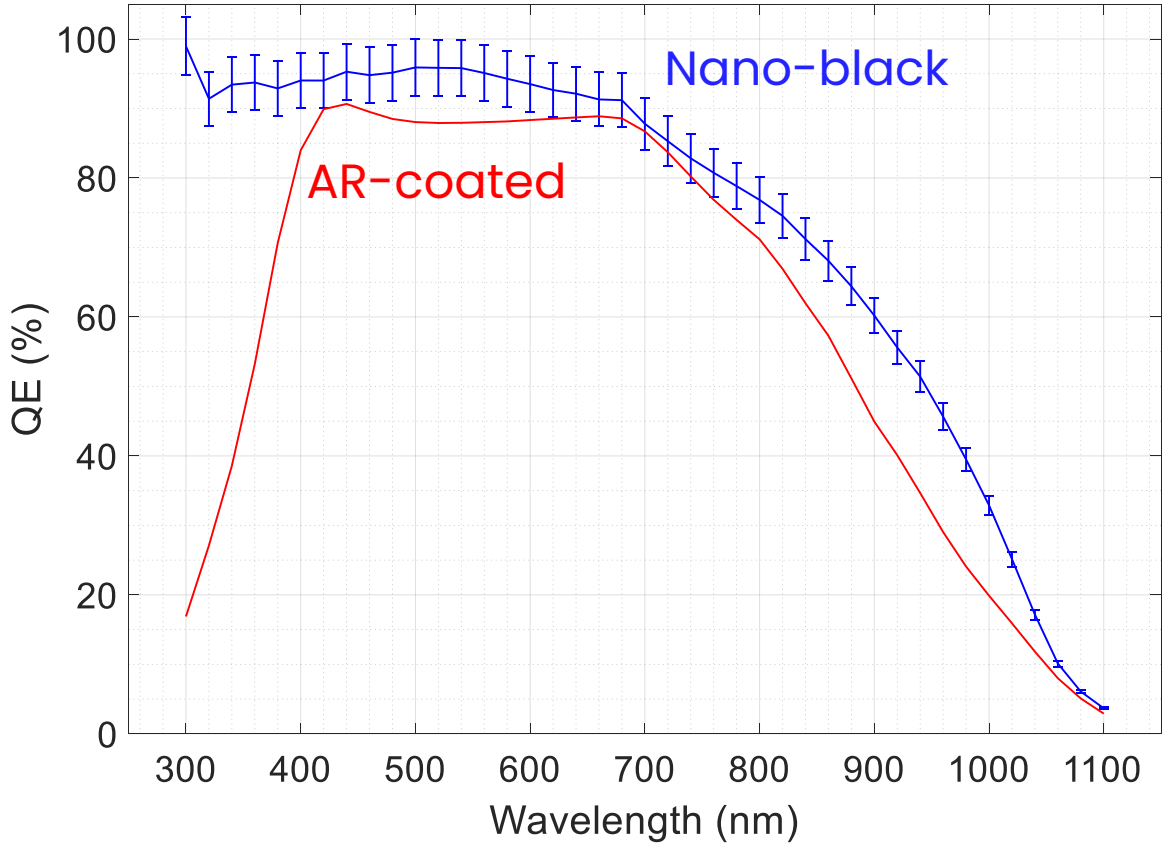
QE and Key Results

Nano-black silicon on CMOS CIS115

- Improved photoresponse (QE), particularly below 400 nm, and in NIR despite 1 µm thinning.
- Reduces dark current to 30% of control
- photo-response non-uniformity (PRNU) and spatial resolution (MTF) are reduced

Although the QE at 300 nm reached 100%, this is partly because the QE calculation assumed a quantum yield = 1, when it's actually > 1 for wavelengths < 330 nm



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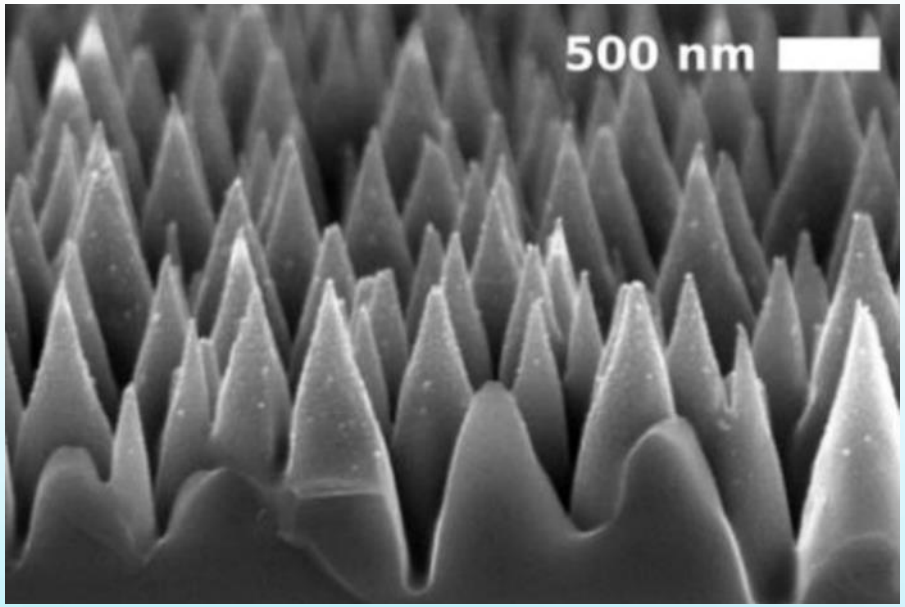
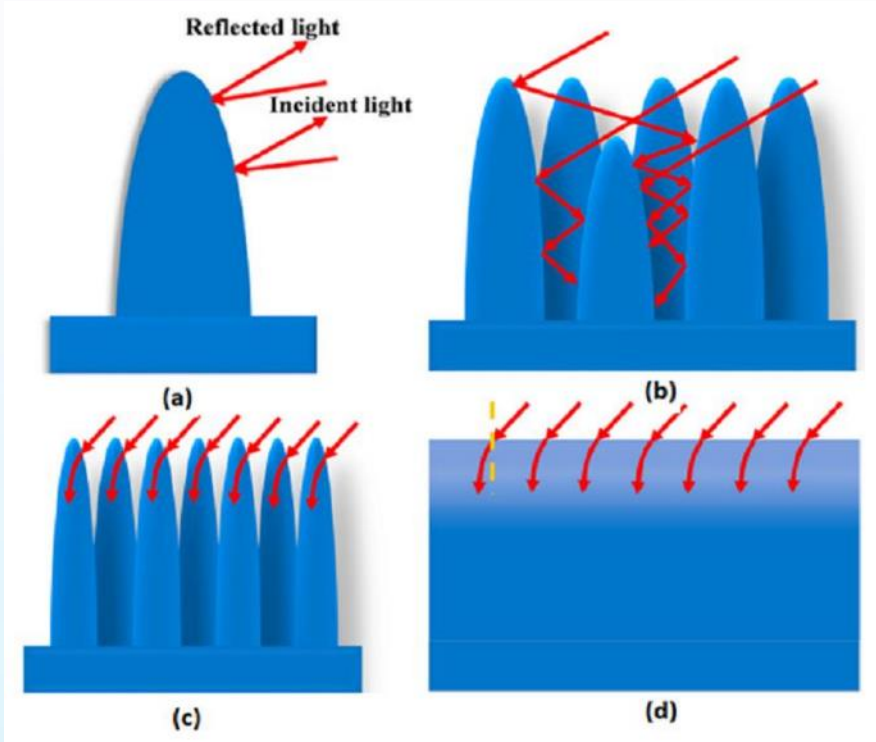
Nano-Black antireflection layer

Fabrication process

The antireflection layer is created by etching into the surface using a low temperature reactive ion plasma etch
Followed by deposition of alumina (Al_2O_3) with a negative charge providing electric field passivation



Nano-spikes, approx. 1 μm high and 400 nm wide
From PRL 125 117702 (2020)



Anti-reflection diagram
From Energies 2020, 13(10), 2631

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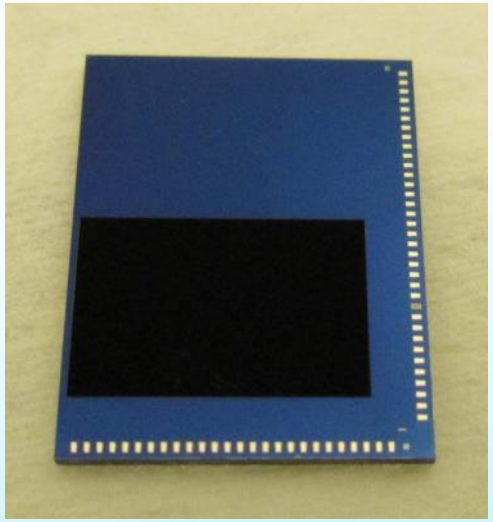
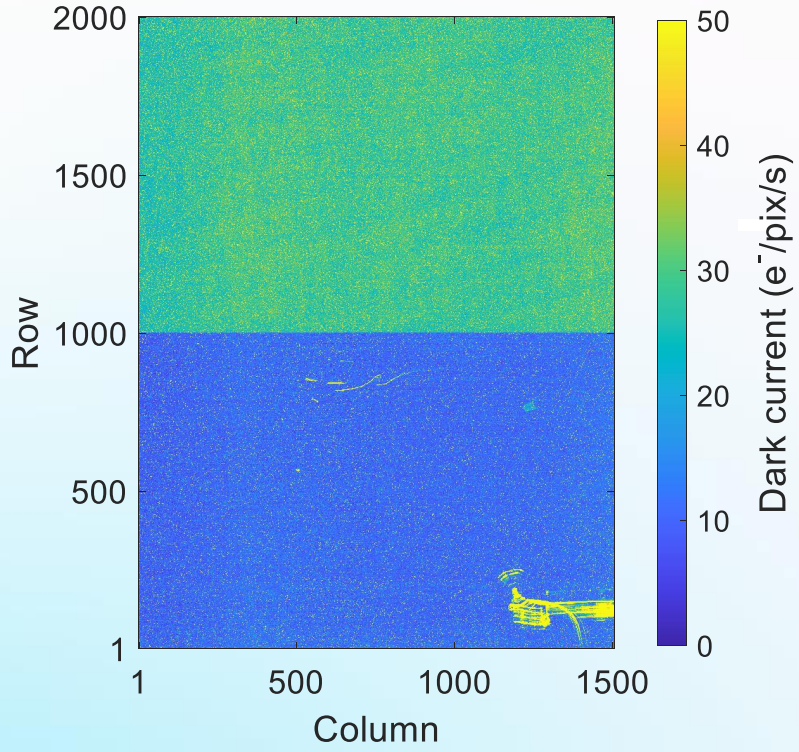
Dark current (at 20 °C)

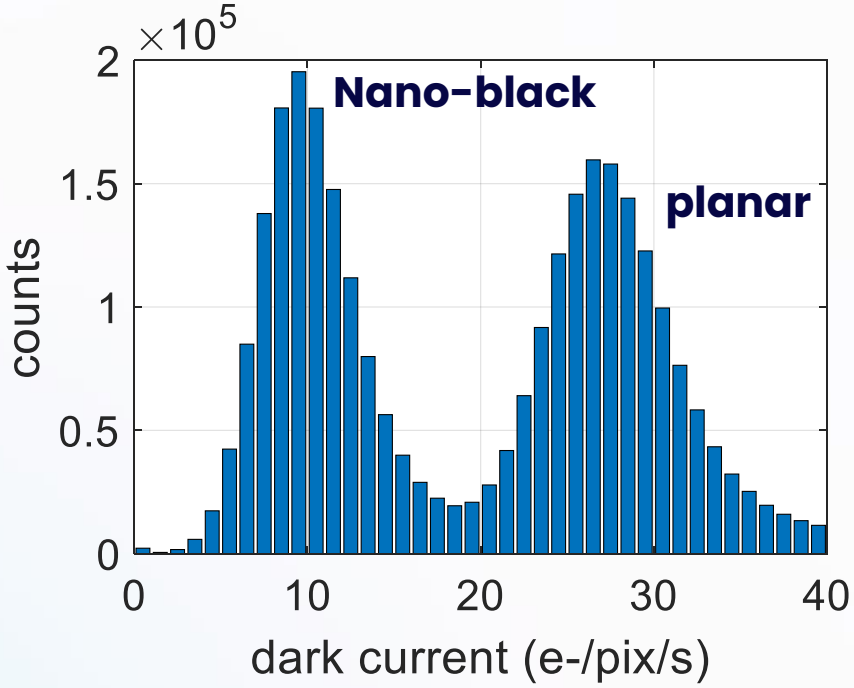
nano-black layer reduces dark current



Half-black chip



Dark current pixel map



Dark current histogram

Dark current is reduced to 30%
- Due to improved passivation

Nano-black : 10 e-/pix/s
Planar: 27 e-/pix/s

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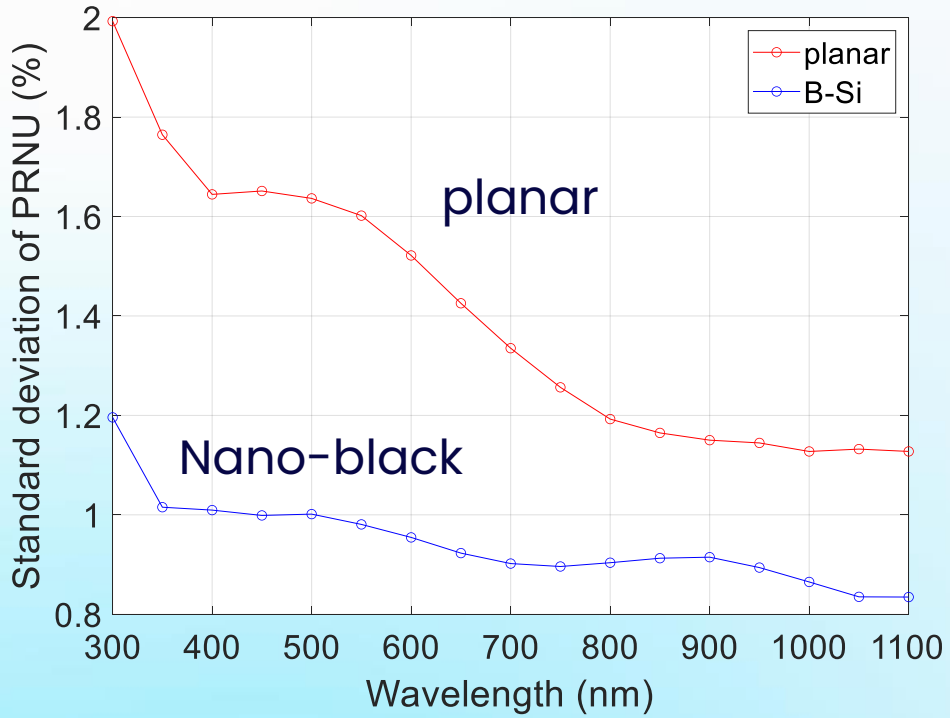
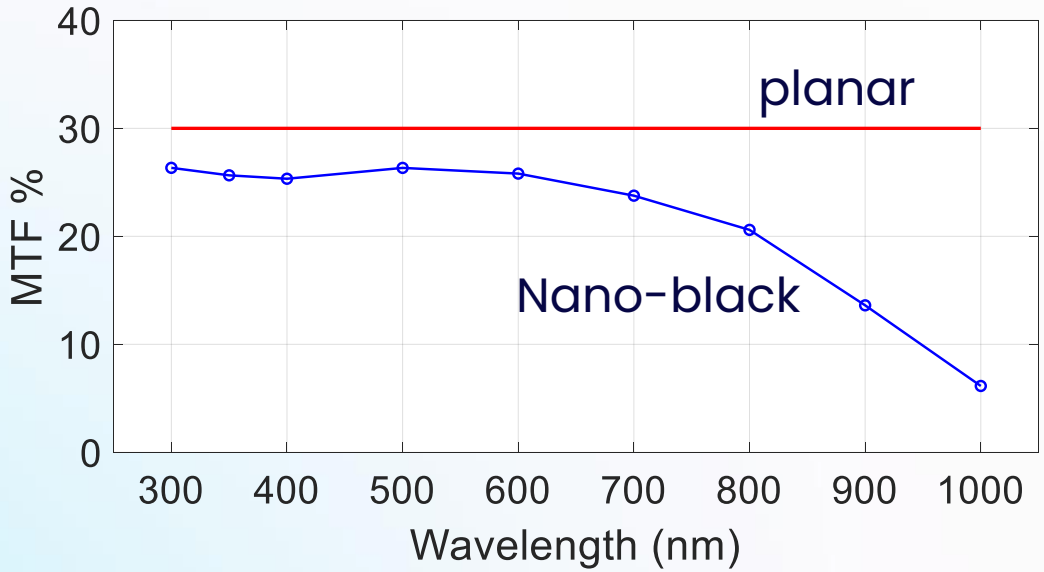
Photoresponse Non-Uniformity (PRNU) and Modulation Transfer Function (MTF)

- Nano-black has lower PRNU, especially at shorter wavelengths



- MTF drops off at longer wavelengths - reduced spatial resolution



indicates scattering, but this could possibly be reduced using deep trench isolation (DTI) of pixels

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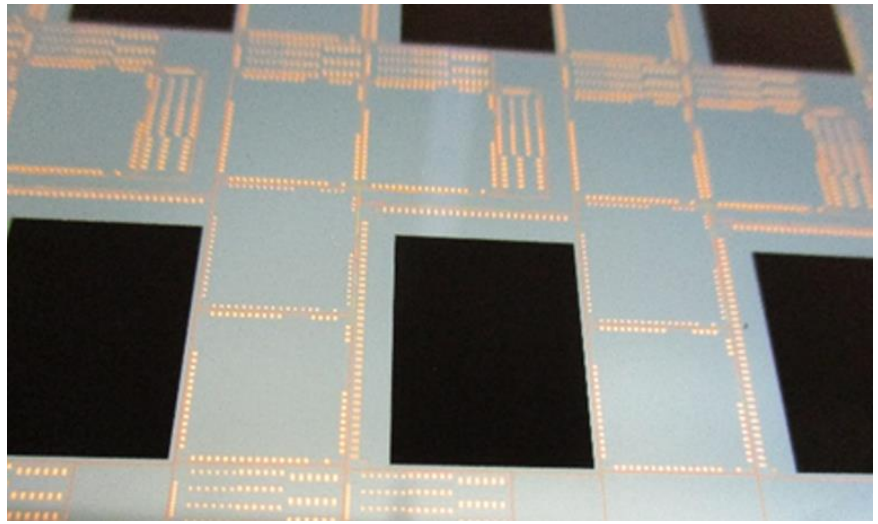
Summary

1. Nano-Black silicon process is compatible with standard CMOS
2. QE is higher than AR-coated below 400 nm, and is improved in NIR
3. Dark current reduced to 1/3
4. PRNU reduced (from 1.6% to 1% at 500 nm)
5. MTF reduced at NIR



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Thank you


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