Radiation Effects on Microlenses, Color Filter Array and Polarizing Filters in CMOS Image Sensor

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Overview

Goal: Study **radiation hardness** of **optical systems** at **pixel level**

DUT: modern **CMOS Image Sensor (CIS)** coming from a wide range of foundries and device providers featuring **Color Filter Array (CFA), Polarizing Filters** and **Microlenses**

Main result:

✓ Pixel level optical systems aren't responsible for the main loss of performances of the detection chain

Figure of Merit

Radiation induced degradation of a pixel optical stack will reflect on a sensor's ability to convert photons into charges, the Quantum Efficiency (QE):

$$QE = \frac{Collected\ photogenerated\ charges}{Impinging\ photons}$$

Degradation

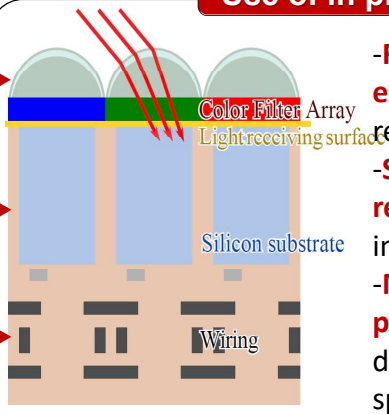
This work

Darkening, Refractive index variation → **↘QE, ↗crosstalk**

Generation/Recombination centers → **↘ QE, ↘ Full Well Capacity, ↘ SNR, ↗ dark current, ↗ lag**

Threshold voltage shift, leakage → **↘ SNR, ↗ Fixed Pattern Noise**

Use of in pixel optical systems

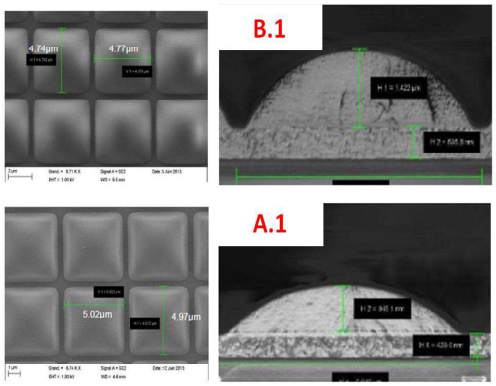


-**Focus light on sensitive element:** increased QE, reduced crosstalk

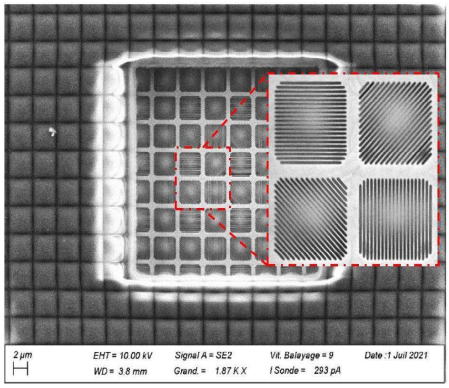
-**Sample spectral response:** easy color imaging

-**Measure light polarization:** material differentiation, reduced specular reflexions

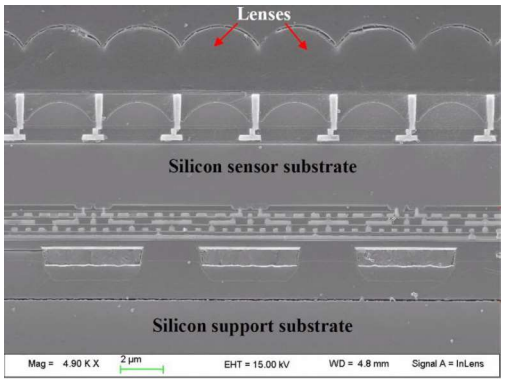
Scanning Electron Microscopy



Top and side view of the microlenses of two CIS

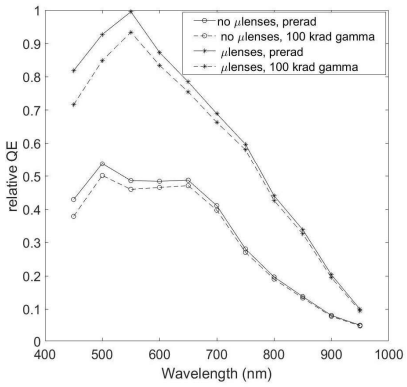


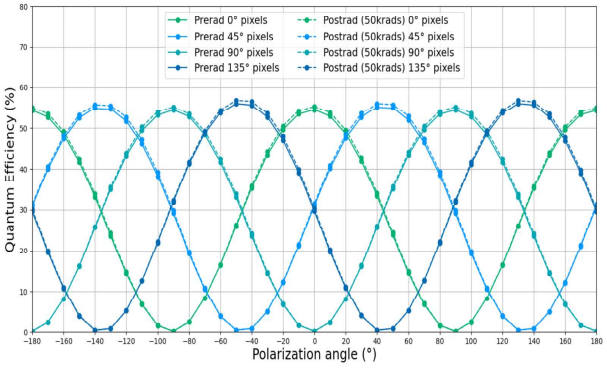
Polarizing filters (tungsten grid) under a microlenses layer)

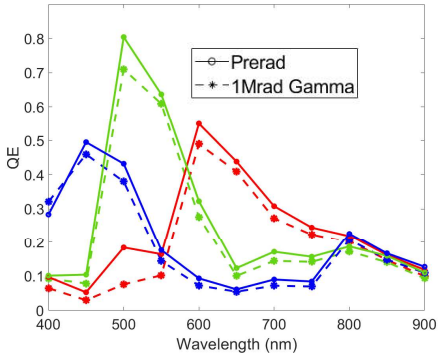


Cross section of a modern CMOS image sensor with two layers of microlenses

Results







- 11 devices from 5 different foundries were tested. Final dose up to 1Grad (typical space mission ≈100krad)
- Radiations have **little to no effects** on pixels' optical stack up to final deposited dose, for all **foundries**, **devices** and **technology nodes**
- Tested pixels optical stack withstand doses **compatible with space and nuclear environment**