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Astronomical Applicability of Colloidal Quantum Dot Short-Wave Infrared Image Sensor with Scalable Pixel Pitch down to sub-2 µm

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Spectral information and imaging with photon wavelengths longer than 1.1 µm (equivalent to Si bandgap) become highly valued in astronomical applications. Thin-film-based image sensors are considered as one of the next-generation imaging platforms for this long-wavelength spectral range that cannot be covered by Si image sensors. Colloidal Quantum Dot (CQD)-based imagers are appealing due to their potential for scaling the pixel pitch and array size. Monolithic processing availability of the photodiode (PD) layer onto the Si Readout Integrated Circuit (ROIC) enables substantially scaling the pixel dimensions of CQD-based imagers compared to flip-chip integrated ones with bulk crystalline PDs made of III-V (InGaAs, InSb, ...) or II-VI semiconductor materials. In addition, the light absorption peak of CQD PD made from PbS can be tuned, covering the extended Short-Wave InfraRed (SWIR) wavelength region, which provides the capability for hyperspectral imaging and spectroscopy. In the sensors presented, the scalability is demonstrated by the pixel pitch down to sub-2 µm for our CQD SWIR imagers beneficial for better resolution, which enables diffraction-limited imaging with oversampling of the optical point spread function that can be used to correct aberrations and lessen requirements on optical system tolerances. Making a single CQD PD imager chip as large as the full wafer size becomes available with the help of full-wafer level processing capability. Thus, a sensor area up to 20,000 mm2, with a maximum 6 Gigapixel number is processible, assuming 200 mm Fab processing and minimum 1.82 µm pixel pitch. The external quantum efficiency (EQE) is shown to be 40% at its peak absorption wavelength of 1450 nm. We believe that this scalable SWIR imager equipped with the competitive EQE values can be applied to limited load satellites (e.g., CubeSat), as the high spatial and spectral resolution sensor enables on-the-fly reconfigurability extending the mission capacity of the satellites.

Collaboration

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