Core-Shell PbSe/CdSe Quantum Dot Mid-Infrared Photoconductor

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Reducing Size, Weight, Power consumption, and Cost (SWaP+C) while maintaining good range and resolution has been the key goal for focal plane array (FPA) imagers. In mid-wave infrared (MWIR), a low SWaP+C imager with fast response time is highly desirable for many applications such as small unmanned aerial vehicles, smart munitions, and missile defense. Elimination of bulky and expensive cryogenic cooling systems and monolithic integration on Si readout integrated circuitry (ROIC) to reduce fabrication cost and to increase yield become two essential requirements for low SWaP+C MWIR imagers. Polycrystalline IV-VI semiconductor PbSe photoconductor (PC) meets both requirements and thus has been used by for years. However, one key challenge for the current PbSe PC FPA is the inhomogeneity of polycrystalline film which requires ROIC to perform non-uniformity correction on pixels and thus increases the power consumption and cost.

In this study, we report a novel threading core-shell PbSe/CdSe quantum dots (QDs) (QD Shish Kebab) room-temperature MWIR detector with much-improved homogeneity. The detector is grown on a SiO_2/Si substrate which enables monolithic integration of FPA on Si ROIC. We have optimized the QDPC's layer thickness, Core to shell ratio, and the total number of layers to improve its performance. The cutoff wavelengths can be tuned with different QD sizes.

To evaluate the performance of the QDPC, we have performed various characterization measurements, including current-voltage (IV) measurements, and blackbody radiometric measurements. The charge separation model is used to explain the QD 3-dimensional (3D) Shish Kebab detector structure.

The successful demonstration of our 3D network Core-Shell PbSe/CdSe nano-structured Photoconductor with improved homogeneity will have significant implications for many applications including large-format FPA monolithically integrated on Si ROIC with small pixel size.

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