High Performance Large Format UV/optical/near IR Detector Arrays

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There is an increasing need for large format imaging and detector arrays. For example, future NASA missions as well as DoD missions will require large format high performance imaging arrays in a mosaic or monolithic focal plane to achieve wide field of view, high-resolution imaging (and spectroscopy). The basic array design for each application might require CMOS or CCDs unique features.

CMOS arrays are the leading candidates for DoD missions where their speed/power performance and windowing capabilities are of key importance. Back-illumination of CMOS arrays allows 100% fill factor, wider spectral range, and high QE.

We have developed complete end-to-end post fabrication processes at JPL that have allowed us to produce high performance back illuminated imaging arrays of widely varying designs including n-channel CCDs, p-channel CCDs, and CMOS arrays. Delta doping was developed at JPL to enable UV sensitivity and enable high QE over the silicon spectral range. In this process an ultrathin layer of highly doped, high quality epitaxial silicon is grown on the back surface of fully fabricated array. We will present results of thinned and boron delta doped n-channel CCDs and CMOS arrays.

For many astrophysics survey missions and dark energy missions, low signal demands long integration time and low noise. CCDs are often detector of choice for these applications. Because of the redshifts involved, such missions often require very thick depletion regions to be able to detect near-IR with high QE. Lawrence Berkeley National Laboratory (LBNL) has developed p-channel devices in ultrahigh purity silicon to achieve a combination of thick fully depleted detectors and low noise required.

To address the new technology required for depleting, passivating, and enabling high QE in UV to NIR with p-channel back illuminated thick devices, we have developed a low temperature process for Sb delta-doping of silicon. This process can be used to form a thin back-surface contact for fully processed back-illuminated, high purity p-channel CCDs. Non-equilibrium growth by Molecular Beam Epitaxy (MBE) is used to achieve very high dopant incorporation in a thin, surface-confined layer. Optimization of this process has enabled the growth of a thin highly conductive back surface electrode on p-channel CCDs. The temperature is kept below 450 °C throughout the entire process, which is required for compatibility with fully processed and functional Al-metallized devices. We will present our latest results on delta-doping of large-format high purity CCDs. Performance parameters such as near-100% internal QE, dark current < $1e^-$/pixel/hour, and exceptional stability and uniformity in the 200-1100 nm spectral range will be presented.

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Figures

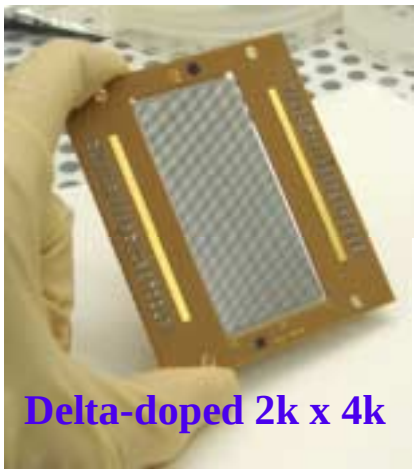

Figure 1. Photograph of an individually-packaged large format (2K x 4K) delta doped array. These arrays are 4-side buttable and can form mosaics of gigapixel focal plane arrays.

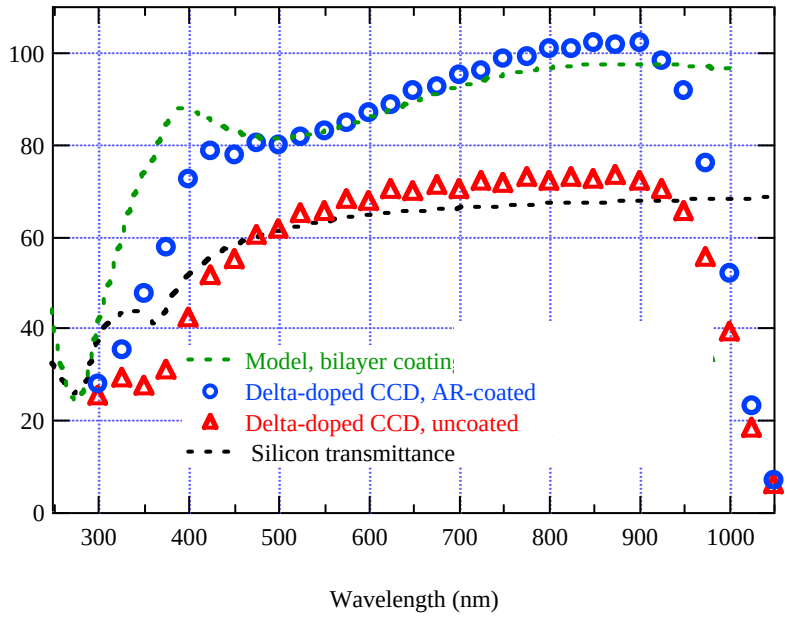

Figure 2. Response of delta doped high purity p-channel array with and without AR coating. The AR coating in this example was designed for a broadband optical/NIR response.

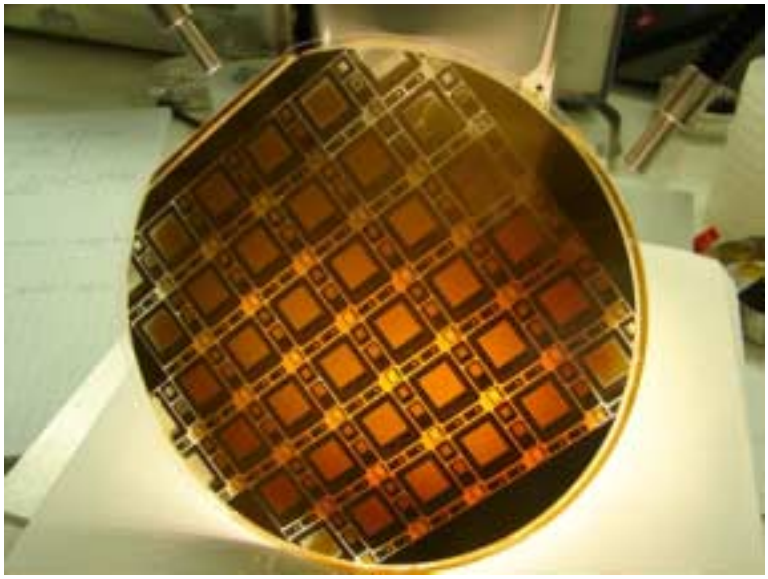

Figure 3. Photograph of a 6-inch wafer containing CMOS arrays, thinned down to several microns.