Curved Focal Plane Arrays for Compact, wide Field of View Optical Systems

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Introduction: Small and low-cost missions place exacting requirements on power, volume, and mass budgets. Curved focal plane arrays (CFPAs) can reduce the optical complexity of instruments by substantially reducing the number of optical elements required and subsequently reducing instrument size, mass, and cost, while increasing the field of view (FOV) and maintaining excellent imaging performance. The development of CFPAs could have a beneficial and significant impact on the design and construction of space-borne optical instruments such as orbiter cameras, ultra wide-angle imagers for mapping the sky, star trackers, rover panoramic cameras, and spectrometers.

CFPAs can potentially enable significant miniaturization and improvement of optical systems. In most optical systems the focal surface is naturally curved, while most detector arrays are flat. While other aberrations depend on the stop and conjugate positions within an optical system, field curvature generally depends only on the basic constructional parameters of the system and the throughput. It is thus very difficult to change, and can be regarded as intrinsic to an optical system. The designer has more degrees of freedom in controlling other aberrations than in controlling field curvature. CFPAs offer a way out of this dilemma by permitting the designer to concentrate on the correction of other aberrations rather than having to abandon a certain design approach due to excessive field curvature.

Two relatively simple approaches to convert flat solid state FPAs into CFPAs are under development at our laboratory. In these techniques, the curvature of the back surface is independent from the front surface VLSI fabrication process of CCDs or other imaging arrays. We have modified fully-processed thick, high-purity detectors and thinned membrane CCDs to have a curved imaging surface. We will discuss the range of required curvatures for FPAs, our two approaches for fabrication of CFPA, and the results on CFPAs.