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A Novel Ultra-High-Speed CMOS Image Sensor Implementation with Variable Spatial and Temporal Resolution using Temporal Pixel Multiplexing

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Temporal Pixel Multiplexing (TPM) is a new imaging modality allowing one CMOS image sensor to do the job of both high-resolution still photography and high-speed video with equal ease. Based on the desired trade-off between the number of frames in a high-speed burst and the video resolution, the sensor splits the pixel array into multi-pixel sub-groups defined prior to image capture. The current TPM design provides a high degree of flexibility in setting the size of these sub-groups, e.g., 2x2, 3x3, etc., and evenly distributes the resulting pixel groups across the entire array. When acquiring a single image frame, all pixels are exposed with the same integration time using a global shutter operation. Data is then readout as in a standard CMOS image sensor. When high-speed video is to be acquired, each pixel in a sub-group is exposed with a different integration time. These times have the same length, but can be offset from each other, resulting in each pixel acquiring a different frame of the high-speed video. The sensor presented here can offset these times by as little as 100ns. Therefore, for example, a 9x9 sub-group can acquire 81 frames of 10Mfps video footage. The resulting output is a single high-resolution image that can be post-processed into a short movie, formed from an ultra-high-speed sequence of lower resolution frames, consisting of pixels which have been exposed at the same time and collected together. This demonstrates the key benefit of the TPM technique - the capability to retrieve both a high-resolution image and a high-speed image sequence from a single picture with no added readout noise.

We present the first silicon implementation of a CMOS sensor employing the TPM imaging technique. The presentation covers the TPM sensor architecture, performance and functionality test results, and application benefits of the TPM method.

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