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# TECHNICAL SUPPORT PACKAGE

On

## CMOS ACTIVE-PIXEL IMAGE SENSOR CONTAINING PINNED PHOTODIODES

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# CMOS Active-Pixel Image Sensor Containing Pinned Photodiodes

Lower dark current and higher blue response are anticipated.

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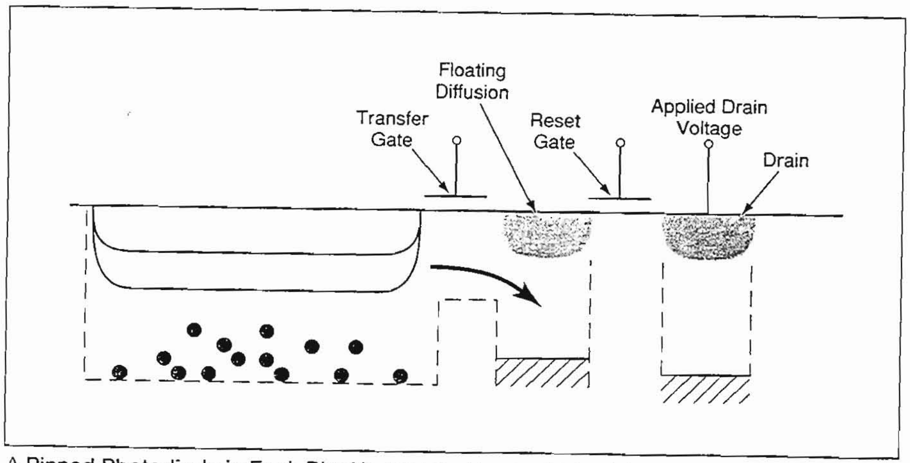
A complementary metal oxide/semiconductor (CMOS) active-pixel image sensor containing pinned photodiodes has been built (but not yet tested) in an effort to improve on a silicon-based active-pixel image sensor that was developed previously and is now in use at NASA's Jet Propulsion Laboratory. The older sensor operates with high quantum efficiency except in the blue part of the spectrum, where the response is diminished by photogates made of polycrystalline silicon ("poly" for short). In addition, the dark current (1 nA/cm$^2$) of the older sensor is greater than desired. Accordingly, the present sensor was designed to incorporate pinned photodiodes as its photoelements because pinned photodiodes can be fabricated without overlying poly. Pinned photodiodes are characterized by no lag, low reset noise, low dark current, and high quantum efficiency.

The sensor contains an array of 256 × 256 pixels on an integrated-circuit chip with an overall size of 1.2 × 1.2 cm and with a 40-pin pad frame. All of the row and column circuitry is designed with a 40-μm pitch to match the pixel size. The circuitry operates at transistor/transistor-logic voltage levels from power supplies of 5, 2.5, and 1.25 Vdc. Row and column addressing of the pixels is accomplished via 8-input NAND gates (one such gate for the rows, the other for the columns). Each 8-input NAND gate contains eight n-channel transistors in series, implemented by use of overlaid poly-1/poly-2 gates, somewhat as in a charge-coupled device.

A column-control logic circuit generates a column-selection signal, which is used to control the serial readout of data and is used with a crowbar signal to perform an operation that reduces fixed pattern noise. Each column-readout circuit contains two sample-and-hold capacitors; one for the signal level and one for the reset level. The crowbar signal activates a crowbar switch, which is a transistor switch in each column-readout circuit that is used to selectively short-circuit the two sample-and-hold capacitors together to reduce the fixed pattern noise generated by threshold-voltage offsets in p-channel source followers in the readout circuitry. Both the signal and reset levels of each pixel are read out, providing for off-chip subtraction to reduce the noise from each pixel.




A **Pinned Photodiode in Each Pixel** is expected to give higher blue response and lower dark noise than does a poly photogate in each pixel in an older device.

The figure illustrates the active-photosensor part of a pixel, with its pinned photodiode and integral transistors. It includes a transfer gate, a reset gate, and a floating diffusion node that connects to the input node of an n-channel source follower. A row-control logic circuit generates a row-selection signal plus the signals that are applied to the transfer and reset gates of each pixel in the selected row. The transfer gate is clocked to transfer the signal charge to the floating diffusion node. A frame-reset signal is also available; this signal is an inverted one that, when low, switches on the reset transistors in all pixels, putting all the floating diffusion nodes at the reset level but not emptying the signal charge from the pinned photodiodes.

The signals from the array of pixels are read out a row at a time. The reset and signal level from each pixel in the selected row is loaded in the sample-and-hold capacitors at the bottom of the column of that pixel. The levels from the columns are then read out serially.

*This work was done by Eric R. Fossum and Russell C. Gee of Caltech and Paul P. K. Lee, and Teh Hsuang Lee of Eastman Kodak Company for* **NASA's Jet Propulsion Laboratory**.

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# A CMOS ACTIVE PIXEL SENSOR USING A PINNED PHOTODIODE

## I. The Novelty

A Complimentary Metal Oxide Semiconductor (CMOS) sensor incorporates a pinned photodiode exhibiting no lag, low reset noise, low dark current and high quantum efficiency.

## II. The Disclosure

### The Problem

A scientific sensor showing high performance in terms of quantum efficiency and low dark current is required.

### The Solution

A CMOS active pixel sensor, recently developed at JPL, is designed to incorporate a pinned photodiode photoelement that does not require polysilicon and has low current.