specifically for processing data at video rates, are an attractive solution, not only because of their number-crunching ability but also because they are fully programmable.

In addition to processing requirements, developers are looking for flexible and high-rate acquisition; high-resolution display with nondestructive overlay; and integrated solutions that require fewer slots. Facing stiff competition in their own vertical markets, developers also require faster time-to-market and will be looking for software tools that save them development time.

As they shop for the next-generation development tools, OEMs and integrators expect higher performance and functionality — at lower cost — which is exactly what PCI solutions promise. □

Novel Sensor Enables Low-Power, Miniaturized Imagers

Multimedia, military, medical and automotive applications to benefit.

by Eric R. Fossum, Senior Research Scientist
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A novel detector technology is poised to supplant traditional charge-coupled-device (CCD) imagers in many applications while opening new imaging markets.

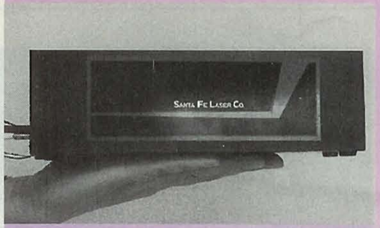
The complementary metal-oxide-semiconductor (CMOS) active-pixel sensor (APS) technology developed over the past three years by NASA at the Jet Propulsion Laboratory (JPL) has reached a level of performance comparable to CCDs with greatly increased functionality but at a very reduced power level.

Size aids integration

Microelectronics-industry-standard CMOS technology is used to produce the APS. The continual reduction in microelectronics feature size permits the integration of both detector and readout amplifier within each pixel. Because this architecture is inherently random access, window-of-region readout is readily achieved, as are electronic pan and zoom.

Because each amplifier is selected only for readout, power dissipation is minimized. The standard 5-V (or 3.3-V) operation of the sensor also contributes to its minimal power dissipation: 10 to 50 mW, depending on on-chip functionality and readout rate.

The imaging performance of the sensors is better than previous CMOS image sensors or charge-injection devices (CIDs) and competitive with nearly all CCDs. The designed fill factor of APS pixels is typically 25 to 30 percent, comparable to interline-transfer CCDs, and can be



readily improved through the use of on-chip microlenses. The device provides a 75- to 80-dB, or 12- to 14-bit dynamic range, and quantum efficiency per pixel is typically 30 percent because the readout area has some photosensitivity. Because there is no charge transfer, there is no smear, and antiblooming protection is built into each pixel.

This second-generation image-sensor technology enables new applications.

The CMOS technology permits easy integration of on-chip timing and control circuits and analog signal-chain electronics. JPL has built a 256 × 256-pixel image sensor that essentially requires only 5 V and a clock to produce high-quality analog video output.

In 1993, JPL began transferring the technology to industry. It now has technology-collaboration agreements with several small companies plus Eastman Kodak, National Semiconductor and AT&T. In addition, some members of JPL's APS research and development team recently formed a new start-up company, Photobit, in La Crescenta, Calif., which will specialize in custom CMOS image sensor design.

Simplified system design

An important on-chip component now under research at JPL is the analog-to-digital converter (ADC). Such a chip has a full digital interface that simplifies system design. JPL and AT&T have demonstrated several chips with 8-bit on-chip ADC. Improved resolution, higher speed and lower power are desired.

Sensors under development at JPL have also demonstrated additional functionality, including multiresolution readout for robotics, very-high-frame-rate imaging (easier to achieve in the APS than in a CCD because of the in-pixel amplifier), and sensors with very high effective dynamic range (greater than 20 bits).

Given the strong interest in the technology and the continued development work (for example, AT&T has already demonstrated a 1024 × 1024-element APS with 10-µm pixel pitch), the applications potential is enormous for these low-power devices in medical, military and multimedia imaging. The sensor should also enable new imaging applications because of its size and power characteristics. □

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