Long the dominant player in the image-sensor market, the charge-coupled-device (CCD) detector now faces a market challenge from the complimentary-metal-oxide-semiconductor (CMOS) image sensor. Though both were developed in the late 1960s, the CCD, for technological as well as economic reasons, emerged as the image sensor of choice and dominated for the next 25 years. With the continuing improvement of CMOS image-sensor design rules, CMOS image-sensor technology emerged from government and university research labs in the early 1990s and improved over subsequent years to emerge as a challenger to CCD technology.

In general, the two approaches present engineers with design tradeoffs. CMOS image sensors can be manufactured less expensively than CCDs, which use older metal-oxide-semiconductor (MOS) design rules. Most image-sensor support circuitry is CMOS based, so it can be integrated on the same chip as the CMOS image sensor, which lowers overall system cost and size. CMOS image sensors do not require multiple voltages for readouts as do CCDs, so they consume only a fraction of the power.

CCD image sensors, on the other hand, suffer less from fixed-pattern and dark-current noise, providing greater sensitivity. CCDs also have superior dynamic range. Both of these attributes have given the technology a solid position in high-end markets such as scientific or medical imaging.

Leading CCD manufacturers are not resting on their laurels, however. Sony (Tokyo, Japan) and Sharp (Osaka, Japan) devote tremendous resources to developing higher-resolution CCDs, particularly for the digital-still camera market. In the fall of 2000, Sony developed a five-million-pixel CCD, while Sharp demonstrated a four-million-pixel CCD. Both these sensors were available in digital-still cameras on the market by the fall of 2001. This environment could make it difficult for CMOS sensor manufacturers to gain a foothold, particularly in high-resolution sensors.

CMOS image sensors have many more potential advantages than drawbacks, however. In addition to the cost, integration, and power consumption issues mentioned earlier, the sheer number of companies involved in the market—including giants like Agilent (Palo Alto, CA), Motorola (Schaumberg, IL), and Toshiba (Tokyo, Japan)—yields price benefits and technological advances. In fact, there are more companies making or researching CMOS sensors than CCDs, and the future bodes well for CMOS. In February 2001 at the International Solid State Circuits Conference, where breakthroughs on image-sensor technol-
ogy have been announced in the past, nine papers focused on CMOS image-sensor technology, while none focused on CCDs.

carving their niche

When CMOS image sensors became commercially available, industry watchers speculated that the technology would create new markets. Let’s take a brief look at some of the individual applications in which CMOS image sensors are doing well.

PC cameras are the premier market for CMOS image sensors. Prominent suppliers of PC cameras include Logitech (Fremont, CA), Intel (Santa Clara, CA), IBM/Xirlink (Armonk, NY), and Creative Labs (Singapore). The large majority of PC cameras use CMOS image sensors, with only the higher-end cameras having CCDs. The emphasis in the consumer PC camera market tends to be on price rather than image quality; hence, CMOS image sensors have an advantage.

Cameras for mobile phones are the holy grail of CMOS image-sensor manufacturers. The opportunity is enormous. Cahners In-Stat (Scottsdale, AZ) forecasts that more than 947 million mobile-phone handsets will be produced in 2005. If only a small percentage of these phones have cameras, it could be enough to sustain several CMOS sensor manufacturers. Just about every CMOS sensor vendor has this market targeted as its number-one growth opportunity. CMOS sensors’ advantages fit this market very well because mobile-phone manufacturers require a small, low-power, integrated imaging solution. With current wireless technology, mobile phones can send or receive still photos. Sanyo (Osaka, Japan), Toshiba, Kyocera (Kyoto, Japan), and Matsushita (Osaka, Japan) have all released, or plan to release in Japan, a mobile phone with an embedded camera.

While still photos can be transferred over the existing mobile-phone infrastructure, video with acceptable frame rate would require much higher data rates. This will likely require the rollout of third-generation (3G) mobile-phone technology, which is currently available only in Japan. NTT (Tokyo, Japan) DoCoMo offers a mobile phone with video capability for about $600. The service allows 384 kb/s download speeds from the service provider and 64 kb/s upload speeds from the customer. 3G service rollouts aren’t expected in Europe until 2003 or 2004, and they aren’t expected in the United States until 2006 or later.

Cameras for personal digital assistants (PDAs) and handheld PCs are becoming increasingly popular accessories. For example, modular cameras are available for the Palm and Handspring PDAs, as well as the HP Jornada. Small size and low power consumption are key in this market, making CMOS the obvious choice over CCDs.

driving the market

Image sensors in the automotive industry have great potential. Emerging applications in this market include exterior side-view and rear-view cameras for collision avoidance, back-seat cameras for minivans and station wagons, and cameras to assist with airbag deployment. The Cadillac division of GM is one of the proponents of cameras in automobiles. Cadillac currently sells about 6000 vehicles a year with night-vision systems that use grille-mounted infrared imagers.

CMOS sensors are ideal for automotive applications due to their low cost, low power consumption, and their compatibility with integrating multiple functions on-chip. The popularity of on-board navigation computers is increasing the number of in-car LCD screens, which could act as displays for camera images. The long product cycles in the industry mean that this market will probably not begin to see significant numbers of image sensors until 2004 and 2005, however.

CMOS image sensors will continue to do well in newer markets that benefit from their inherent advantages. This will be most widely seen in portable applications, such as cameras for PDAs and cell phones, which will be big markets for CMOS image sensors within five years. In comparison with CCDs, CMOS image sensors can provide a small footprint and integrated solutions with low power consumption. Meanwhile, CCDs will remain strong in markets where high resolution is a key factor, such as digital still cameras. Within the next five years, however, CMOS image sensors’ advantages and subsequent use in rapidly growing markets will result in more CMOS image sensors sold than CCDs.

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