

Toward one Giga frames per second: Evolution of In-situ Storage Image Sensors

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In 2001, a video camera of one million frames per second (1 Mfps) was developed by Etoh et al. In-situ Storage with more than one hundred CCD memory elements were installed for each pixel. Simultaneous recording in all pixels realized the ultra-fast image capturing. The pixel count was 86 kpixels. The type of the sensors was named ISIS, In-situ Storage Image Sensor. They have been continuously evolving in the frame rate, the sensitivity and the pixel count. In 2011, a backside illuminated ISIS with EM-CCD achieved 16 Mfps with 165 kpixels and the sensitivity of several photons per pixel. It was a prototype image sensor. The authors are currently developing the practical version with 344 kpixels. The authors proposed a new architecture which can achieve 100 Mfps with the fill factor of 100%. The theoretical highest frame rate achievable by this architecture is 1 Gfps.

In 2012, a CMOS version was reported by Tochigi et al. The highest frame rate of the camera was 20 Mfps for 50 kpixels.

Another direction of evolvement of ISISes is introduction of new functions: among them are in-pixel signal accumulation which drastically improves S/N ratio in imaging of reproducible phenomena with very low light intensity, and user-friendly utility functions, such as a built-in multi-camera, a double-trigger system, and so forth.

The sensors are expected to be applied not only to the ultra-high-speed imaging for visible light, but also to imaging with other electromagnetic waves, imaging TOF MS, pulse-neutron radiography, etc.

This paper reviews the evolution of the ISISes.

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