Designation: E2642 – 09 (Reapproved 2021)

Standard Terminology for Scientific Charge-Coupled Device (CCD) Detectors[1]

This standard is issued under the fixed designation E2642; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This terminology brings together and clarifies the basic terms and definitions used with scientific grade cooled charge-coupled device (CCD) detectors, thus allowing end users and vendors to use common documented terminology when evaluating or discussing these instruments. CCD detectors are sensitive to light in the region from 200 nm to 1100 nm and the terminology outlined in the document is based on the detection technology developed around CCDs for this range of the spectrum.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.3 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E131 Terminology Relating to Molecular Spectroscopy

3. Significance and Use

3.1 This terminology was drafted to exclude any commercial relevance to any one vendor by using only general terms that are acknowledged by all vendors and should be revised as charge-coupled device (CCD) technology matures. This terminology uses standard explanations, symbols, and abbreviations.

4. Terminology

4.1 *Definitions:*

advanced inverted mode operation (AIMO), *n*—a commercial tradename given to a method of reducing the rate of generation of dark current. Also known as **multi-pinned phase** operation.

analog-to-digital (A/D) converter, *n*—an electronic circuitry in a CCD detector that converts an analog signal into digital values, which are specified in terms of bits that can be manipulated by the computer.

anti-blooming structure, *n*—a structure built into the pixel to prevent signal charge above full-well capacity from blooming into adjacent pixels.

Discussion—Anti-blooming structures bleed off any excess charge before they can overflow the pixel and thereby stop blooming. These structures can reduce the effective quantum efficiency and introduce nonlinearity into the sensor.

antireflective (AR) coating, *n*—a coating applied to either the front surface of the CCD or the vacuum window surfaces, to minimize the amount of reflected energy (or electromagnetic radiation) so as to maximize the amount of transmitted energy.

back-illuminated CCD (BI CCD), *n*—a type of CCD that has been uniformly reduced in thickness on the side away from the gate structure (see Fig. 1b) and positioned such that the photons are detected on that side.

Discussion—A BI CCD leads to an improvement in sensitivity to incoming photons from the soft X-ray to the near-infrared (NIR) regions of the spectrum with the highest response in the visible region. However, compared to a front-illuminated CCD, it suffers from higher dark currents and interference fringe formation (etaloning) usually in the NIR region. Also called back-thinned CCD.

binning, *n*—the process of combining charge from adjacent pixels in a CCD prior to read out.

Discussion—There are two main types of binning: *(1)* vertical binning and *(2)* horizontal binning (see Fig. 2). Summing charge on the CCD and doing a single readout results in better noise performance than reading out several pixels and then summing them in the computer memory. This is because each act of reading out contributes to noise (see **noise**).

CCD bias, *n*—the minimum analog offset added to the signal before the A/D converter to ensure a positive digital output each time a signal is read out.

Discussion—The CCD bias is set at the time of manufacture and remains set over the lifetime of the camera.

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[1] This terminology is under the jurisdiction of ASTM Committee E13 on Molecular Spectroscopy and Separation Science and is the direct responsibility of Subcommittee E13.08 on Raman Spectroscopy.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

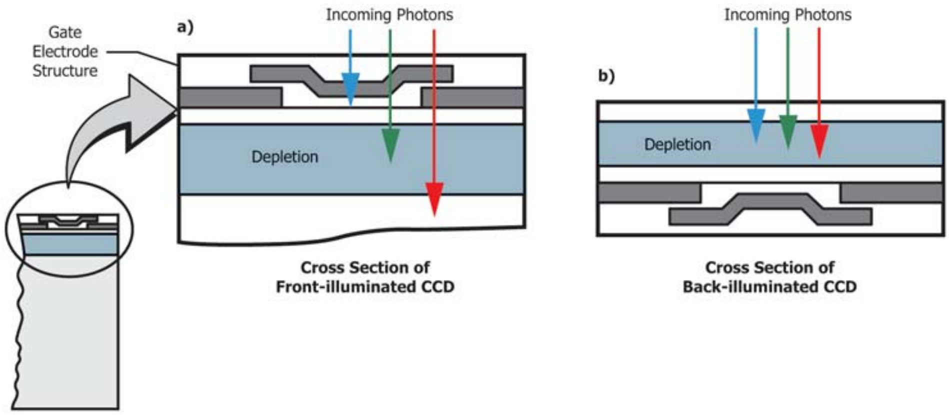

FIG. 1 Cross Sections of Front-Illuminated (a) and Back-Illuminated (b) CCDs

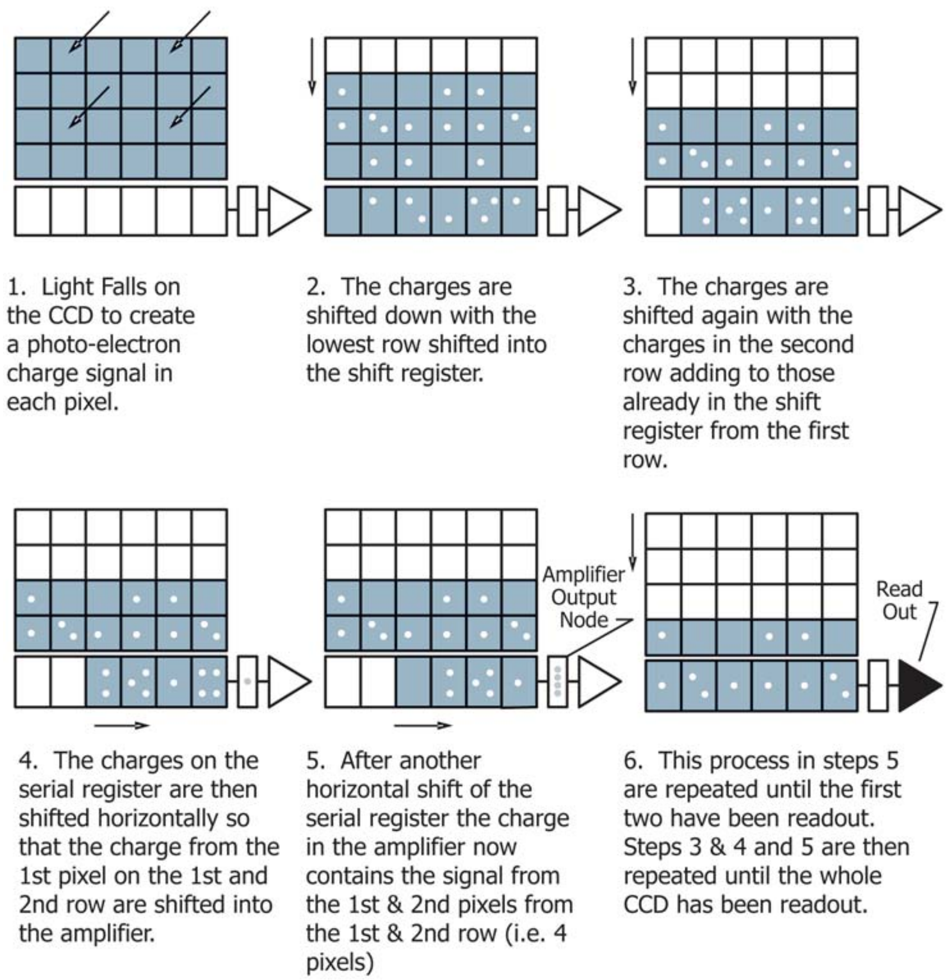

FIG. 2 Example of a 2 × 2 Vertical and Horizontal Binning Methodology

charge, *n*—measure of number of electrons that are contained in a pixel potential well.

charge-coupled device (CCD), *n*—a silicon-based semiconductor chip consisting of a two-dimensional matrix of photo sensors or pixels (see Fig. 3).

Discussion—The matrix is usually referred to as the image area. Electronic charge is accumulated on the image area and transferred out by the application of electrical potentials to shielded electrodes. The size of pixels in the sensor is typically 26 µm × 26 µm; however, sensors can be manufactured in a variety of different pixel sizes ranging from 6 µm × 6 µm to 50 µm × 50 µm. Although mathematically incorrect, the dimension unit of a square pixel is typically given in square microns (for example, a pixel of dimension 26 µm × 26 µm is specified as 26 × 26 μm^2).

charge transfer, *n*—the process by which a CCD moves electrons or charge from one pixel to the next.

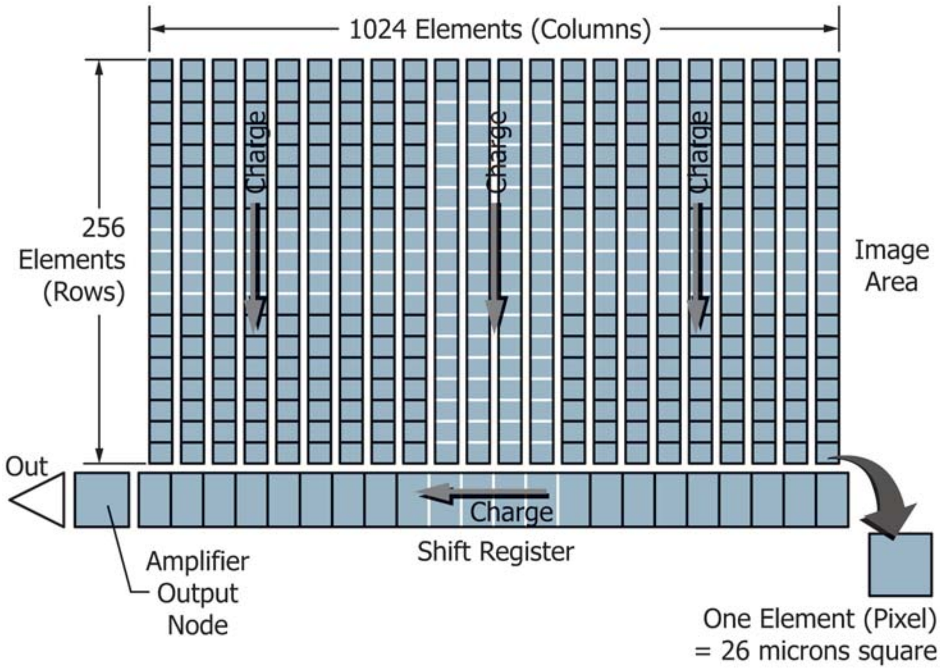

FIG. 3 Typical 1024 × 256 (26 × 26 µm^2 pixel) Element CCD Sensor Used for Spectroscopy

charge transfer efficiency (CTE), *n*—measure of the ability of the CCD to transfer charge from the point of generation to the device output.

Discussion—It is defined as the fraction of the charge initially stored in a CCD element that is transferred to an adjacent element by a single clock cycle. The value for CTE is not constant but varies with signal size, temperature, and clock frequency.

column, *n*—a line of pixels in the CCD's image area that is perpendicular to the horizontal register.

complementary metal oxide semiconductor (CMOS), *n*—technology widely used to manufacture electronic devices and image sensors similar to CCDs. In a CMOS sensor, each pixel has its own charge-to-voltage conversion circuit, and the sensor often also includes amplifiers, noise-correction, and digitization circuits. Due to the additional components associated with each pixel, the sensitivity to light is lower than with a CCD, the signal is noisier, and the uniformity is lower. But the sensor can be built to require less off-chip circuitry for basic operation (see Fig. 4).

correlated double sampling, *n*—a readout sampling technique used to achieve higher precision in CCD readout.

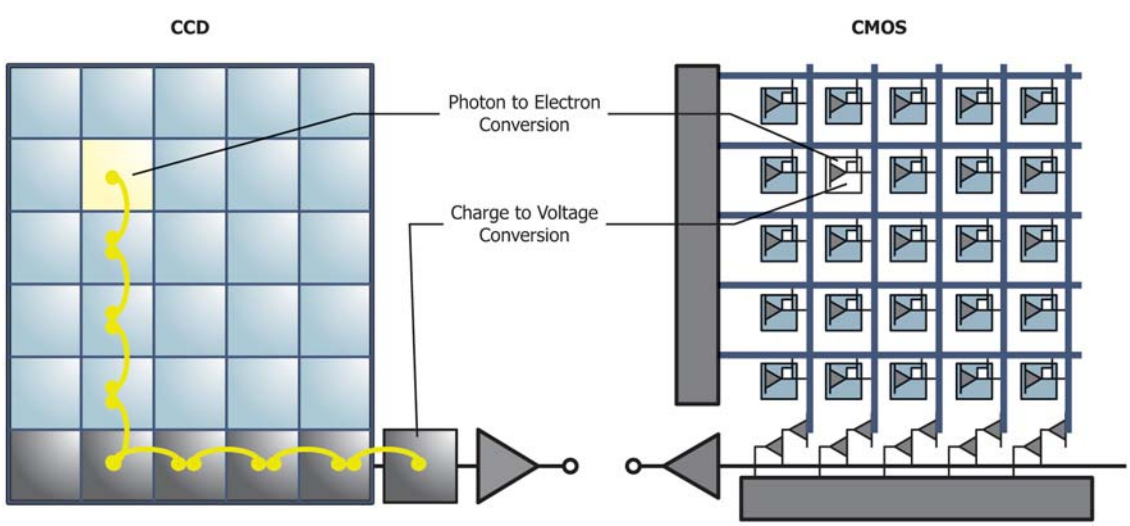

FIG. 4 Typical Architectures of CCD and CMOS Sensors