CMOS Technology in Sensing Fields

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Abstract

The role of CMOS Image Sensors since their birth around the 1960s has been changing a lot. Unlike the past, current CMOS Image Sensors are becoming competitive with regard to Charged Couple Device (CCD) technology. They offer many advantages with respect to CCD, such as lower power consumption, lower voltage operation, on-chip functionality and lower cost. Nevertheless, they are still too noisy and less sensitive than CCDs. Noise and sensitivity are the key-factors to compete with industrial and scientific CCDs. It must be pointed out also that there are several kinds of CMOS Image sensors, each of them to satisfy the huge demand in different areas, such as Digital photography, industrial vision, medical and space applications, electrostatic sensing, automotive, instrumentation and 3D vision systems. In the wake of that, a lot of research has been carried out, focusing on problems to be solved such as sensitivity, noise, power consumption, voltage operation, speed imaging and dynamic range. In this paper, CMOS Image Sensors are reviewed, providing information on the latest advances achieved, their applications, the new challenges and their limitations.

Introduction

Image sensors have recently attracted renewed interest for use in digital cameras, mobile phone cameras, handy cam coders, cameras in automobiles, and other devices. For these applications, CMOS image sensors[1] are widely used because they feature on-chip integration of the signal processing circuitry. CMOS image sensors[2] for such specific purposes are sometimes called smart CMOS image sensors, vision chips, computational image sensors, etc.

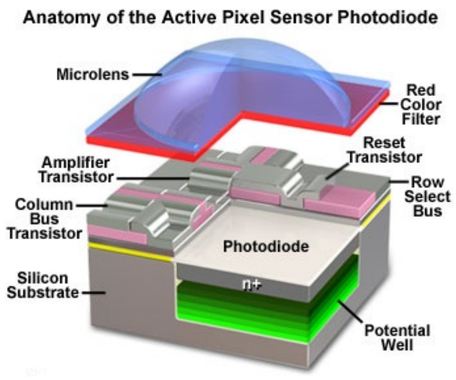

Fig.1: Active Pixel Sensors

Smart CMOS Image Sensors & Applications[3] focuses on smart functions implemented in CMOS image sensors and their applications. Some sensors have already been commercialized, whereas some have only been proposed; the field of smart CMOS image sensors is active and generating new types of sensors. The Complementary metal oxide semiconductor (CMOS) image sensors have been the subject of extensive development and now share the market with charge coupled device (CCD) image sensors, which have dominated the field of imaging sensors for a long time.

Passive pixel sensors [2] contain one where as the active pixel sensor contains three transistors. In order to have enhancement, pixel containing four transistors was made in the advanced active pixel sensor on by representing it as 4T active pixel sensor which in turn had complicated process flow of fabrication but the quality of the image will be best. The fabrication of the passive pixel sensors was terminated because of the signal to noise ratio problems .

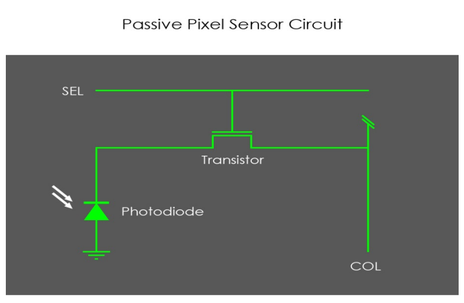

Fig.2: Passive Pixel Sensors

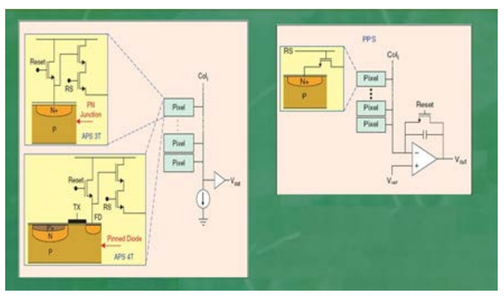

Fig.3: Types of Active Pixel Sensors

Photodiode (PD) type APS which was considered as a standard in 1968.It is having three transistors in which one is termed as reset transistor which resets the voltage of photodiode, a select transistor involves source follower and to buffer the photodiode voltage over vertical column bus. This type of active pixel sensor is preferred to many applications which operate in low frequency. Photo gate based active pixel sensor was entered into market. It uses the same CCD's principle operation in integrating transport and readout operation in every pixel internally. This charge transfer and correlation will double the sampling allows a low noise level operation. It is applicable to low light applications and high performance.

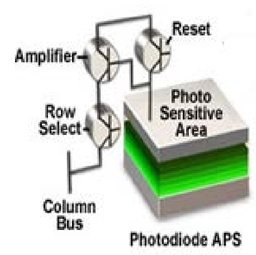

Fig.4: Photodiode Active Pixel Sensors

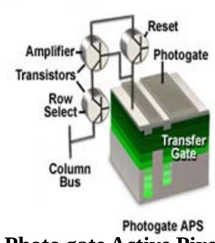

Fig.5: Photo gate Active Pixel Sensors

Parameter	CCD Image sensor	CMOS image sensor
Transistor isolation	Reverse bias pn -junction	LOCOS/STI ;may exhibit stress-induced dark currents
Simultaneity	Simultaneous readout of every pixel	Sequential reset for every row; rolling shutter
Thickness of gate oxide	Thick for complete charge transfer (>50 nm)	Thin for high speed transistor and low voltage power supply(<10nm)
Gate Electrode	Overlapped 1st & 2nd poly-Si layers	Polycide poly-Si
Isolation layers	Thin for suppressing light guide	Thick approximately 1µm
Metal layers	Usually one	Over three layers

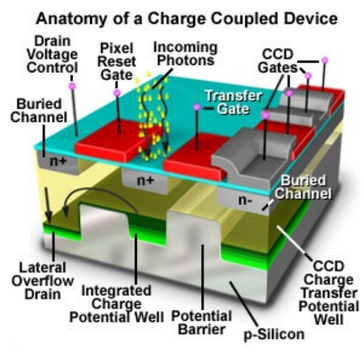

Fig.6: CCD sensor

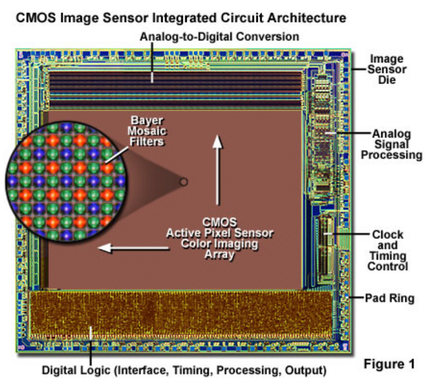

Fig.7: CMOS sensor

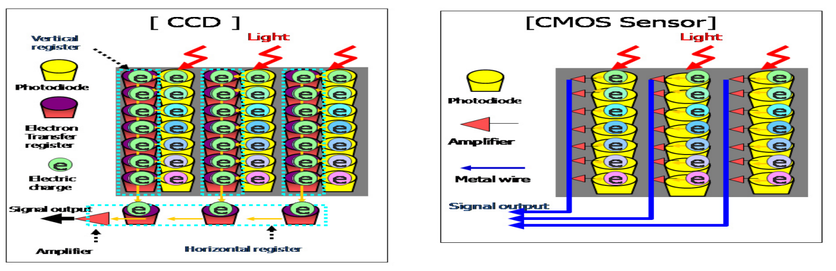

Fig.8: Operation -CCD CMOS sensor

Smarter temperature sensors are needed because the systems in which they are being applied are getting more and more complex. This implies that the designers of such systems will have less knowledge about subsystems such as temperature sensors.

A temperature sensor with moderate accuracy can be integrated within a wireless sensor network (WSN) prototype for environmental applications (–40, +120C).It is based on a temperature dependent current integrating topology.

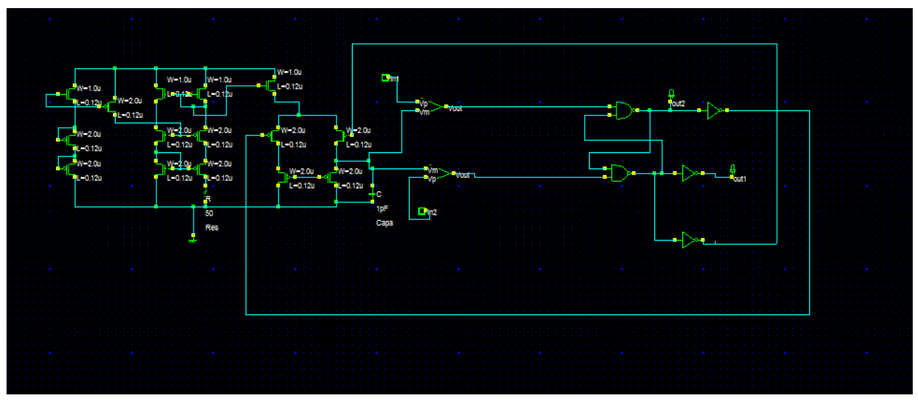

Fig.9: Schematic of Temperature sensor

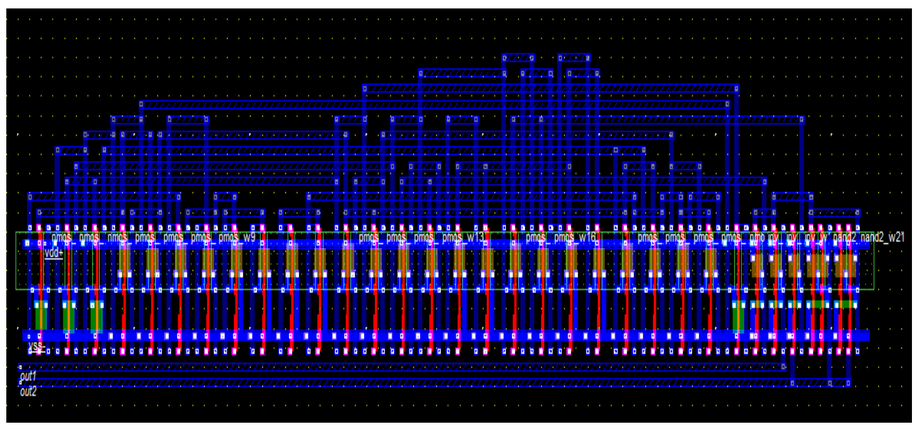

Fig.10: Layout of Temperature sensor

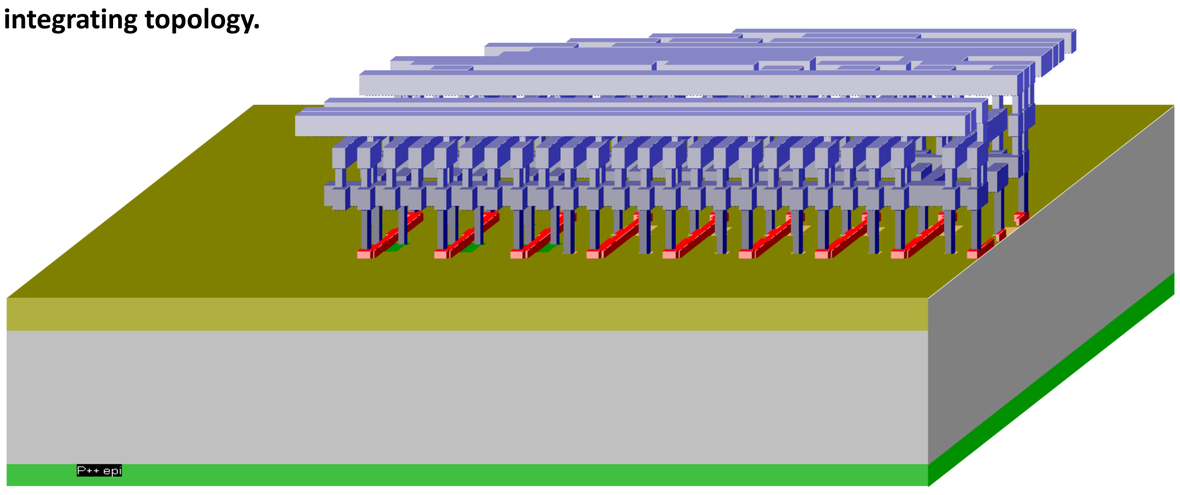

Fig.11: 3D view of Fabrication for Temperature sensor

Conclusion

In this paper, a literature survey was made on sensors implemented with CMOS technology and some of the parameters have been compared and analyzed .It has been observed that this CMOS technology was applied in scientific applications, aeronautical applications as well as image processing fields. Gradually the complexity was also decreased in circuit implementation .We have implemented the Temperature sensor circuit with layout .In order to reduce its power consumption ,low power logic styles will be applied in future work.

Referrences

[1]. Bigas, M., et al., *Review of CMOS image sensors.* Microelectronics Journal, 2006. 37(5): p. 433-451.

[2]. Fontaine, R., *The Evolution of Pixel Structures for Consumer-Grade Image Sensors.* IEEE Transactions on Semiconductor Manufacturing, 2013. 26(1): p. 11-16.

[3]. Theuwissen, A.J.P., *CMOS image sensors: State-of-the-art.* Solid-State Electronics, 2008. 52(9): p. 1401-1406.