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Stereoscopic image sensor in CMOS technology

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Abstract

This paper presents a stereoscopic image sensor in CMOS technology. An array of microlenses (fabricated with post processing techniques) separates the left and right optical channels to form the stereoscopic image. An array of optical filters tuned to the primary colors allows a multicolor usage. The fill factor is increased by applying the Canon's 1.5 transistor (1.5 T) concept and photodiodes with octagonal shapes for increasing the fill factor. The reflow method applied to the AZ9260 thick photoresist allows the fabrication of microlenses with high reproducibility and low cost.

Stereocopic image sensor, microlens, reflow, AZ9260.

1. Introduction

The available image sensors are not ready for stereoscopic acquisition and suffer from two major visualization problems. The first one is the unavailability of image sensors with the necessary specifications, i.e., the present resolution for distal sensors is 800×600 pixels with a pixel-size of 3 μm or above [1]. The second problem is the lack of stereoscopic vision which means exams without or with a deficient depth perception. The stereoscopic vision as well as the high-resolution imaging enhances the quality of the exams. Better resolution allows the medical doctors to understand the status of the patient and to quickly identify health problems. The traditional solution based on two cameras for getting two viewpoints can fail because the viewpoints may be very different amount them, whose consequence is the induction of psicovisual confusion in the medical doctors. This happens due the human brain is significantly more sensitive and less tolerant to bad stereo images. Thus, it can't tolerate differences between the right and left images. To resume, the image sensor presented in this paper provides means to acquire stereoscopic images with high resolution.

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2. Architecture

Figure 1(a) shows the general concept of the miniaturized stereoscopic image sensor. The image sensor is composed by two entrance apertures from where the left and right channels are passing before being focused by an objective lens. The objective focus the two incident beams in the direction of the microlens, where the light is concentrated the in a small area. After the passage by the optical filters, the individual rays coming from each entrance aperture are directed towards the respective CMOS photodiodes. Figure 1(b) shows stereoscopic image formation by microlens and the corresponding focus on CMOS photodiodes. The two viewpoints are separated by focussing each side on respective sensor column.

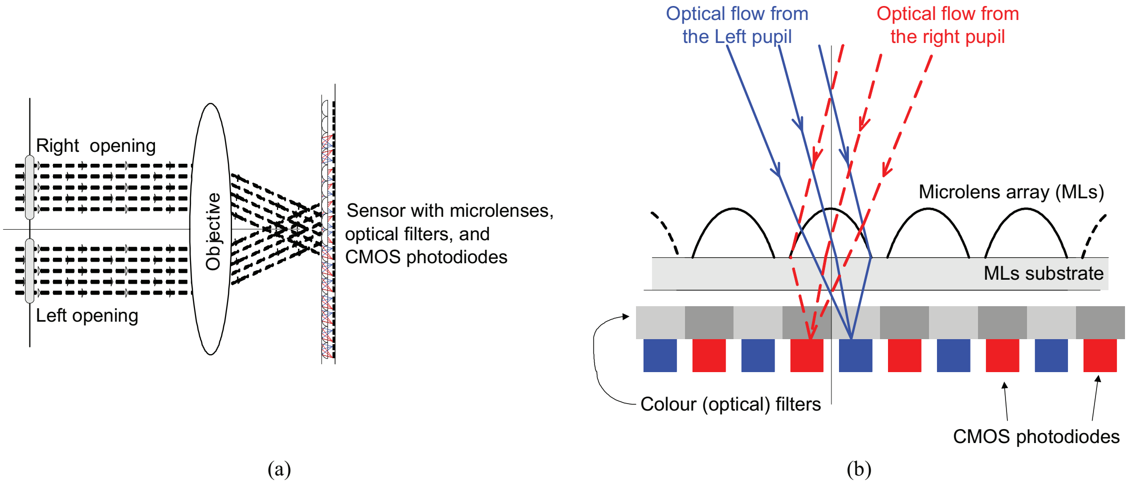

Fig. 1. (a) The architecture of the proposed image sensor in CMOS technology and the concept behind the stereoscopic image formation. (b) The detailed stereoscopic image formation by the microlens..

The photodetector is a n^+/p-epilayer junction photodiode fabricated in a CMOS process, because it provides the best possible quantum efficiency in the desired spectral range of photodiodes available in a CMOS process, at the same time yielding the highest possible fill factor, since a deep n-well is not required for every pixels [2]. A shared-pixel architecture (proposed by the Canon company) uses the 1.5-transistor concept to maximize the fill factor - see the Figure 2(a) [3]. The pixel consists of transfer transistors (M_1, M_2, M_3 and M_4), reset transistor (M_5), amplifying transistor (M_6) and four photodiodes. By using M_5 as a row select transistor, a conventional row select transistor becomes unnecessary. In this architecture, the reset transistor (M_5) and the amplifying transistor (M_6) are shared by four photodiodes (PD_1 to PD_4). As a result, a minimum number of transistors per pixel are necessary. Further improvements of fill factor are expected by using the octogonal shape in the 4-neigbors pixels, because it provides a shared chip-area to integrate the next-to-the-pixel circuitry [4] – Figure 2(b).

The fabrication of thin films with a band-pass around a given wavelength is done by successively depositing different dielectric materials in order to obtain a dielectric multilayer structure. For each primary color, the thin films yield a passband around the respective wavelengths. The green colour requires a special care, since each pixel is composed by a transfer MOSFET, and the amplifier circuit - M6 in Figure 2(a) - is shared - shading in Figure 2(a) - by four neighbours pixels, thus the Figure 2(a) arrangement must be provided: GREEN near red (GnR), red (R), blue (B) and GREEN near blue (GNB), all arranged in two lines [5]. The dielectric materials containing in the optical filters are composed by a stack of TiO2 and SiO2 thin films (refractive indexes in the visible spectrum: about 3.0 and 1.5, respectively). A huge pass-band optical filter on top blocks the nonvisible part of the spectrum.