R&D

Single-chip Compact Super Hi-Vision (SHV) Camera System

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We are researching and developing a new compact SHV camera system with the goal of making 8K (Super Hi-Vision:SHV) program production more mobile. We recently developed compact SHV camera system by a single-chip color imaging method (hereafter called a single-chip system) that uses a single color image sensor without a color separation prism.

Even the smallest camera head of the conventional SHV camera systems includes a special lens that weighs at least 30 kg. The lens uses a prism to separate light into red (R), two green (G), and blue (B) components that are picked up by four image sensors. The size of the camera control unit (CCU), which handles the camera head control and video signal processing is also at least twice the size of the current HDTV broadcasting camera system.

Reducing the camera size requires the development of both a smaller optical system (lens and color separation prism) and a smaller signal processing system for the camera. While the size of the signal processing system can be reduced through higher levels of integration of its electronic circuits, developing a smaller optical system necessitates either reducing the size of the image sensor itself or incorporating a single-chip system with no prisms. However, reducing the size of the image sensor involves using a smaller pixel, which leads to a drastic decrease in resolution and sensitivity. For this reason, we fabricated a new 2.5-inch 33-megapixel color CMOS image sensor that does not need a prism. This resulted in a new single-chip camera system with a sampling structure (Figure 1) and pixel count equivalent to those of a conventional 1.25-inch 8.3-megapixel four-chip SHV camera (Figure 2).

This new camera head weighs 5.3 kg, or less than 10 kg when combined with the lens and viewfinder. Its compatibility with commercially available 35-mm full-frame lenses enables it to be used in various shooting styles. We also achieved a high level of integration of the video signal processing circuit and succeeded in reducing the CCU size to less than half that of the previous model.

Our future work will involve enhancing the camera system's image quality and operability, and we will advance toward the goal of building high-performance single-chip image sensors for shooting full-specification SHV video*.

* SHV video that is compliant with 33 megapixel over RGB, a 120-Hz frame rate, and a wide color gamut (ITU-R BT.2020).

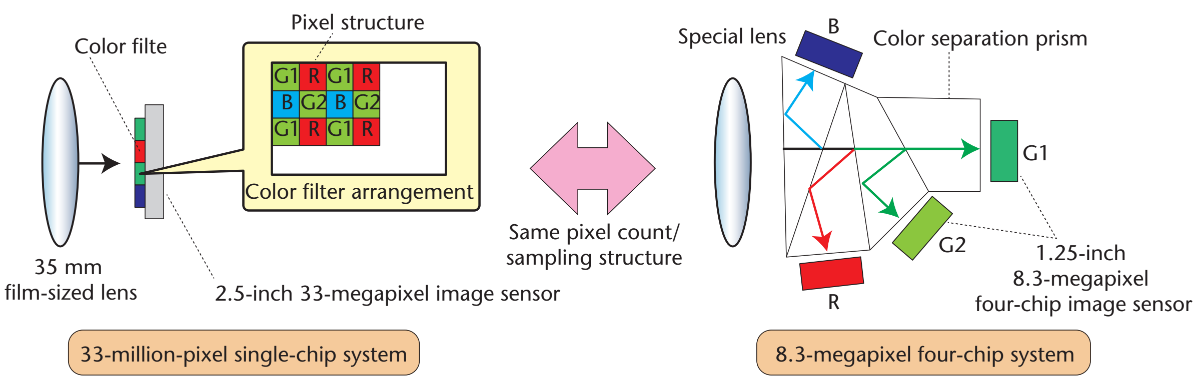


Figure 1: 33-megapixel single-chip system and 8.3-megapixel four-chip system

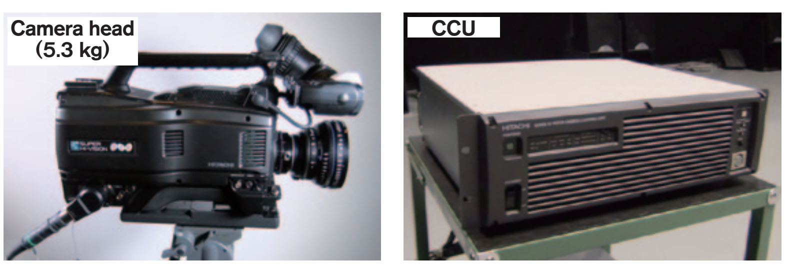
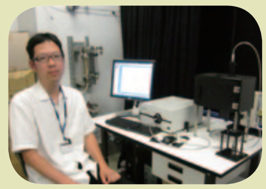


Figure 2: Single-chip SHV camera system

Stacked Organic Photoconductive Films with Narrow Separations for High-Quality Compact Cameras



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The current camera systems generate a color video signal by using either a prism or color filters to separate the incident light into blue, green, and red (the three primary optical colors). However, there are tradeoffs that make it difficult to obtain a small camera with high picture quality. For example, a prism is a bulky device that makes it hard to reduce the size of a camera, whereas a color filter allows for a compact camera but degrades the picture quality such as the sensitivity and the resolution. With the aim of resolving this tradeoff, STRL has suggested a new imaging device consisting of three types of organic photoconductive films; each absorbs only one of the three primary colors and converts it into a charge while the other two are transmitted. These organic films are layered alternately with transparent circuits that read out the charges generated in the individual organic films. This device will eliminate the need for a prism and for color filters, and hence, it will lead to the advent of small, high-quality color cameras.

Approaches and Challenges

STRL is developing an organic imaging device in which organic films and transparent circuits are separated by thin interlayer insulators (Figure 1). The narrow separation (1/100 mm) between the organic films makes it possible for the incident light to be focused on all three organic films without any resolution degradation.

To fabricate this structure, it is necessary to fabricate the interlayer insulator and the transparent circuits at a low temperature, because of the heat susceptibility of the organic film. We reviewed the materials and devised a fabrication process that works at 150°C or less, which is the upper temperature limit of organic films.

Prototype Device

Recently we constructed a prototype device using this low-temperature fabrication technology. In the device, 1/100-mm-thick interlayer insulator sandwiched between green and red organic films and transparent circuits (Figure 2 (a)). We obtained an output image of a subject (the letter "N") colored yellow, green, and red from the device, which indicates that the green and red colors were clearly in focus and confirms the effectiveness of our approaches (Figure 2 (b)).

Our future work will enhance the resolution by increasing the pixel number of the transparent circuit, and the construction of a prototype device that will have three narrowly separated organic films.

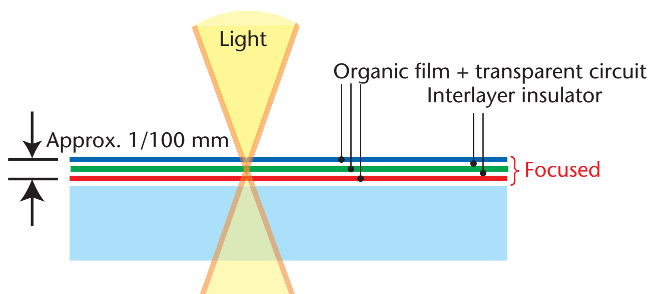
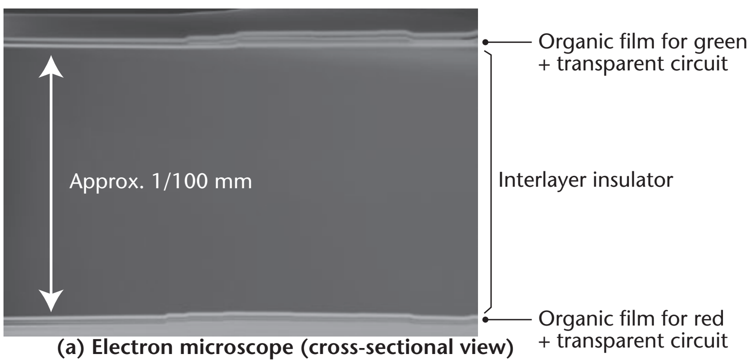
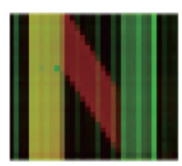


Figure 1: Organic imaging device with narrowly separated organic films



(a) Electron microscope (cross-sectional view)



(b) Shooting result

Figure 2: Prototype imaging device with closely aligned organic films

R&D

Spin Light Modulation Device Based on Tunnel Effect

STRL is developing a spatial light modulator as a holographic display device for a future three-dimensional television system that can reconstruct natural stereoscopic images. This modulator displays three-dimensional images by electrically changing the spatial distributions of the amplitude, phase, and polarization of incident light from an optical source by using a two-dimensional array of micro-optical devices, called light modulators.

Displaying natural three-dimensional movie by using holography will require fast-responding spatial-light modulators with micrometer resolution. STRL has developed a spin light modulator with these characteristics. This device is made of a magnetic material, and its magnetization direction is reversed when electrons with a uniform spin*1 are injected into it. This behavior is a result of a physical phenomenon called spin-transfer switching. The uniform magnetization direction then induces the magnetic Kerr effect, which produces a rotating light polarization plane. These two physical phenomena enable this spin-injection device to modulate light.

However, the magnetization reversal of the previous devices required a large electric current. For this reason, we fabricated a spin light modulator based on the tunnel effect*2. This new modulator has a three-layer structure consisting of a pinned layer with a fixed magnetization direction, an insulating (spacer) layer, and a light modulation layer that is capable of changing the magnetization direction (Figure). When a voltage is applied to this device, the tunnel effect causes an extremely small current (tunnel current) to flow through the insulating layer, where a current would not ordinarily flow. This tunnel current corresponds to a highly efficient flow of electrons with a uniform spin direction, and it enables a magnetization reversed with a small amount of current.

A two-dimensional array of these devices makes it possible to modulate light electrically and make a three-dimensional movie. Our future work will involve verification of the spin-transfer switching of this device and the development of fast ultrahigh-definition spatial-light modulators.

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*1 Spin: one of the properties of the electron. Spin has two directions, up and down, and it interacts with the magnetization directions (North and South).

*2 Tunnel effect: a phenomenon that electrical current flows through a very thin (approx. 1/10,000 mm) insulator sandwiched between two metal upon application of a voltage.

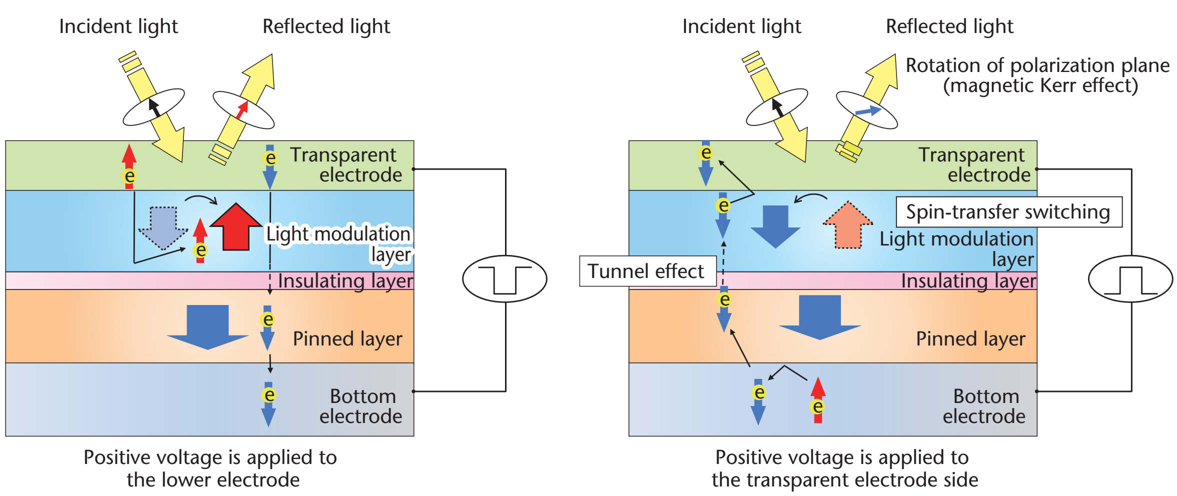

Figure: Structure of spin light modulation device based on the tunnel effect