Column

Butterflies, MEMS, and Displays

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It seems that printed materials and computer displays have become very colorful these days. In my school days and when I join the faculty, I remember that the computer displays were monochrome CRT monitors that displayed green text on a black background, and the more expensive displays depicted green graphics with electron beams. Then before I knew it, these monitors had been replaced by LCD monitors in high-resolution color. In the days leading up to this years Olympics, electronic shops in Akihabara and Shinjuku have been overflowing with large displays projecting beautiful pictures. I believe displays will further evolve toward three-dimensional stereoscopic images in more realistic colors.

It should be possible to produce devices with high added value using MEMS to implement functions expressed in nanoregions. While carbon nanotubes and quantum dots have attracted much attention as devices used on a nanoscale, light interference is a phenomenon that involves wavelengths of light, which are on the order of submicrons. Accordingly, we could call light interference a function manifested on a nanoscale. While carbon nanotubes and quantum dots have recently been created artificially, objects in which the phenomenon of light interference can be observed have existed in the natural world since long ago.

These photos taken by Eiji Iwase depict a Morpho butterfly and its scales. A Morpho butterfly does not produce colors through pigmentation in its wings. Rather, light is reflected and diffracted by minute three-dimensional structures in the surfaces of the scales and appears to our eyes as beautiful colors through light interference. The wavelengths of light that can be seen through interference depend on the surface structure. Hence, the colors can be changed by changing the structure of the surface. Changing microstructures of a surface is a specialty of MEMS to achieve an effect considerably different from the fixed light wavelengths produced from LED illumination and pigments.

Humans have photoreceptor cells corresponding to the RGB (red, green, and blue) colors. When light enters the human eye, these photoreceptor cells read wavelengths of the RGB components and see combinations of the component magnitudes as colors. However, the photoreceptor cells of insects are different from those of humans, possessing a sensitivity to light having wavelengths different from the RGB wavelengths. In other words, insects apparently receive different visual stimuli from that received by human photoreceptor cells when humans view nature. In previous discussions with researchers who observe the behavior of insects while shining lights on their visual systems, they asked me if it would be impossible to create an LCD panel that could be used to visually stimulate insects. Certainly our liquid crystal displays use only RGB components, which cannot stimulate photoreceptor cells sensitive to UV rays.

While LCD monitors depict colors by combining illumination and intensities of the three primary colors of light, the colors obtained from this display represent only a portion of the colors in nature. In other words, these representations are missing data for light of wavelengths other than the three primary colors and data of light spectrums dependent on the direction of light reflection. Therefore, while light produced by these displays appears somewhat natural to humans, it cannot be said to reproduce nature.

Enter MEMS. If MEMS can be used to freely adjust the spectrum of light rays emitted into space at each point of the display, it should be possible to reproduce sensations of light dependent on the positions of the light sources, objects, and the eye, such as a silver-like metallic luster. MEMS are also effective for incorporating light-emitting elements having wavelengths other than RGB in displays.

So how, specifically, can we implement these ideas? I heard that a mathematician once said, "I have proved it, but there is not enough space to write it down." In the same way, I would like to say that I have an idea, but there is not enough space in this paper to explain.

Photo 1 The Morpho butterfly

Photo 2 An enlarged view of the wing scales

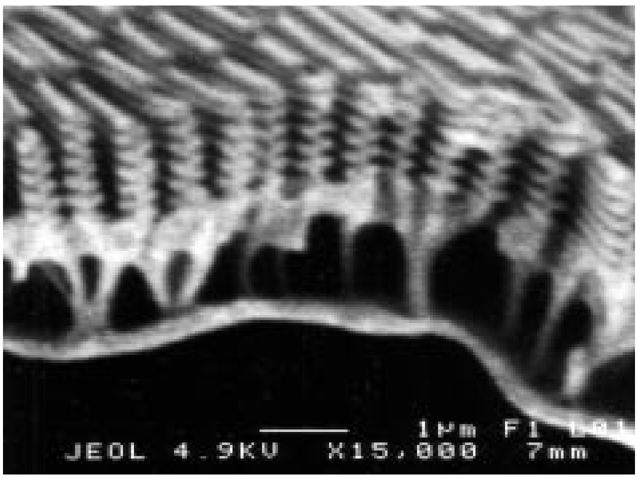

Photo 3 A cross-sectional view of the scales further enlarged; the microstructure of the scales produces beautiful colors through light reflection, diffraction, and interference