Stack organic films and capture light! Recent research progress on organic imaging devices

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In recent years, the resolution of imaging systems, such as 8K Super Hi-Vision, has become even higher, and the number of pixels of imaging devices (which capture light and convert it to electric signals) has increased considerably. It is, however, a problem that as the number of pixels of imaging devices increases, the area per pixel decreases, and the amount of light entering each pixel also decreases, thereby decreasing the sensitivity of the devices. Furthermore, in the case of an imaging device for a compact camera, a color filter array is arranged on each pixel, and each color filter transmits only one of the three primary colors of light, i.e., red, green, and blue [see Fig. 1 (a)]; due to this filter array, the decrease in sensitivity of the device becomes more noticeable.

NHK STRL is advancing research on organic imaging devices that will form the basis of a compact, high-resolution camera. In the part of an organic imaging device that captures light, three different organic photoconductive films (organic films) are used in a stack instead of silicon photodiodes as conventionally used [Fig. 1 (b)]. Each organic film has the property that it only absorbs one color of light from the three primary colors and converts it into an electric signal while letting light of the other colors through; accordingly, it is possible to separate the colors by stacking films that absorb/transmit red, green, and blue. This structure enables all three primary colors of light to be captured with one pixel, making it possible to create a compact, high-sensitivity, high-resolution imaging device.

Since the above-described organic imaging device uses organic films stacked on top of each other, each organic film is sandwiched by transparent electrodes. During the fabrication of the device, the organic film can be damaged, especially when the upper transparent electrode is being formed on it; accordingly, to protect the organic film, a protective layer between the organic film and the upper transparent electrode is needed. Conventional protective layers have to be formed that are several times thicker than the organic films, and owing to this requirement, it has been difficult to increase the efficiency of converting light into electrical signals [Fig. 2 (a)]. In the present study, by reviewing the material of the protective layer and the method of forming the upper transparent electrode, we were able to reduce the thickness of the protective layer to less than one-tenth of the conventional thickness [Fig. 2 (b)]. As a result, the efficiency of the organic film for green light, which is conventionally around 10%, was increased to 80%. Our next aim is to create a compact, high-quality, image-pickup device for 8K cameras by also increasing the efficiency of the organic films for red and blue light.