Optically Controlled Quantum-Dot-Based Volumetric Display Exhibiting Multiple Patterns

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1. Introduction

Volumetric displays are those of the displays which can represent natural 3-D images. Unlike conventional 2-D displays, volumetric displays have depth information and enable 3-D images to be observed from any surrounding viewpoint. One of the methods to make volumetric displays represent color and motion 3-D images is an electrical controlling. Actually, we can easily get electrically controlled volumetric displays consisting of arrays of light-emitting diodes arranged in a 3-D layout as products.

However, the electrical controlling has an inevitable issue called “occlusion” because it needs an electrical wiring for power supply. The issue of occlusion means that volume elements (voxels) are physically hidden by the wiring or other voxels. The issue prevents the volumetric displays from being more high-definition and reduces an image quality. Therefore, in this study, we propose an optically controlled volumetric display based on quantum dots (QDs) which don’t need electrical wiring [1].

2. Material and Method

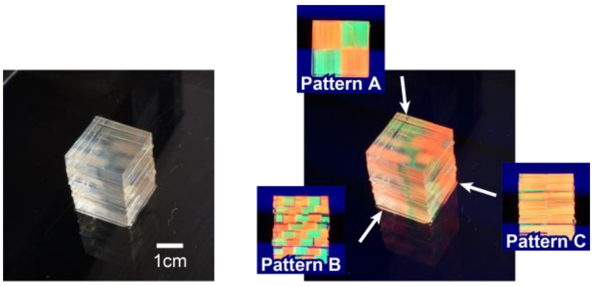
QDs are nanoscale semiconductor devices and have many unique properties. For example, they can emit light with various colors depending on their size by external light irradiation. Furthermore, QDs exhibit higher quantum efficiencies and narrower emission spectra than other luminescence materials. In addition, QDs achieve a 3-D layout at high-definition because they are nanoscale devices and don’t need any wiring. These properties are great benefit to the volumetric displays. Moreover, we consider that an optical energy transfer between different sized QDs will provide additional functions to the volumetric displays.

In this study, we demonstrate the QD-based volumetric display that exhibits three different 2-D patterns A, B and C that may be viewed simultaneously from three orthogonal viewpoints. Here, the patterns A, B and C are the checkered (red and green), the striped (red and green) and the uniform (yellow) patterns, respectively. Although the volumetric display designed in this study can exhibit only simple three patterns, we’ll be able to design a volumetric display which represents arbitrary numbers and arbitrary patterns by using an algorithm proposed by Nakayama *et al.* [2].

To fabricate the QD-based volumetric displays, we need to prepare voxels composed of the QDs. Thus, we fabricated QD voxels by solidifying the mixture of QDs and transparent heat-curable polymer. QD voxels can represent any color depending on a kind of QDs. We prepared two kinds of voxels which emit red and green light, respectively. Further, we constructed the volumetric display by arranging the voxels according to the design.

3. Result

Figure 1 shows a prototype of the QD-based volumetric display composed of 5×5×5 voxels. Under natural light, the volumetric display emits essentially no visible light (Fig. 1a). When we irradiate ultraviolet light to provide power supply, 3-D color image appears and we can simultaneously observe three 2-D patterns form different viewpoints (Fig. 1b). We confirmed the volumetric display can represent multi-color which is not only red and green, but also yellow (a color between red and green).



a b

Figure 1 Prototype of the QD-based volumetric display. (a) View under natural light. (b) View when excited by ultraviolet light.

4. Conclusions

In this study, we proposed the QD-based volumetric display and demonstrated it. From experimental results, we confirmed that the QD-based volumetric display can represent multi-color 3-D images without the issue of occlusion.

In future work, we’ll develop the new system which enables us to optically access individual voxels for representing motion images. Furthermore, we’ll establish automating fabrication process to achieve more high-definition.

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References

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