Patterned Glass Etching for Popping-Up Signage

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ABSTRACT

We propose a new optical component for hygienic glass cover that shows popping-up signs. A low-cost and highly flexible design of Arc 3D was successfully achieved by a patterned glass etching method. A 3D display can be easily installed with only a single piece of glass and a light source.

1 INTRODUCTION

The new coronavirus wreck has led to increased attention to hygiene issues. Today, people are frequently required to wash their hands and disinfect with alcohol. However, risks arise with touching machines. The operation of machines is essential for daily life. A lot of buttons are used in operation of machines, including elevators, doors, vending machines, switching light, air conditioners, and so on.

In public places, buttons that are touched by an unspecified number of people pose a hygiene problem. Therefore, the display of guide marks in mid-air and the sensing of pressing gestures are important technologies to enable the user to operate buttons without touching them.

Furthermore, there are too many different button symbols for different types of machines. Arc 3D is an aerial display method generated by scratches on an arc, which is characterized by a low-cost, smooth motion field of view and wide viewing angle [1-3]. Since an aerial display can be generated by processing the surface of an acrylic plate, it can be installed on existing buttons as a retrofit.

However, the conventional arc 3D is mainly produced using special tools such as a compass cutter, and it takes time to produce the parts sequentially. In addition, the arc3D substrate must be disinfected, and the substrate must be highly resistant to chemicals.

This paper proposes a new optical component for the use of hygiene glass cover with a popping-up signage. We clarify the possibility of realizing arc 3D on a glass substrate by using patterned etching method. Then, we compare the effect of pattern groove depth for arc 3D.

2 PRINCIPLE

Fig.1 shows the principle of arc 3D. Arc-shaped scratches are fabricated on a transparent substrate. Since the scattered light of a scratch has directionality, the bright points on an arc illuminated with a single light source are different for both eyes. This difference gives binocular parallax. Moreover, the bright points move accordingly when the viewing position changes. Thus, these binocular and motion parallax give depth perception. It has been reported that the perceived distance is proportional to the radius of the arc [2]. When the illumination light is applied to an arc 3D substrate, the conical scattered light in a limited range is visible. Thus, one bright point corresponds to one arc. A figure is constructed by connecting these bright points with many arcs. A conventional arc 3D is shown in Fig. 2. Bright points composes a face with a depth.

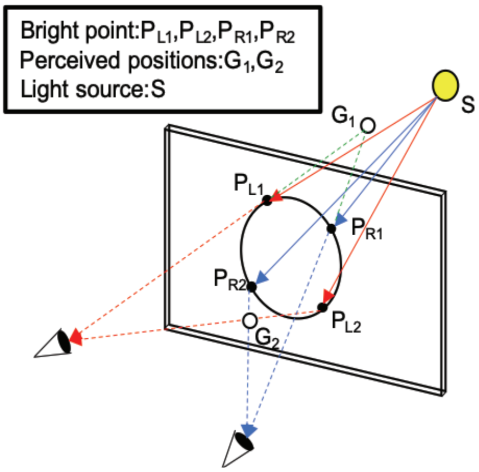


Fig. 1 Schematic diagram showing principle of Arc 3D.

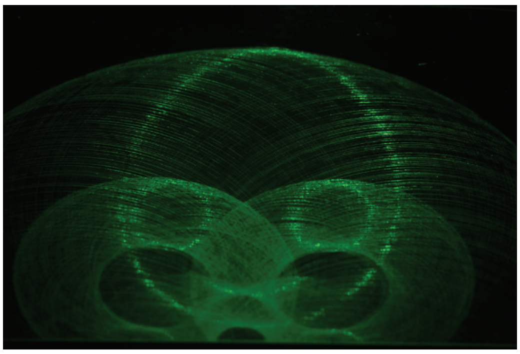


Fig 2. Conventional arc 3D fabricated on a plastic substrate with a compass cutter.

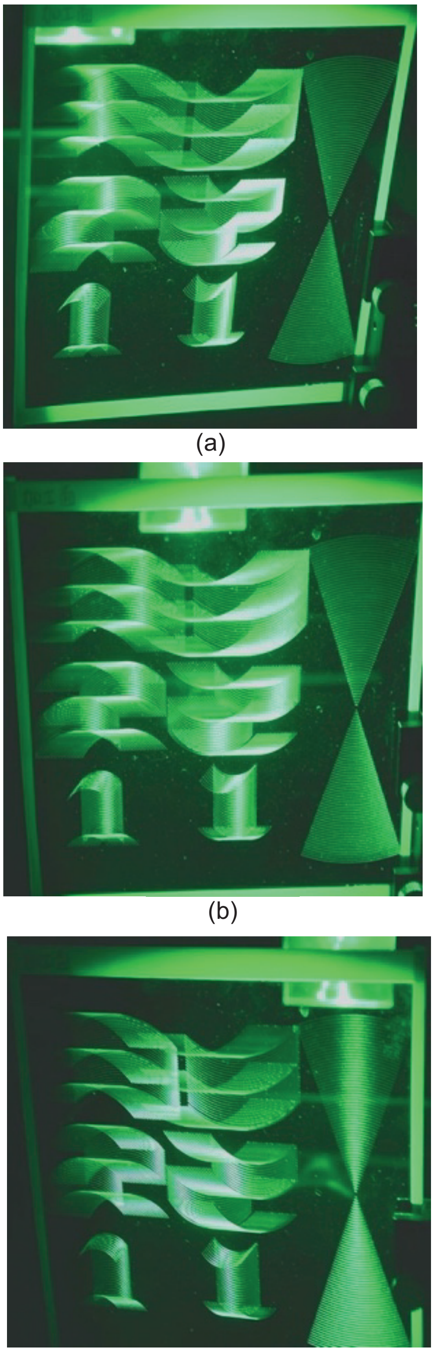
3 EXPERIMENTS

3.1 Arc 3D by pattern etching method.

We have fabricated arcs on a glass substrate in a chemical etching process, which enables us to fabricate plenty of arcs at the same time by use of a mask pattern. Fig. 3 shows viewed results of our developed Arc 3D glass that was illuminated by a quasi-parallel light. The photographs of the arc 3D glass were taken from the left to the right. We have confirmed that the bright points are moving on the arc depending on the viewing position.

3.2 Arc 3D with extremely shallow and thin line widths

We have tried making more thin arcs. Fig. 4 shows an arc 3D glass with a very thin and shallow line width. These photographs were taken from the left to the right as in Fig. 3. Uniformly scattered lights on the arcs were reduced. Thus, the glass plate looks transparent.

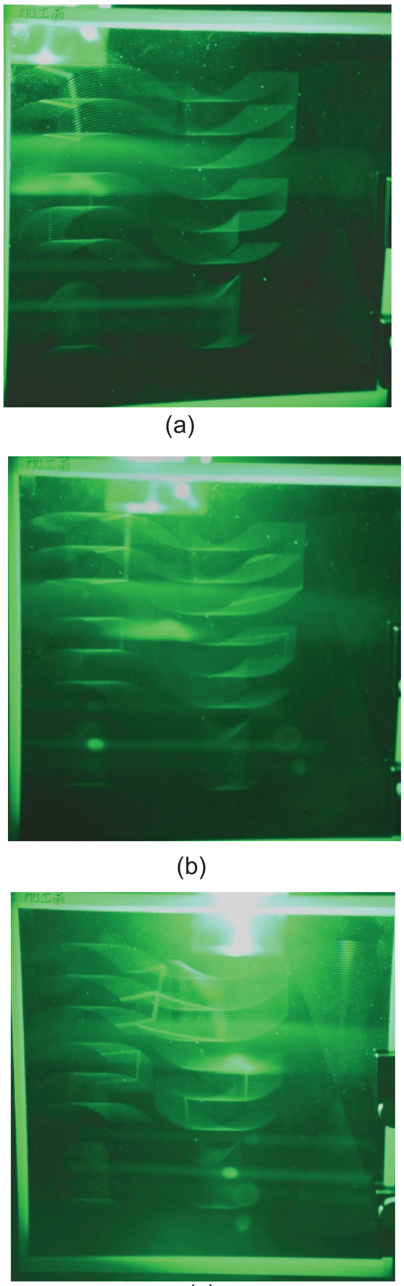


(a)

(b)

(c)

Fig.3 Arc 3D on a glass substrate (#1) viewed (a) from the left, (b) in front, (c) from the right.



(a)

(b)

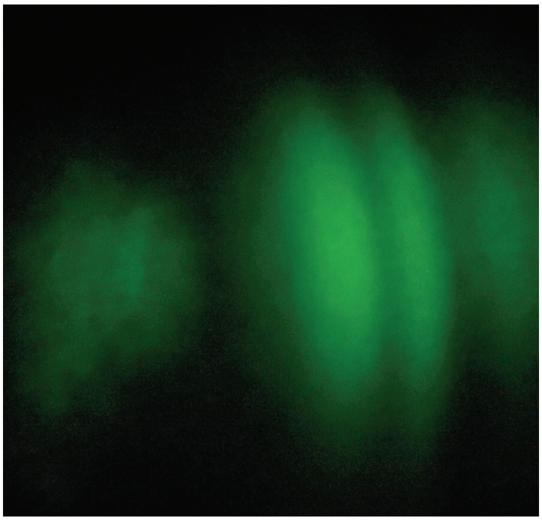
(c)

Fig. 4 Arc 3D with extremely shallow and thin line width (#2), (a) from the left, (b) in front, (c) from the right.

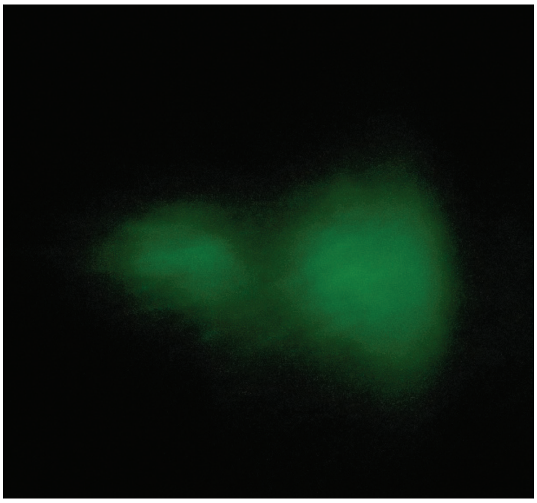
3.3 Comparison of the two type of arc 3D

This section compares the Arc 3D in Fig. 3 (hereinafter referred to as #1) with the Arc 3D in Fig. 4 (hereinafter referred to as #2). The clarity of each point with arcs is better in #2. In #1, a point appears to be spread out and the number lines displayed in Arc 3 are hard to see. In #2, each point is visible, and the number lines displayed in Arc 3D are clearly visible. On the other hand, #1 is better for the viewing angle. When viewed from the front, all the numbers from 1 to 3 are visible in #1, whereas 3 and 2 are barely visible in #2. The same was true for the and right viewing angles

Fig. 5 shows images of the scattered light in the #1 and #2 grooves. The light from a laser pointer is shone on a groove and the scattered light is projected onto a screen. The left side of the image is the laser pointer and the right side is the scattered light. It is clear that the scattered light of #2 is weak in comparison.



(a)



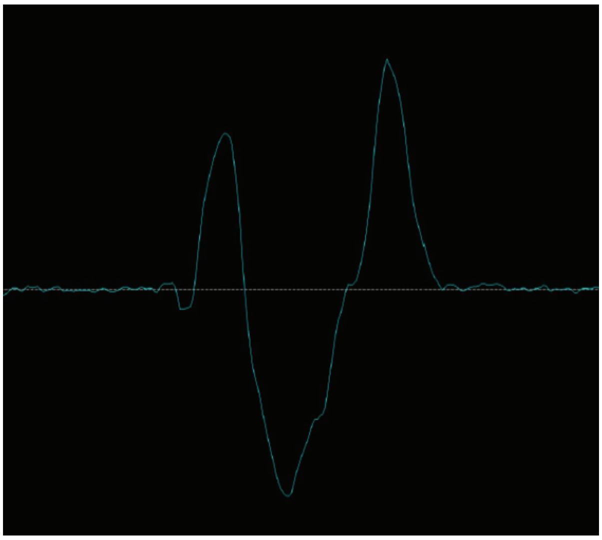
(b)

Fig.5 Comparison of scattered light in (a) the arc 3D glass #1 and (b) the arc 3D glass #2.

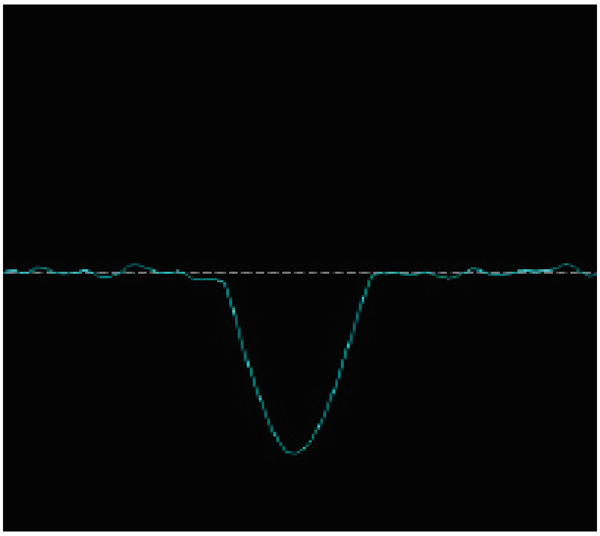
(a) is #1, (b) is #2.

3.4 Comparison by cross-section of the arcs

This section compares the cross-sectional data of an acrylic plate made with a compass cutter and the cross-sectional data of an arc 3D glass fabricated by patterned glass etching method. Cross-sectional data of the two types of arc 3D displays are shown in Fig. 6. Comparing the arc made with a compass cutter (Fig. 6(a)) with those processed by patterned glass etching (Fig. 6(b)), the glass-etching arc is smoother in shape. On the other hand, the arc scratch made with the compass cutter had some raised areas on both sides of the grooves.



(a)



(b)

Fig. 6 Cross-sectional data of the arcs. (a) Arc was made on an acrylic plate by use of a compass cutter. (b) Arc was processed on a glass plate by the pattern etching method.

4 DISCUSSION

Arc 3D by a pattern glass etching method was used as an optical component for the aerial display of aerial buttons to enable low-cost and highly flexible design. There are some problems with arc 3D (#2) by the pattern etching method. Firstly, although the bright spots are in #2, the positions where they can be seen are very limited in the top, bottom, left and right of the screen. As shown in Fig. 5, the scattered light is so weak that we cannot see the bright spots when we look at them from a little bit off from the position. Secondly, the light appears to be distorted, and in Fig. 3, the upper center of the figure appears to be distorted to the left and right, making it difficult to read the displayed numbers. Because the angle of view is narrow, it is necessary to hit the light source close to the line of sight, which may affect the position of the bright spot. Third, the display appears to be double. In some cases, a display close to the light source appeared to be double-vision when viewed with both eyes. Since these problems are not felt in #1, it is possible that there could be better conditions between #1 and #2 regarding the line width and depth of the groove. In the future, it is necessary to verify the conditions under which clear and wide viewing angle can be obtained.

Moreover, the cross-sectional data show that the grooves generated by the compass cutter are raised on both sides of the grooves. In contrast, the grooves generated by glass etching method do not have a raised edge on both sides of the grooves. The grooves are uniform and smooth. The bright spots in the arc 3D glass appear to be bright spots when lights scattered in the grooves enter the eyes. However, the raised side of the acrylic panels may cause the scattered light from the grooves to impinge on the raised area, increasing the extra scattering and blurring the bright spots.

5 CONCLUSIONS

Arc 3D display was successfully realized by the grooves fabricated on a glass substrate by chemical pattern etching method. The developed Arc 3D features low cost, high design flexibility, and high chemical resistance. In addition, the depth and width of the arc grooves on the substrate significantly changed the visible bright spots, so it is necessary to verify the optimal conditions

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