Driving Waveform for Removing Temporal Dark Image Sticking in AC Plasma Display Panel

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ABSTRACT

The experimental observation on the IR emission during a ramp-up reset period shows that the activated MgO surface and the wall charges accumulating on the address electrode prior to the reset period are two dominant factors for a temporal dark image sticking phenomenon. The new driving waveforms, including pre-reset and reset waveforms, and negative-going ramp-type X bias, are proposed for a complete elimination of the temporal dark image sticking without deteriorating the address discharge characteristics. As a result of monitoring the difference in the IR emission and luminance between the cells with and without image sticking, it is observed that the proposed driving waveform can remove the temporal dark image sticking completely without deteriorating the address discharge characteristics.

Ⅰ. INTRODUCTION

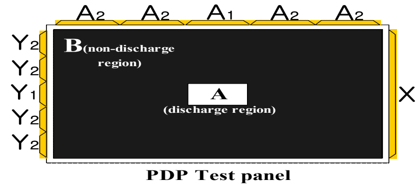
Despite the suitability of flat panel devices for digital high definition television, plasma display panels (PDPs) still suffer from the critical problem of image sticking, where a residual image appears in a subsequent image when the previous image was continuously displayed over a few minutes. When the appearance time of the ghost image is relatively short, such temporal image sticking is also referred to as image retention. Although the iterant strong sustain discharge during a sustain-period is known to induce an image sticking problem, the image sticking phenomenon is not still fully understood [1, 2, 3, 4, 5]. As such, this paper focuses on the temporal dark background image-sticking problem. Our experimental observation illustrates that the activation of MgO surface and the wall charges accumulating on the address electrode, which are induced by a strong sustain discharge, are closely related to the temporal dark image sticking phenomenon.

Accordingly, this paper proposes a new driving waveform that can minimize the MgO effect in reset discharge during the ramp up-period and erase the wall charges accumulating on the address electrode prior to the reset-period without deteriorating the address discharge characteristics. To compare the effects of both conventional and proposed driving waveform on the temporal dark image sticking, the IR emission and luminance during the ramp-up period are examined using the luminance analyzer (CS-200) and photo-sensor amplifier.

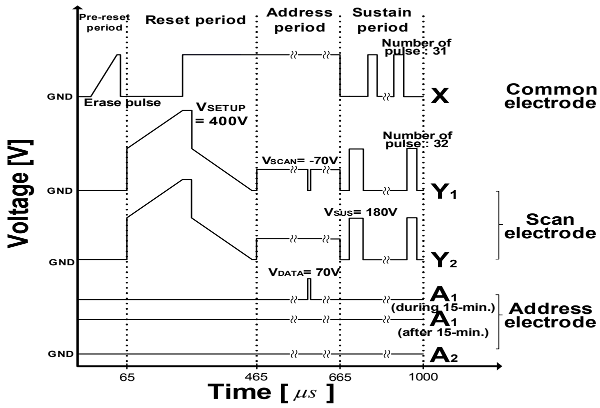
Ⅱ. ANALYSIS OF TEMPORAL DARK IMAGE STICKING IN AC-PDP

A. Driving Waveform for Producing Temporal Dark Image Sticking

Figs. 1 (a) and (b) show the (a) 4-in. test panel and (b) driving waveform employed in this research for producing the temporal dark image sticking. To produce the image sticking cell, a sustain discharge on the square-shaped pattern (region A) shown in Fig. 1 (a) was produced repeatedly for 15- min. where the driving waveforms shown in Fig. 3 (b) are applied to the three-electrode. To produce a residual image caused by the image sticking, the entire region of the test panel was abruptly changed to the dark background image immediately after the 15-min. sustain discharge.



(a)



(b)

Fig. 1. (a) 4-in. test panel and (b) driving waveforms employed in this research for producing temporal dark image sticking.

B. Temporal Dark Image Sticking Phenomenon and its measurement

Fig. 2 (b) illustrates the retention of square-shaped image pattern under the ensuing dark background image immediately after (a) a fifteen-minute sustain discharge. Since the dark ghost image only lasts for a certain time, the phenomenon is called 'temporal dark image sticking'. As shown in Fig. 2 (b), the ghost image, *i.e.*, square-shaped image pattern, appeared due to a background luminance difference (ΔL= 0.14 cd/m^2) between the cells with and without image sticking under the dark background, indicating that temporal dark image sticking is closely related to the reset discharge during the reset-period [2]. As shown in Fig. 2 (b), the temporal dark image sticking can be measured in terms of the luminance difference between the image sticking and no image sticking cells. Fig. 3 shows the changes in IR (828 nm) emissions measured from the cells with and without image sticking when applying the conventional ramp-type reset waveform during a reset-period. As shown in Fig. 2 (b), in an image sticking cell, the IR emission was observed to be shifted to the left, indicating that the firing voltage was reduced in the image sticking cell due to the MgO activated surface [2]. Accordingly, the temporal dark image sticking can be measured from the luminance or IR emission difference between the cells with and without image sticking.

In addition, due to the MgO surface activation caused by the iterant strong sustain discharge, the reduction of the firing voltage during a ramp-up period cause a temporal dark image sticking, as shown in the IR emission data of Fig. 2 (b). As a result, the reset discharge related to the activated MgO surface needs to be minimized for reducing the temporal dark image sticking. In this sense, the new driving waveform is proposed and its function is investigated carefully as follows.

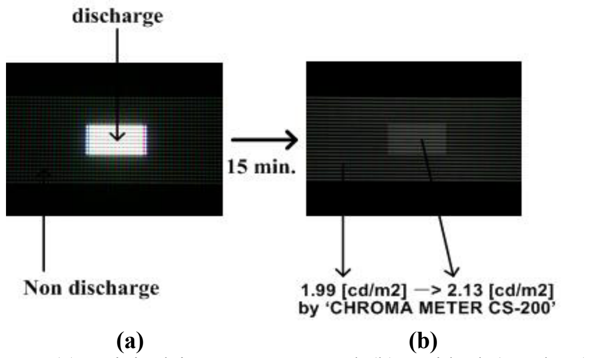


Fig. 2. (a) Original image pattern and (b) residual (or ghost) square-shaped pattern under dark background captured from 4-in. test panel.

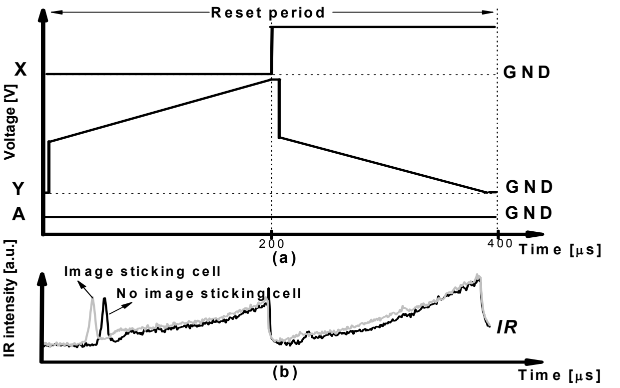


Fig. 3. (b) Changes in IR(828nm) emissions measured from cells with and without image sticking when (a) applying conventional ramp-reset waveform.

Ⅲ. DRIVING WAVEFORM FOR REDUCING TEMPORAL DARK IMAGE STICKING

A. Two Critical Factors for Temporal Dark Image Sticking

(1) Up-going Ramp Waveform Due to MgO Activation

Fig. 4 (a) shows the proposed ramp waveform using a plate gap reset discharge between the Y and A electrodes, where the ramp waveform applied to the Y electrode is similar to that in the conventional ramp waveform [3], but another ramp wave- form with the same voltage slope of 1.22 V/μs as that applied to the Y electrode is applied to the X electrode. This another ramp waveform applied to the X electrode plays a role in minimizing the reset discharge between the activated MgO surfaces. As shown in the IR emission data of Fig. 4 (b), the amount of IR emission were very low for both types of cell (*i*.e., cells with and without image sticking), because the reset discharge was predominantly produced between the scan (Y) and address (A) electrodes due to the ramp reset waveform using a plate gap reset discharge. As a result, the background luminance was considerably reduced, and no dark image sticking was invisible when the original white image pattern displayed for 15 minutes was abruptly changed to a dark background, as shown in Fig 5 (b). However, as seen in Figs. 4 (b) and 5 (b), this proposed waveform showed the misfiring discharge due to the unstable reset discharge, and the slight difference in the IR emission for both cells. The misfiring discharge shown in Fig. 5 is thought presumably due to the insufficient initialization caused by the plate gap reset discharge.

(2) Difference in Wall Charges Accumulating on Address Electrode Prior to Reset discharge Between On- and Off-Cells

The difference of the amount of wall charges accumulating on the address electrode prior to the reset period between the cells with and without image sticking is another dominant factor for causing a

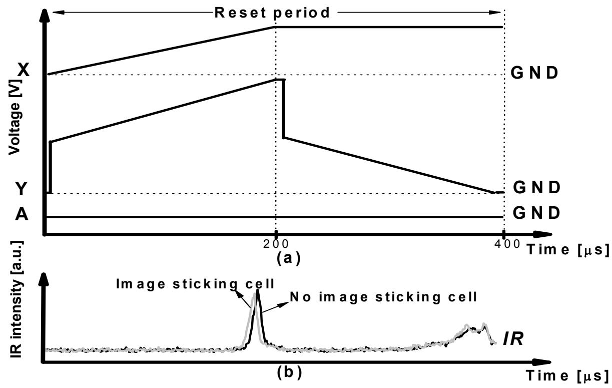


Fig. 4. (a) Proposed reset waveform for producing plate gap discharge (Case 1), and (b) changes in IR (828 nm) emissions measured from cells with and without image sticking when applying proposed reset waveform.

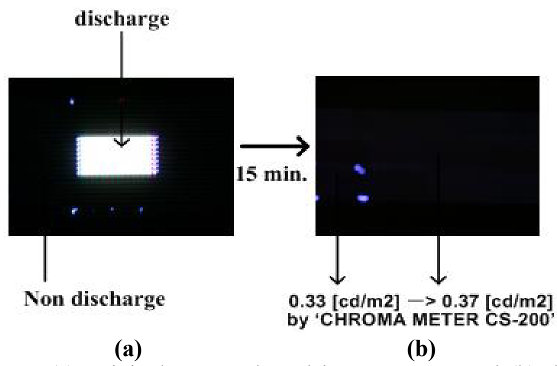


Fig. 5. (a) Original square-shaped image pattern and (b) dark background image pattern after fifteen-minutes display of original square-shaped image pattern when using proposed face reset discharge waveform.

temporal dark image sticking. To minimize the difference of the wall charges for both cells, the ramp-type pulse is newly applied to the address electrode as a pre-reset pulse between the erase pulse and ramp-up pulse, as shown in Fig. 6. It is expected that the proposed ramp-type address pulse will erase the wall charges accumulating on the address electrode prior to the reset-period, thereby contributing to the initialization of the wall charges for both cells with and without image sticking. Fig. 7 shows the changes in the IR emission during the ramp-up period for the cells with and without image sticking when applying the conventional [Fig. 6 (Ⅰ)] and proposed ramp-type address pre-reset pulse [Fig. 6 (Ⅱ)]. In the case of adopting the proposed pulse shown in (Ⅱ) of Fig. 6, the firing voltages for both cells with and without image sticking

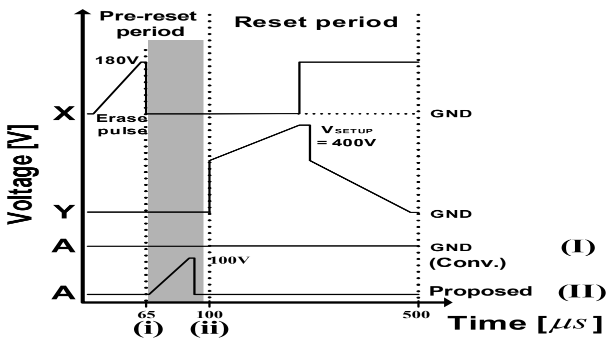


Fig. 6. Proposed ramp-type address pre-reset waveform for initializing wall charges in reset period.

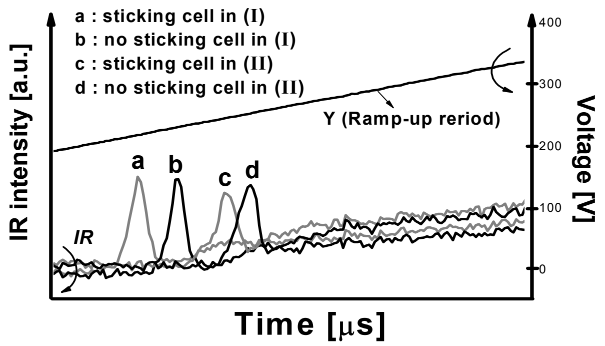


Fig. 7. Changes in IR (828nm) emissions measured from cells with and without image sticking when applying conventional waveform and proposed ramp-type address pre-reset waveform.

was increased and the firing voltage difference between both cells with and without image sticking was also reduced slightly. Furthermore, their IR intensities were also reduced. These changes are induced by the removal of the wall charges accumulating on the address electrode, especially for the imaged sticking cell where the iterant strong sustain discharge has been produced. To investigate the changes in the wall voltage relative to the pre-reset voltage, the Vt close curve was measured before [(i) in Fig.6] and after [(ii) in Fig.6] applying the pre-reset pulse. As shown in Fig. 8, the firing voltage between the Y-A electrodes was increased in proportion to the increase in the voltage of the proposed pre-reset pulse, which means that the large amount of the wall charges on the three electrodes, especially the address electrode prior to the ramp-up period has been erased considerably. The result of Fig. 8 indicates that the proposed pre-reset pulse contributes to alleviating the difference in the ignition time and intensity of the IR between the cells with and without image sticking even under the activated MgO surface condition.

B. Proposed Driving Waveform for Reducing Temporal Dark Image Sticking Based on Two Critical Factors

For minimizing the MgO effect in the reset discharge during the ramp-up period and erasing the wall charges accumulating on the address electrode prior to the ramp-up period, the new driving waveform (case 2) shown in Fig. 9 is proposed to reduce the temporal dark image sticking. The driving waveform of Fig. 9 can erase the wall charges accumulating on the address electrode prior to the ramp-up period, as shown in the IR emission data of Fig. 10. Due to the plate gap reset discharge plus the elimination of the wall charges, the ignition time and intensity of the IR (828 nm) emission waveforms were observed to have no difference between the cells with and without image sticking, as shown in Fig. 11 (b). In this case, the very slight luminance difference (ΔL=0.02: this level is no perception level in human eye) was observed, as shown in Fig. 12 (b). Furthermore, in this proposed waveform, any unstable discharge was not observed, but the subsequent address discharge characteristics were a little deteriorated, as shown in Table.1

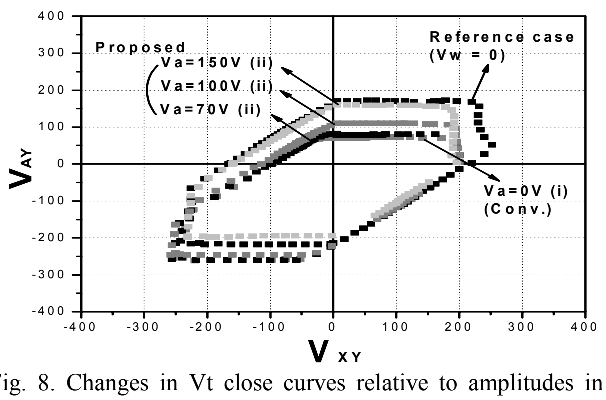


Fig. 8. Changes in Vt close curves relative to amplitudes in proposed ramp-type address pre-reset waveform.

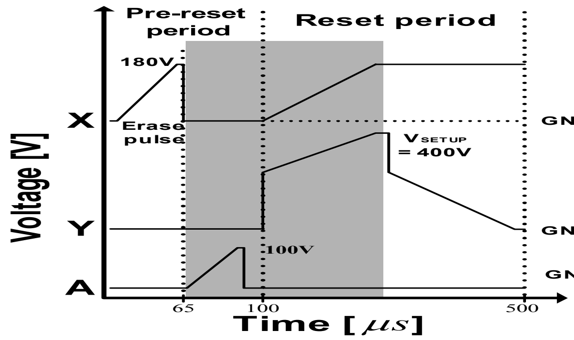


Fig. 9. Proposed driving waveform for reducing temporal dark image sticking. (Case 2)

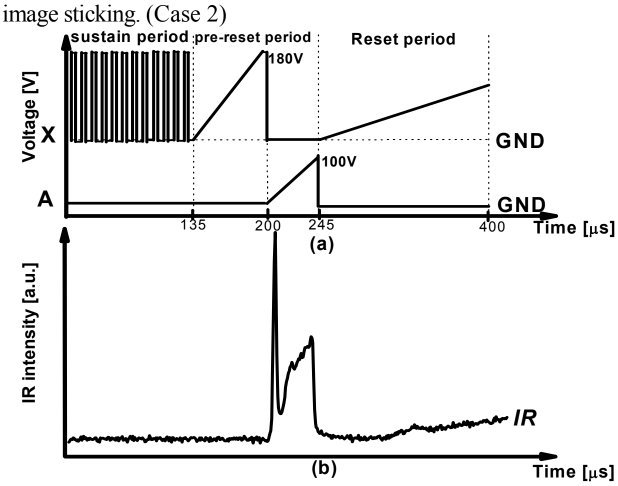


Fig. 10. IR (828nm) emission during pre-reset period when applying the driving waveforms of Fig. 9.

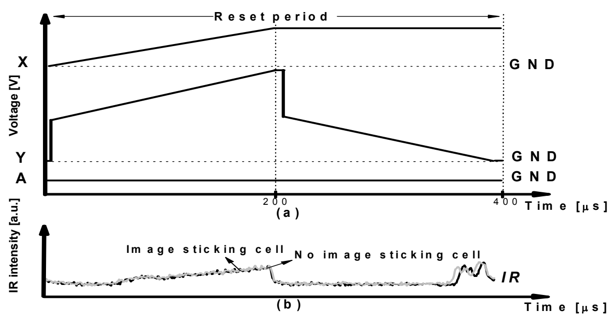


Fig. 11. (a) Proposed driving waveform for reducing temporal dark image sticking and (b) changes in IR (828nm) emissions measured from cells with and without image sticking when using proposed driving waveform.

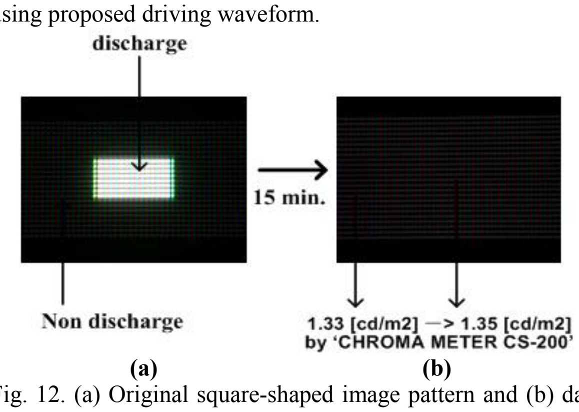


Fig. 12. (a) Original square-shaped image pattern and (b) dark background image pattern after fifteen-minutes display of original square-shaped image pattern when using proposed driving waveform.

C. Driving Waveforms Including Negative Ramp Bias Applied to Common (X) Electrode During Ramp-down Period to Compensation for Improving Address Discharge Characteristics

Fig. 13 shows the finally proposed driving waveform including the ramp waveform using a plate gap reset discharge, ramp-type pre-reset waveform, and negative-going ramp-type X bias for removing the temporal dark image sticking without deteriorating the address discharge characteristics under the low background luminance. The negative-going ramp bias applied to common (X) electrode during the ramp-down period play a role in the less erasing of the wall charges accumulating on the Y and A electrode through the ramp-up period [6], thus resulting in lowering background luminance, and improving the subsequent address discharge characteristics. In the case of adopting the proposed driving waveform of Fig. 13, the ignition time and intensity of the IR (828 nm) emission waveforms were observed to have no difference between the cells with and without image sticking, as shown in Fig. 14 (b). In this case, the very slight luminance difference (ΔL=0.02: this level is no perception level in human eye) was also observed, as shown in Fig. 15 (b). As shown in Fig. 16 and Table 1, the finally proposed driving waveform of Fig. 13 can remove not only the temporal dark image sticking completely but also the deterioration of address discharge characteristics.

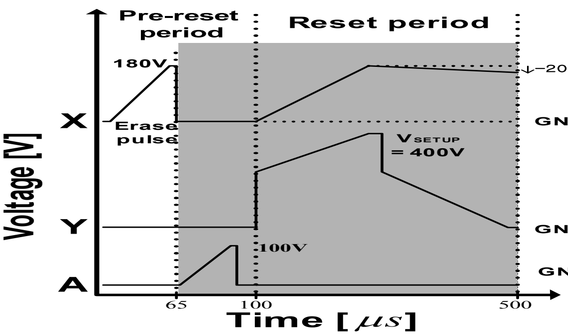


Fig. 13. Finally proposed driving waveforms for improving address characteristics. (Case 3)

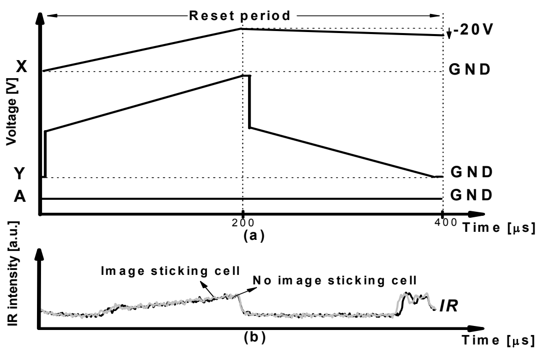


Fig. 14. (a) Driving waveforms of Fig. 13 during ramp-period and (b) changes in IR(828nm) emissions measured from cells with and without image sticking when applying driving waveform of Fig. 13.

Ⅳ. CONCLUSION

The experimental observation on the IR emission during a ramp-up reset period shows that the activated MgO surface and the wall charges accumulating on the address electrode prior to the reset period are two dominant factors for a temporal dark image sticking phenomenon. The new driving waveforms, including pre-reset and reset waveforms, and negative-going ramp-type X bias, are proposed for a complete elimination of the temporal dark image sticking without deteriorating the address discharge characteristics. As a result of monitoring the difference in the IR emission and luminance between the cells with and without image sticking, it is observed that the proposed driving waveform can remove the temporal dark image sticking completely without deteriorating the address discharge characteristics.

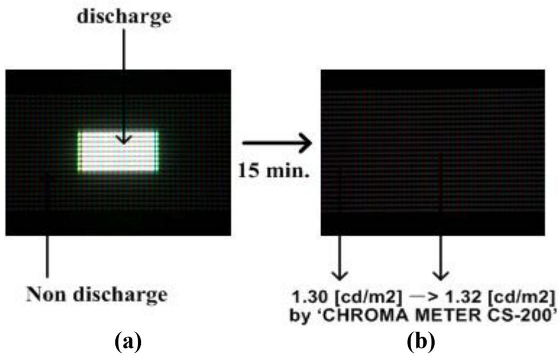


Fig. 15. (a) Original square-shaped image pattern and (b) dark background image pattern after 15-min. sustain discharge when applying proposed driving waveform of Fig. 13.

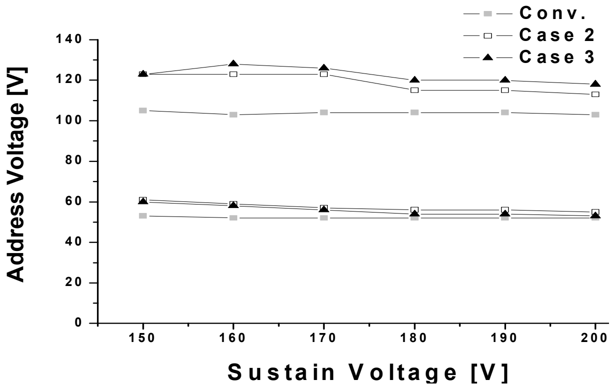


Fig. 16. Comparison of dynamic voltage margins for various driving waveforms including conventional, cases 2 and 3.

Table.1. Comparison of results between the conventional driving waveform and the proposed driving waveforms.

	Min. address Voltage	Background luminance (no image sticking cell)	Background luminance (image sticking cell)	Difference of perceived luminance (Standard)	Difference of perceived luminance (Dark)
Conv.	52V	1.99 [cd/m^2]	2.13 [cd/m^2]	0.08	0.28
Case 1	58V	0.33 [cd/m^2]	0.37 [cd/m^2]	0.07	0.27
Case 2	56V	1.33 [cd/m^2]	1.35 [cd/m^2]	0.02	0.06
Case 3	54V	1.30 [cd/m^2]	1.32 [cd/m^2]	0.02	0.06

Ⅴ. REFERENCE

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