Marking on a Transparent Acrylic Resin by YAG Laser

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The wave length of the YAG laser is shorter than that of carbon dioxide laser.• So, the YAG laser penetrates into transparent colorless materials. New making method and its application were studied by using this characteristics of YAG laser. The topics of this paper are as following.

(1) Difference between CO_2 laser marking and YAG laser marking on colorless and transparent plates.
(2) Scanning of YAG laser ray on the surface of transparent plates.
(3) Mutual change into " Transparent board" and "Sign board " by switching ON-OFF of the Light Emitted Diode (LED)
(4) Scanning of YAG laser ray on the section of transparent plates.
(5) Whitening by heat treatment of the board marked by YAG laser
(6) Edge type back light panel for liquid crystal display(LCD) by YAG laser marking
(7) Nameplates by metallic vapor deposition on the lower surface of transparent board

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1. Introduction

The YAG laser ray was irradiated to the surface and the section of the acrylic resin board respectively and making a new nameplate and a back light was examined.

2. Difference between CO_2 laser marking and YAG laser marking on colorless and transparent plates.

Four kinds of changes take place by irradiating laser ray to the surface of the materials. The surface of the material evaporates or discolors in the thermal energy of the laser ray when the CO_2 laser ray (Wave length 10.6 micron) is irradiated to the surface of the material. And marks are drawn by these changes on the surface of the material. Then, the marks are drawn on the material with concave or with color. As the wave length of the ray of the YAG laser(1.06 micron) is short, the ray of the YAG laser penetrates into transparent stuff such as the glass. Therefore, marking on the surface of the glass is impossible by the YAG laser. When the YAG laser is irradiated to transparent acrylic resin, the mark is also not formed. However, the white line is marked in the section of transparent acrylic resin when the irradiation of the YAG laser is repeated.

3. Scanning of YAG laser ray on the surface of transparent plates

Photo.1 shows the mark formed when the YAG laser is repeatedly scanned to transparent acrylic resin. The samples are put on the black paper to make the white mark of transparent acrylic resin easy to see. The white mark is drawn when the scanning frequency of the YAG laser to transparent acrylic resin is adjusted to four times or more. This white mark is not due to hollow formed on surface of transparent acrylic resin. The mark is due to white lines formed in section of transparent acrylic resin board. Photo.2 shows marks drawn in the section of the transparent acrylic resin board. The section in the marked part changes to the opaque white color.

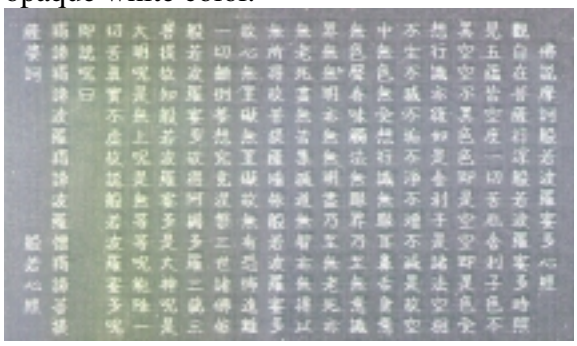


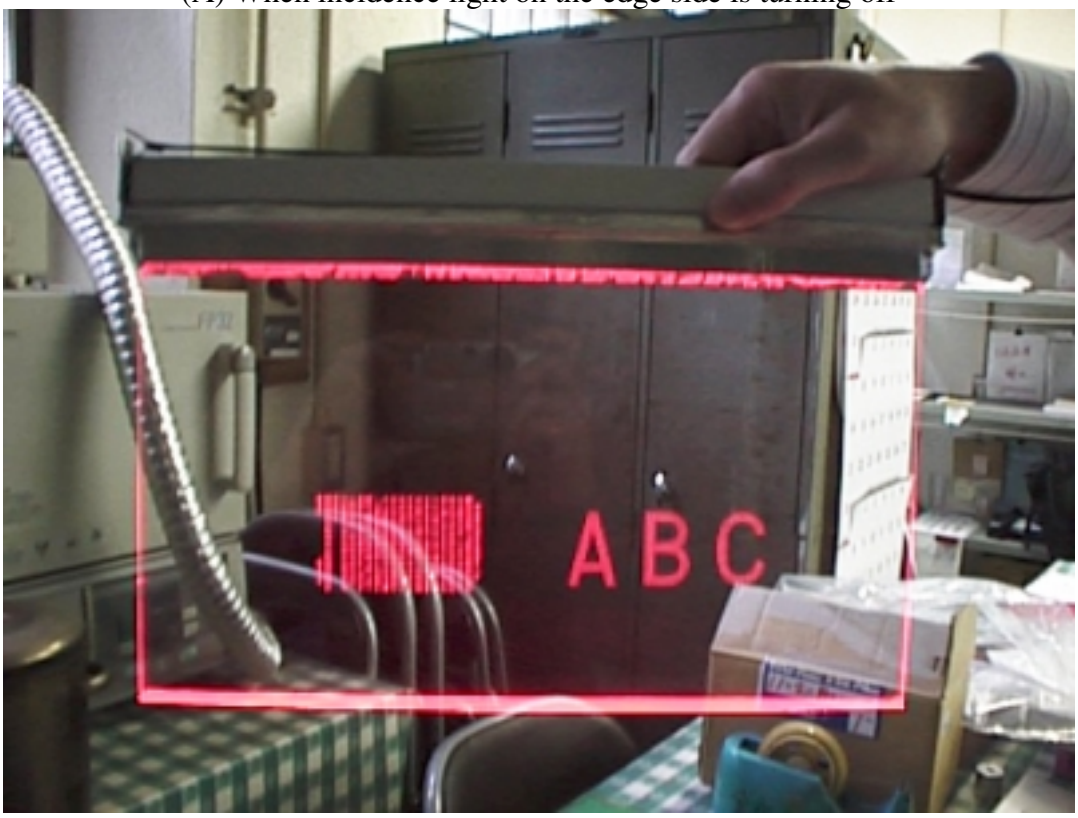
Photo.1 Marks drawn by repetition irradiation of YAG laser

Photo.2 Section of transparent acrylic resin board marked white color

4. Mutual change into " Transparent board " and " Sign board " by switching ON-OFF of the Light Emitted Diode (LED)

When strength of marking is weak, the transparent acrylic resin board is almost transparent (Photo. 3(A)). However, a clear mark appears to the transparent acrylic resin board when the light of LED (light emitting diode) is applied on the edge part of this board. Photo. 3(B) shows this situation. This board is a special display board according to ON-OFF of light source changed into the transparent board and the display board.

(A) When incidence light on the edge side is turning off



(B) When incidence light on the edge side is turning on

Photo.3 Display board by YAG laser marking

Some ideas of the usage of the panel changed into the transparent board and the display board are proposed.

(1) Panel which warns the following car of interval between my car and the following car

Sentences said "The interval is short . Please open the interval for your safety" are written on the acrylic resin board by the YAG laser. This plate is put by a back window of my car. When LED (light emitting diode) is turned off, this panel is a transparent board. Therefore, this panel does not obstruct the car drive. LED is lit only at time when the following car approached and the warning sentence is displayed. Photo.4 shows this warning board.

(2) Partition panel in car of taxi

The map, list of hotels or the timetable of the airplane is written on the acrylic resin board by the YAG laser. This acrylic board is used as the partition panel in the car of the taxi. When the passenger of the taxi wants to see the map, list of hotels or the timetable of the airplane, LED is lit. Because the panel is a transparent board when LED is not lit, the panel does not become a trouble though the passenger of the taxi sees forward. Moreover, this panel is a partition board for defending the safety of the driver of the taxi.

Photo.4 Warning board to the following car

(3) Door in meeting room
All aspects of the acrylic resin board are marked by the YAG laser. The door of the meeting room is made with this board. LED does not light when the meeting room is not made use of. Because the door is a transparent board, the situation to which the meeting room is not made use of is understood. When the meeting room is made use of, LED is lit. Because all aspects of the door shine, outside people can not see the situation of the meeting room.

(4) Display board by overlapping
The character is written on the acrylic resin board by the YAG laser. When this acrylic board is put on the picture or the photograph, the character can be blinked by blinking LED.

(5) Display board used in water
The character is written at the bottom of a long acrylic resin board by the YAG laser. Bottom where the character is written is put in water, and LED is arranged in the top. The display board used in water is made. The character of the display board does not peel off by water

5. Scanning of YAG laser ray on the section of transparent plates
When the laser ray is scanned to the section in parallel to the section, the mark of two dimensions is drawn on the acrylic resin board. At this time, the position of the mark of two dimensions can be controlled by the position of the focus of the laser ray.

6. Whitening by heat treatment of the board marked by YAG laser
The mark is drawn on the transparent acrylic resin board by the YAG laser ray. This marked plate is heated for 20 minutes at 150• . A strong white mark appears to the transparent acrylic resin board by this heating. These samples are shown in Photo.6

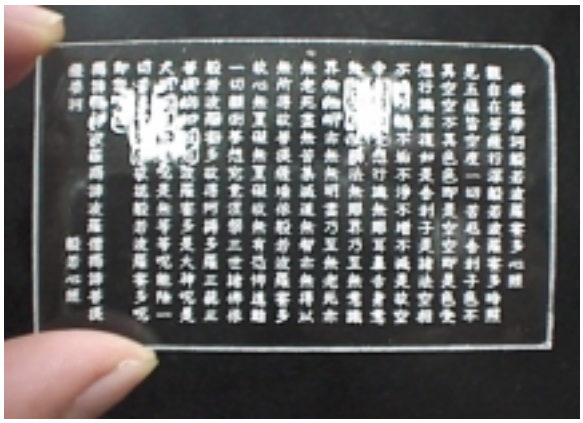
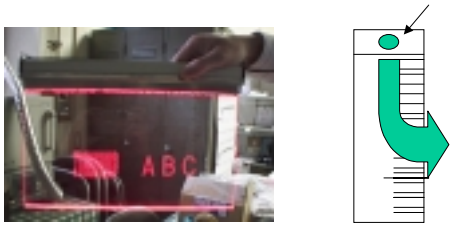


Photo.6 The sample of heat treatment after laser marking

7. Edge type back light panel for liquid crystal display (LCD) by YAG laser marking.
When the YAG laser is irradiated to the surface of the acrylic resin board, the mark is drawn. The surface of an acrylic board shines when light is applied to the edge of this acrylic board. That is, the line source of light is converted into the surface source of light. Because the light of LED reflects by the white line drawn in the section of the acrylic resin board, the line source of light is converted into the surface source of light. The liquid crystal panel also needs the technology to convert the line source of light into the surface source of light. Then, the possibility of manufacturing back light of the liquid crystal panel by the YAG laser marking was examined. Fig.10 shows the principle of the surface source of light of the acrylic board marked by the laser and the surface source of light with the back light of the liquid crystal panel.



(A) Board by YAG laser marking

(B) Liquid Crystal Display (LCD)

Fig.10 Change of the line source of light to the surface source of light

To know recent technology of " back light", Japanese patents and home pages concerning " back light " of the liquid crystal panel were investigated

(1) Publication number: 06118247
Date of publication of application: 28.04.1994 MANUFACTURE OF EDGE LIGHT GUIDE BOY:

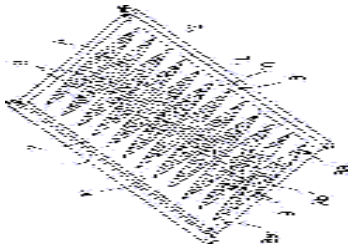


Fig.11 Patent of back light (1)

Only the one side of the acrylic resin board is made a rough side by the sand blast. Some part of the rough side is painted.

(2) Publication number: 06313883
Date of publication of application: 08.11.1994 BACK LIGHT DEVICE FOR LIQUID CRYSTAL PANEL

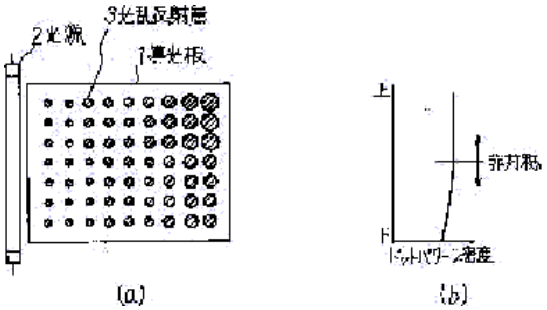


Fig.12 Patent of back light (2)

Small, white circles are printed on a place near the source of light. Large, white circles are printed on a place far from the source of light.

(3) Publication number: 07013024
Date of publication of application: 17.01.1995
LIGHT TRANSMISSION PLATE FOR BACK LIGHT OF LIQUID CRYSTAL DISPLAY DEVICE

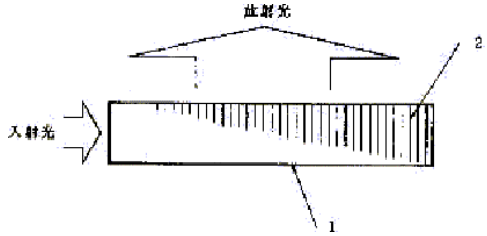


Fig.13 Patent of back light (3)

A shallow crack is made in a place near the source of light. A deep crack is made in a place far from the source of light. These cracks are made by bending a plastic board.
(4) Publication number: 07120752
Date of publication of application: 12.05.1995 BACKLIGHT FOR LIQUID CRYSTAL DISPLAY DEVICE

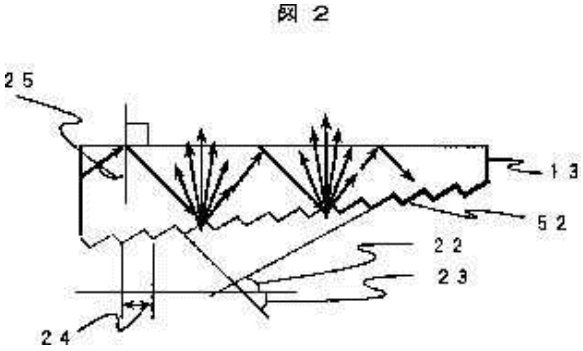


Fig.14 Patent of back light (4)

The acrylic resin board is thin in a place far from the source of light. This inclination board is minute stairs structure.

(5) Publication number: 08101313
Date of publication of application: 16.04.1996 BACK LIGHT AND LIQUID CRYSTAL DISPLAY DEVICE USING IT

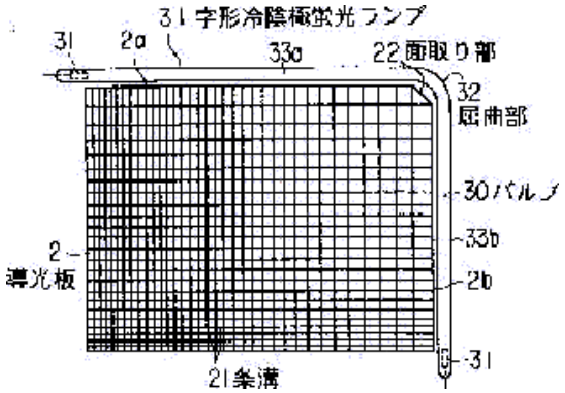


Fig.15 Patent of back light (5)

The interval of the ditches is large in a place near the source of light. The interval of the ditches is small in a place far from the source of light.

(6) Publication number: 09159833
Date of publication of application: 20.06.1997 LIGHT TRANSMISSION BODY

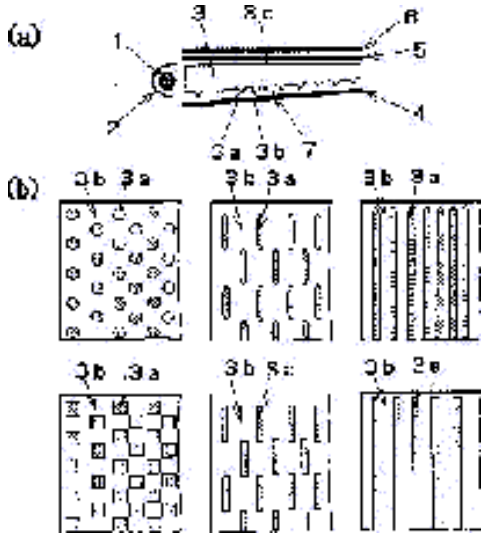


Fig.16 Patent of back light (6)

The triangle which has upheaved to the one side of the acrylic resin board in the convexity is formed. A lot of triangles can be arranged by various pattern.

(7)Publication number: 09178947
Date of publication of application: 11.07.1997
LIGHT TRANSMISSION BODY FOR BACK LIGHT OF LIQUID CRYSTAL DISPLAY DEVICE

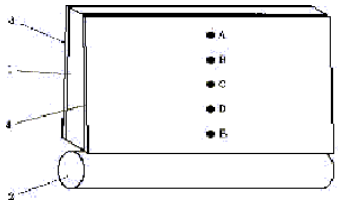


Fig.17 Patent of back light (7)

The acrylic resin board contains the particle of acrylic resin with a different polymerization degree.
(8) Publication number:09281338
Date of publication of application:
BACK LIGHT SYSTEM FOR LIQUID CRYSTAL DISPLAY

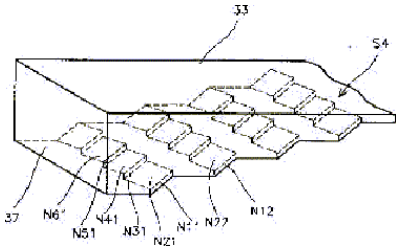


Fig.18 Patent of back light (8)

A lot of minute slopes are made.

(9) Publication number: 09318944
Date of publication of application: 12.12.1997
MANUFACTURE OF LIQUID CRYSTAL DISPLAY ELEMENT, MANUFACTURE OF BACK LIGHT, AND THEIR MANUFACTURE SYSTEM

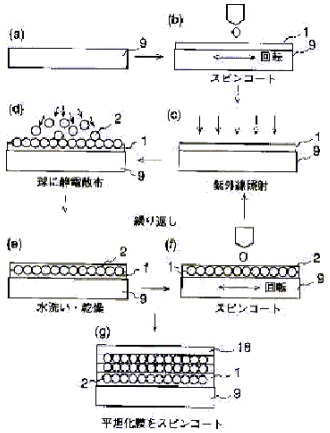


Fig.19 Patent of back light (9)

A spheroidal particle is coated to a multi layer.

(10) Publication number: 10170724

Date of publication of application: 26.06.1998 BACK LIGHT FOR LIQUID CRYSTAL DISPLAY DEVICE

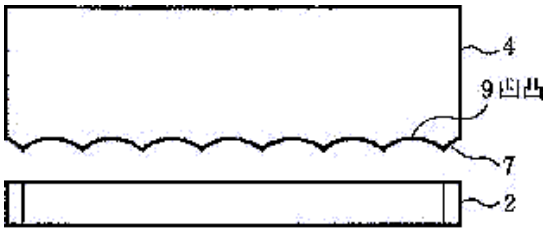


Fig.20 Patent of back light (10)

A minute ruggedness to have circular arc shape is made.

(11) Publication number: 10333144
Date of publication of application: 18.12.1998
DIRECT VISION TYPE LIQUID CRYSTAL DISPLAY DEVICE EQUIPPED WITH BACK LIGHT

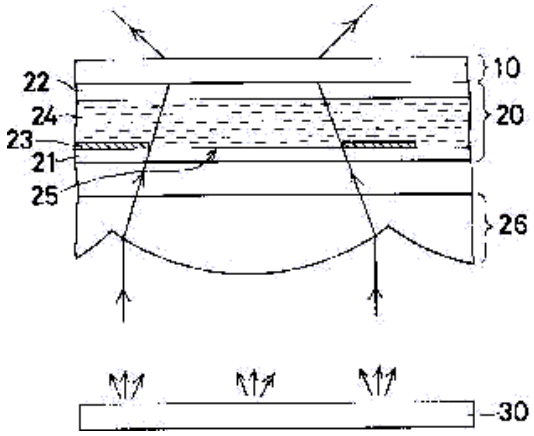


Fig.21 Patent of back light (11)

The micro lens array is arranged.

(11) Publication number: 11065488
Date of publication of application: 05.03.1999 BACKLIGHT DEVICE AND LIQUID CRYSTAL DEVICE USING THE SAME

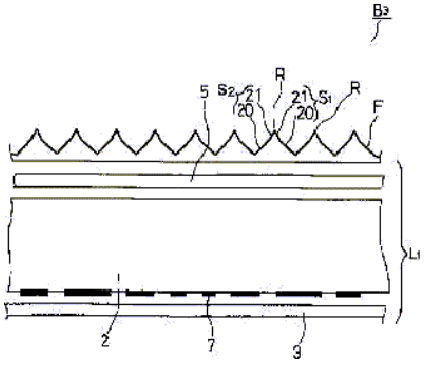


Fig.22 Patent of back light (12)

Use of the film lens with various angles of slope

The home page of the back light was retrieved. Making round hollows and the ditches by the carbon dioxide laser on the acrylic resin board was introduced (Fig.23 and Fig.24). URL of the home page is http://village.infoweb.ne.jp/~fvgf2080/main-4.html

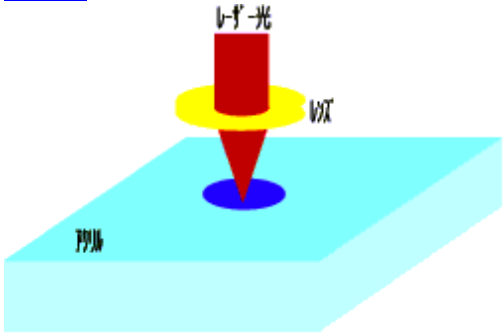


Fig.23 Back light panel with round hollows by carbon dioxide laser

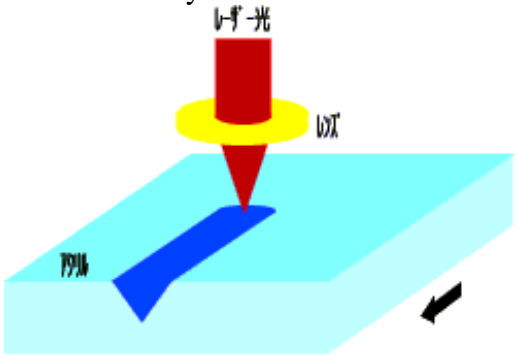


Fig.24 Back light panel with ditches by carbon dioxide laser

As a result of the patent retrieval and home page retrieval, the following information was obtained about making the back light.

(1) The back light is made by the print method, the molding method, and the laser processing method, etc.
(2) As for the laser processing method, method by the carbon dioxide laser is introduced at the home page.
(3) Back light by the YAG laser processing is not reported on the patents nor at the home pages.

Photo.7 shows the experimental result of the back light. When the YAG laser was scanned on whole surface in the same

frequency of scanning, the reflection light of the sample was not uniform. The scanning frequency of the laser was reduced in a place near the source of light. And, the scanning frequency of the laser was increased in a place far from the source of light. The reflection light of this sample was uniform.

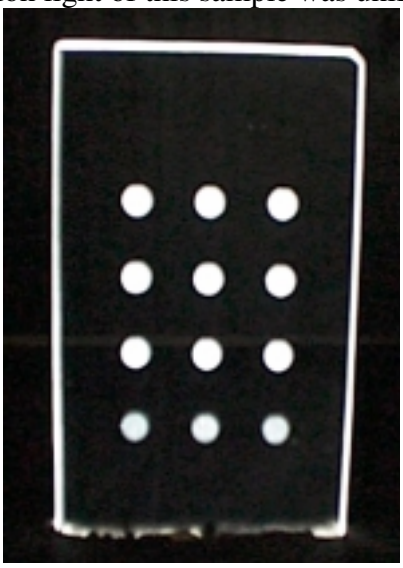


Photo.7 Back light by YAG laser marking on the transparent acrylic resin

8. Nameplates by metallic deposition on lower surface of transparent board

Fig.25 shows the principle of this method. The transparent and colorless glass board or plastics board laid above the metallic board. When the YAG laser is irradiated, the laser ray penetrates into transparent material and evaporates the metal lying under the transparent board. Evaporated metallic vapor is deposited on lower surface of the transparent board. The mark is drawn with the vapor deposited metal. The experiment by this idea was executed. Following metals sheets were used for experiments. These are brass, copper, stainless steel, aluminum of purity 99.5%Al, and aluminum alloy of 5000 series. The glass board was put on six kinds of metallic boards, and the YAG laser was irradiated respectively. As a result, the mark by a metallic deposition was drawn on lower surface of the glass board. Photo.13 shows these marks. The adhesion of the deposited metal was weak when the irradiated laser ray was weak. The adhesion of the deposited metal was strong when the irradiated laser ray was strong. And, the metal deposited to the glass board was not taken off though rubbed with the finger or the cloth. A metallic board bonds to a transparent substrate because of the heat of the laser ray occasionally. When the transparent acrylic resin board was used as a transparent substrate instead of the glass board, the mark was formed.

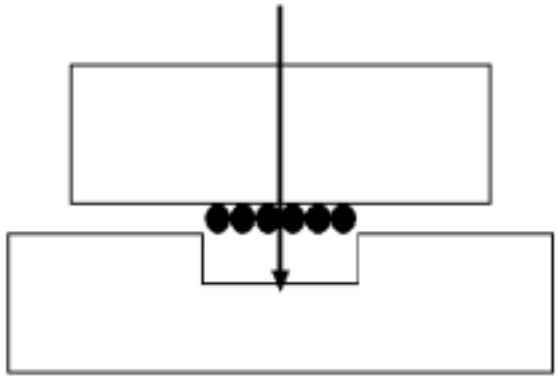


Fig.25 Principle of metallic deposition by YAG laser ray

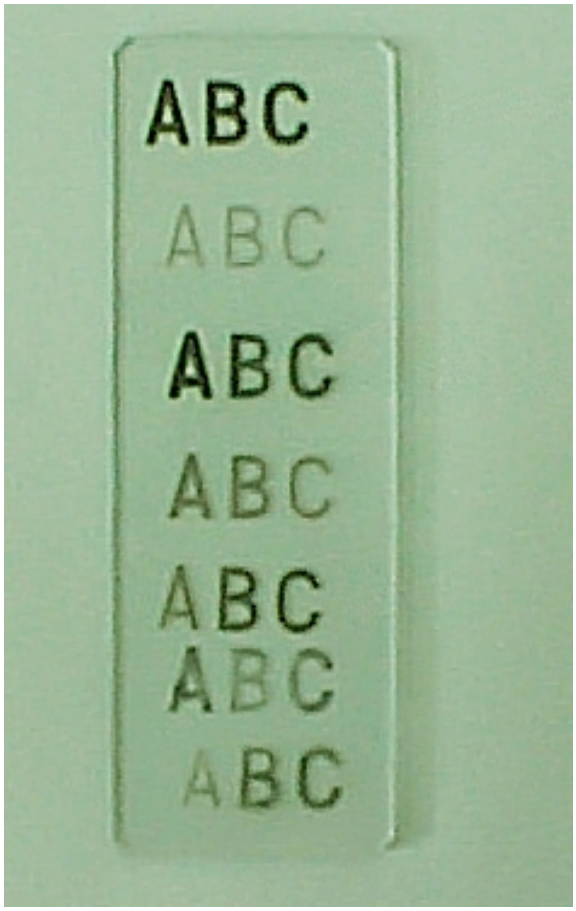


Photo.13 Mark drawn on the lower surface of the glass by metallic deposition

9. Conclusion

Some marking methods and applications by YAG laser were reported. The following results are obtained.

(1) Special display board according to ON-OFF of light source changed into the transparent board and the display board
(2) Back light board
(3) Metal deposition in the atmospheric condition

This research was carried out by the research fund for small and medium-sized enterprise of Tokyo Metropolitan Government.