

Award Accounts

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Technology for Forming of Barrier Ribs on a Plasma Display Panel (PDP) by Applying a Photosensitive Glass Paste

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Technologies for processing inorganic compounds into high-definition products are used in many areas including thin-film transistors and liquid crystal displays. These technologies are based on the technology of depositing thin films of 1 μm or less in thickness using vacuum processes such as sputtering and vapor deposition. The present review compiles the results of research made on photosensitive paste technology for processing inorganic materials into high-definition thick films of several micrometers to less than 200 micrometers in thickness. The technology for processing inorganic materials into films of several micrometers to less than 200 micrometers in thickness is used for producing the electrodes and barrier ribs of plasma display panel (PDP), and is expected to widely spread into such areas as IC packages in the future.

The development of electronics in recent years has been remarkable. Especially the technologies for integrating ICs and LSIs including semiconductors support the growth of the electronics industry as a whole. This progress in the technologies follows the progress in ultraprecise processing technologies, especially the technologies for processing inorganic materials into high-definition products.

A typical conventional method for forming a pattern of an inorganic material is a thin-film etching method[1,2] using the photolithography used for manufacturing thin-film transistors and liquid crystal displays. In this method, a thin film of an inorganic material is formed on the surface of a work (silicon wafer or glass substrate) by a method of vapor deposition, sputtering or the like, and a pattern is formed on it by means of photolithography using a photoresist, followed by etching to leave necessary portions only. However, since this method uses the formation of a thin film in vacuum, it is difficult to form a pattern of an inorganic material with a thickness of tens of microns to hundreds of microns.

Meanwhile, in recent years, the widening areas of displays and LSIs require forming a pattern of an inorganic material with a thickness of several microns to less than 200 microns. However, in the case where a thick film is formed in vacuum, there is a problem that high productivity cannot be obtained since long-time sputtering or vapor deposition is necessary. Therefore, as a conventional method for forming a thick film pattern of an inorganic material, it is usual to print, using a meshed screen, a pattern of a paste obtained by dispersing a glass powder or ceramic powder into an ethyl cellulose solution, and subsequently to fire it at 500 to 600 °C for removing the binder and sintering the inorganic powder, thereby forming a pattern of a metallic, vitreous or other inorganic material on a glass substrate.[3–5] This method is widely used still now for producing electronic parts, microprocessors (MPU), etc. However, this method is not suitable for achieving an extremely high-definition or a larger area, being limited by the precision of the meshed screen. Furthermore, a thick film with a thickness of more than 10 μm requires a process of repeating high-precision pattern printing several times. However, repeated printing has a problem that the processing accuracy declines greatly compared with printing once only, since the expansion and contraction of meshes cause displacement in repeated printing. Especially a large-area display of PDP or the like requires highly accurate processing in forming a thick large-area film. Many methods using screen printing have been attempted, but they are not employed since it is difficult to achieve a high accuracy in repeated printing.

Furthermore, in the case where a photosensitive paste material consisting of an inorganic material and a photosensitive organic material is used, since photolithography can be used for processing, high accuracy and large area can be achieved. However, this method has seldom been used industrially, since the conventional photosensitive paste technology is not suitable for uniformly exposing and developing a photosensitive

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paste mainly composed of an inorganic material.

The present review describes the successful application of photolithography technology suitable for highly accurate processing to the formation of a thick film pattern. That is, a photosensitive glass paste material controlled as to the optical properties and photoreaction properties of an organic material and an inorganic material was designed; as a result, photolithography technology could be used to form a pattern from an inorganic material of more than 100 μm. Especially, this is the result of the research made to develop a photosensitive glass paste that could be processed into a paste material with a thickness of 100 to 200 μm by one time of exposure, for efficiently and accurately forming PDP discharge cells. This technology attracts attention since it can respond to the HDTV quality PDP expected to develop henceforth. Furthermore, this technology allows higher definition and higher integration to be achieved in the information area of displays, thin-film transistors and the like, and has a potential to greatly innovate conventional production methods. Since this technology has been practically applied, very high-definition displays are produced in a simple production process.

This review compiles the history of research and development ranging from the start of R&D in 1994 through the application of the technology to PDPs for production in 2000 to the start of mass production in a factory specially constructed for this technology in 2001.

1. Present Situation of PDPs

The number of television sets sold in the world every year is more than 120 million, and the number in Japan is more than 10 million. Television sets are a major item of household electric appliances, and play a central role in modern culture. These TVs use the cathode-ray tube (CRT) technology invented in the latter half of the 19th century; in view of the characteristic of the technology, it is difficult to produce thin TVs. So, TVs occupy large spaces in the households. Furthermore, a larger TV has a very large weight, and a 40-inch or larger TV is not produced since it would weigh more than 100 kg.

As an approach for presenting wall-mounted thin TVs, 42-inch to 50-inch PDPs begin to be widely offered and accepted.[6] A PDP has a set of discharge cells, each of which corresponds to one pixel and has a size of less than 200 micrometers to many hundreds of micrometers. For this reason, since a larger PDP remains the same in thickness in principle, a thin PDP can be provided. Furthermore, since a PDP can display an image at a speed higher than that of a liquid crystal display,[6] it can display a beautiful dynamic image. So, it is suitable for a TV image. Moreover, a larger PDP has a weight smaller than that of the equal-sized CRT TV, and a 42-inch PDP weighs about 20 kg, equivalent to the weight of a 20-inch CRT TV. Because of these advantages, PDPs are widely used as public displays in hospitals, schools, railway stations, airports, restaurants, etc. Furthermore, in recent years, information tends to increase in both variety and volume, and these tendencies encourage rapid progress in the digitalization of image information. Therefore, PDPs are highly expected as display devices for displaying digital information. A PDP has discharge cells of less than 200 micrometers to many hundreds of micrometers accurately formed on a glass substrate; an accurate electric discharge occurs in each of the discharge cells, to accurately emit the light of each pixel. So, a PDP is suitable not only as a digital display but also as a display for a large volume of information, such as HDTV quality images. For this reason, PDPs begin to be widely used also as household TVs. Also henceforth, the mass production of PDPs will be intensified to allow further cost reduction, and it is expected that PDPs will be even more widely used.[7–9]

2. Structure and Principle of PDP

The structure of a PDP is shown in Fig. 1. A PDP consists of a front panel and a rear panel,[10–16] and the space formed between these panels is charged with a mixed rare gas (Xe–Ne, etc.). In the front panel with transparent electrodes for discharging, bus electrodes for lowering the resistance values of the transparent electrodes, a transparent dielectric layer and a protective layer (MgO).[17] As the electrodes of the front panel, scanning electrodes for deciding the discharge position and sustaining electrodes for sustaining the discharge with the scanning electrodes form a pair. In the rear panel with address electrodes for deciding the discharge positions on a glass substrate, a dielectric layer, barrier ribs, and phosphors[18–20] for emitting light in respective colors of RGB. The barrier ribs

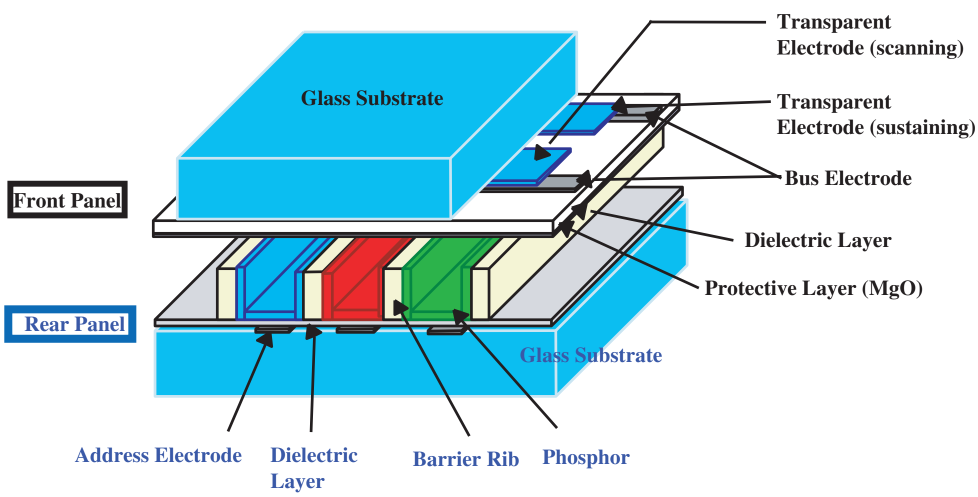

Fig. 1. Schematic structure of plasma display panel (PDP).

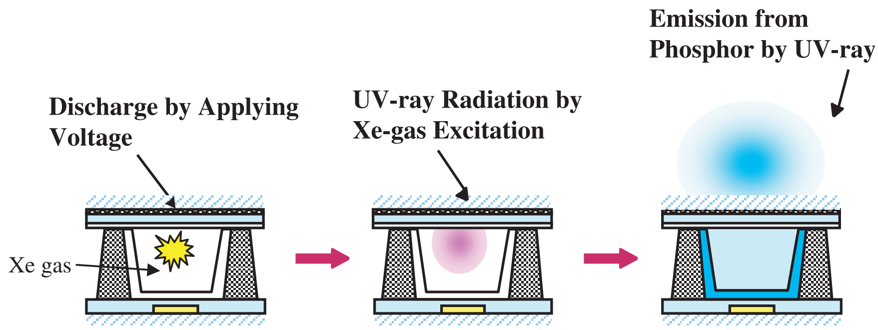

Fig. 2. Mechanism of operating for PDP.

partition the respective cells of RGB (separate the phosphors of respective colors and inhibit the discharge interference between pixels) and keep the clearance between the front panel and the rear panel uniform.

A voltage is applied to the determined positions between the address electrodes and the scanning electrodes, to cause discharge, and the discharge is sustained between the scanning electrodes and the sustaining electrodes (Fig. 2). The discharge excites the Xe in the mixed gas, to radiate ultraviolet light (wavelengths = 147 nm and 172 nm).[21,22] The phosphors of respective RGB colors formed in the rear plate absorb the radiated ultraviolet light, to emit visible light. In the respective pixels, the intensity (number of times) of the discharge is controlled for gray scale levels of images.[23–25]

A PDP has the following four features.
(1) Thin thickness and light weight.
(2) A wide viewing angle to assure good visibility even from a side.
(3) No strain even at a corner of the screen.
(4) Progressive high image quality.

Compared with the thickness and weight of a CRT, a PDP is 1/5 or less in thickness and 1/2 or less in weight. Even if a larger screen is employed, the thickness does not increase (10 cm or less). This is the reason why large-screen PDP TVs are widely used in households. Furthermore, a PDP is a light-emitting display that spontaneously emits light, and has a viewing angle of 160°, being very wide in visibility compared with a liquid crystal display.[6] So it is suitable for a household where several family members watch one TV, sitting around it. Furthermore, unlike the CRT, it has such features that the fuzzy image in the periphery does not occur, that geomagnetism does not affect it, and that respective pixels can be accurately displayed in progressive display.

Moreover, a PDP is simpler in structure and production process than a liquid crystal display (LCD); in the production of larger-screen PDPs, it is easy to improve quality and productivity.[8] Therefore, PDPs allow cost reduction as large-screen displays with higher quality and productivity, compared with CRT displays and LCDs (Fig. 3). In 2004, the cost is expected to reach 10000 yen/inch, and further efforts will be made to reduce the cost to 5000 yen/inch in future.

If the cost can be reduced with the above-mentioned features, it is expected that PDPs will be the main large displays. In the past three years, the market size for PDPs has expanded to almost double every year, and with the quantitative increase, the prices have declined (Fig. 4).

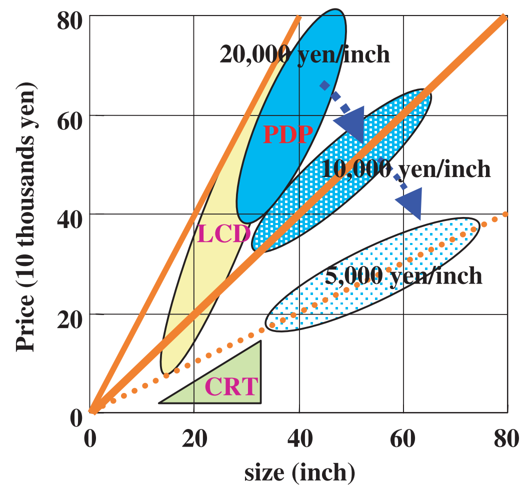

Fig. 3. Position of PDP in display industry.

3. Production Process of PDP

Figure 5 shows a production process of PDP. For the rear panel, at first, address electrodes of a metal such as silver or copper are formed on a glass substrate. In succession, a dielectric layer made of a glass or ceramic material is formed. Then, barrier ribs are formed as a pattern, and finally, the respective cells are selectively covered with phosphors (inorganic oxides) of RGB. Furthermore, for the front panel, transparent electrode elements of ITO or the like and bus electrodes of silver, copper or the like are formed on a glass substrate, and a transparent dielectric layer (glass material) is formed to cover them. Finally, an MgO protective layer is formed.

In succession, the respectively produced front panel and rear panel are bonded to each other using a glass with a low melting point, and the space between both the panels is evacuated and charged with a mixed rare gas. Furthermore, driver ICs for driving are mounted to complete a PDP module. Finally, an image display and signal processing circuit, power supply and other items are mounted, and a front filter, speaker and housing are installed to complete a PDP TV.

The technique for forming electrodes and barrier ribs requiring the formation of high-definition patterns is described below in detail. At first, various methods for forming a pattern of a metallic material as electrodes or the like are shown in Fig. 6. In the thin-film etching method, a thin film is formed on a substrate by means of sputtering or similar treatment,

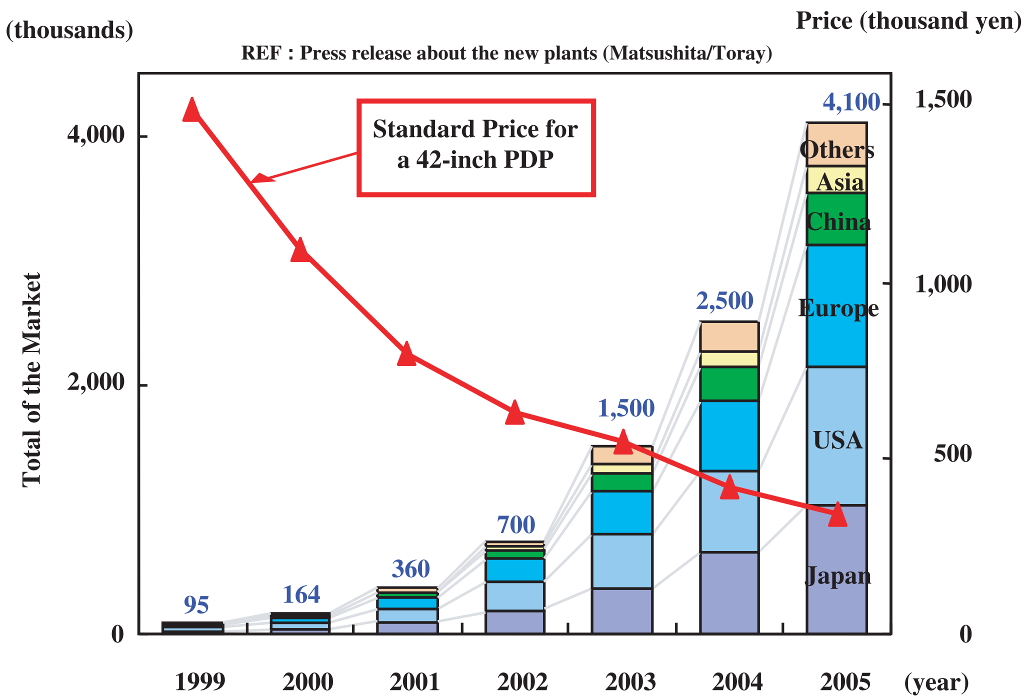

Fig. 4. Trend of PDP's market size and standard price for a 42-inch PDP.

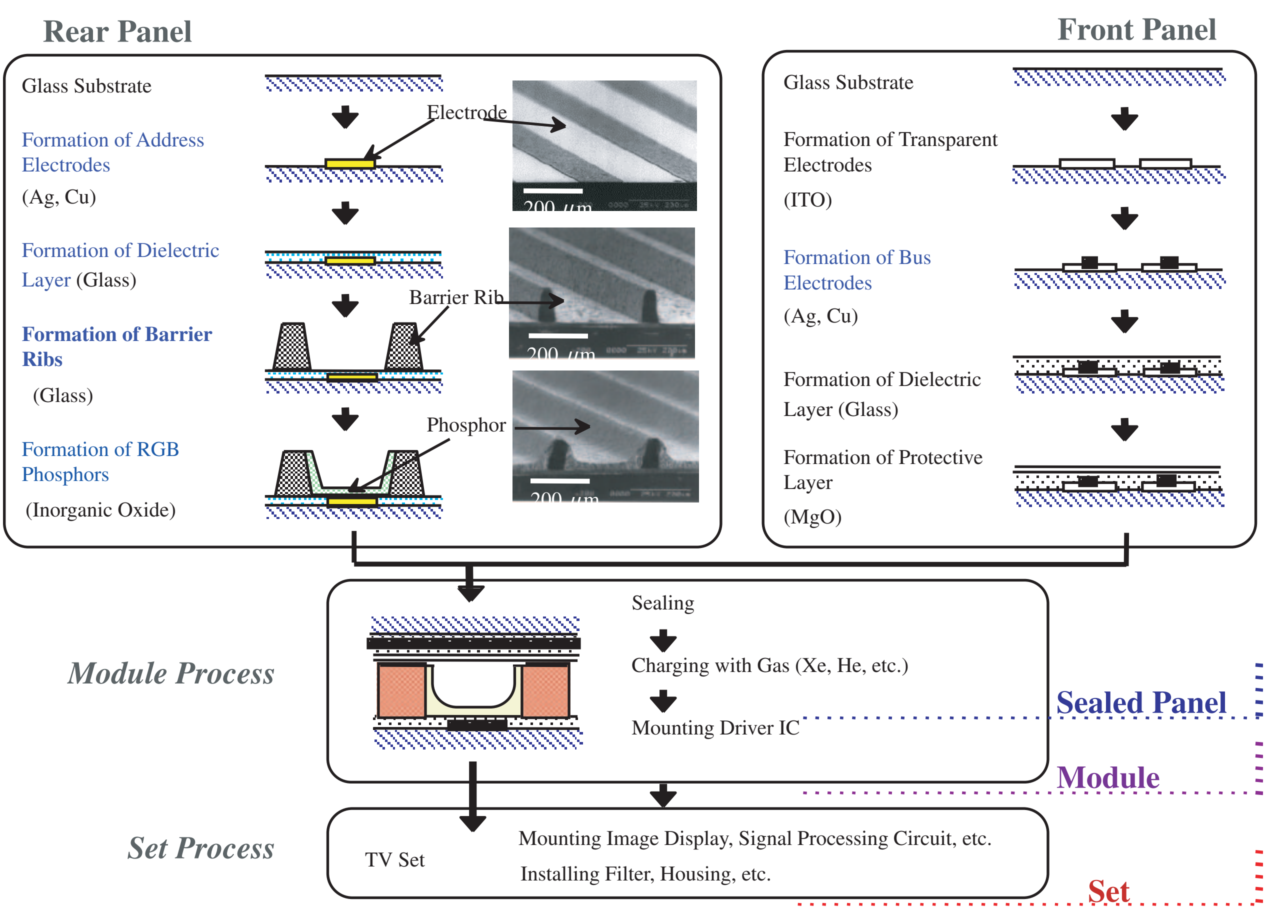

Fig. 5. Schematic diagram of producing process for PDP.

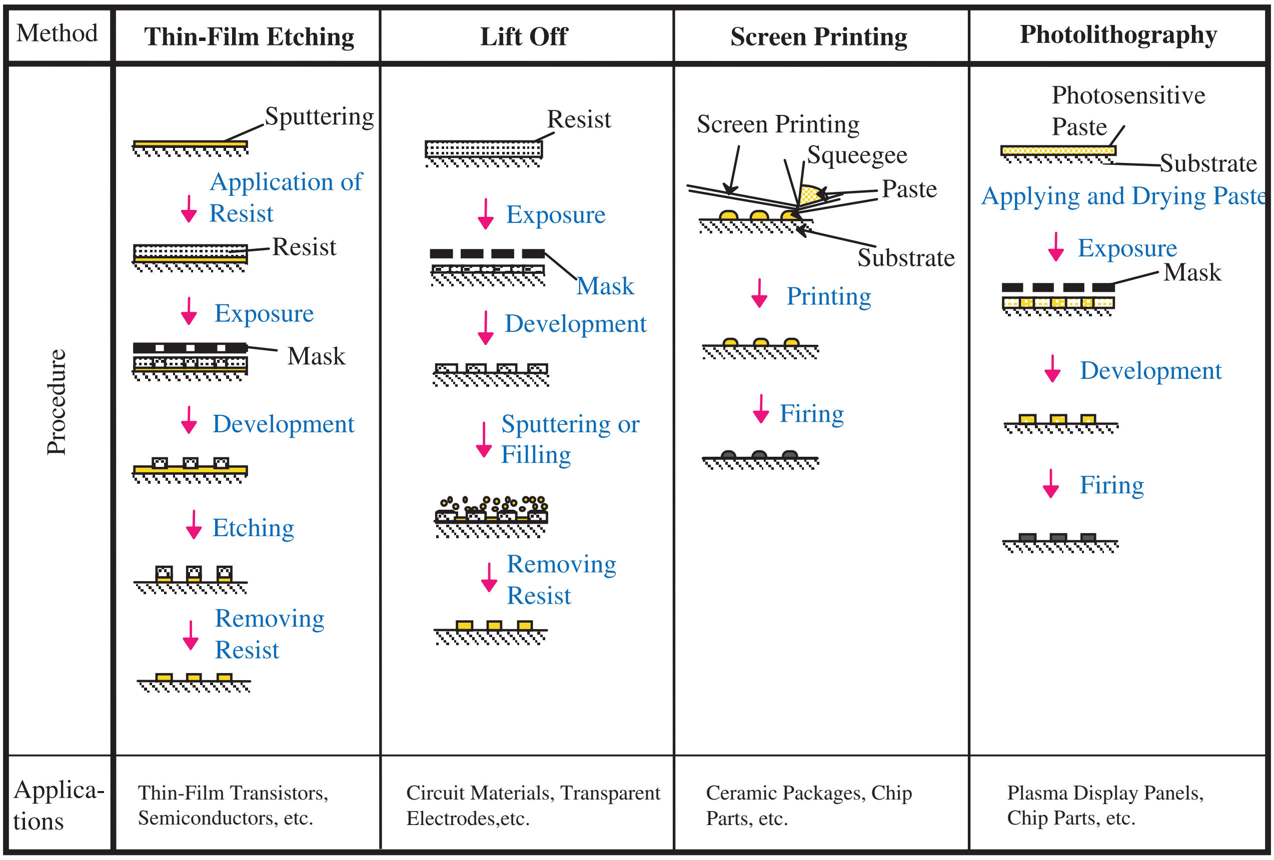

Fig. 6. Technologies for forming pattern of inorganic materials.

and is coated with a resist, being exposed through a photomask and developed. In the subsequent etching step, the thin film is etched, and finally the resist is removed. This method is widely used for producing thin-film transistors, semiconductors, and so on. This method allows the formation of a high-definition pattern but requires a vacuum step such as sputtering; since there are many steps, cost reduction is difficult. Next, in the lift-off method, a resist is applied on a substrate, exposed and developed to form a resist pattern, and an inorganic material is deposited on it by means of sputtering or similar treatment, the resist then being removed to form a pattern. This method is used for high-definition processing of a material not suitable for sputtering. In the screen-printing method, a paste containing an inorganic material is placed on a screen having some openings and is transferred onto a substrate by means of a squeegee and fired to remove organic material. This method is used for producing ceramic packages, chip parts, and so on. However, for the production of large-area PDPs and the like, the screen printing method is not presently used, since it is difficult to form and sustain the high-definition partial openings in the meshed screen. In the photolithography method, a photosensitive paste containing an inorganic material is applied on a substrate, dried, directly exposed through a photomask, developed and fired. This method is widely used for PDPs.

Barrier ribs are formed of a vitreous material (insulator), to form discharge cells for emitting light of RGB. The barrier ribs have a three-dimensional structure of stripes or lattices having a height of 100 to 150 μm and a width of 30 to 80 μm at a pitch of 130 to 400 μm. The barrier ribs partition the respective discharge cells of RGB and must be formed to cover a large area uniformly at high accuracy (for example, for a 42-inch screen, the barrier ribs must be formed uniformly in a plane of 930 × 520 mm). After the barrier ribs are formed, the spaces formed by the barrier ribs are coated with phosphors capable of emitting light of RGB one after another in a pattern, to complete a rear panel. Therefore, the barrier rib forming technique is most likely to affect the control of discharge spaces most important in a PDP. Known methods for forming the barrier ribs include the screen-printing method,[3] sandblasting method[26] and photolithography method (Fig. 7). In the screen-printing method, a pattern of a glass paste is printed on a glass substrate using a screen-printing machine and dried; this is repeated 10 to 15 times. Finally, the built-up pattern is fired to form barrier ribs. This screen-printing method requires a highly accurate screen, but the screen is not suitable for highly accurate processing, since the screen is elongated due to the mesh structure. Furthermore, since the thickness that can be formed by one time of printing is about 10 μm, it is necessary to repeat printing 10 or more times for forming the barrier ribs, making it difficult to achieve higher productivity. This method had been used for producing some PDPs till several years ago, but since PDPs became higher in definition, it became difficult to ensure high accuracy in repeated printing. The method is not presently used. The sandblasting method undergoes the following process; a glass paste is applied on a glass substrate, dried, further

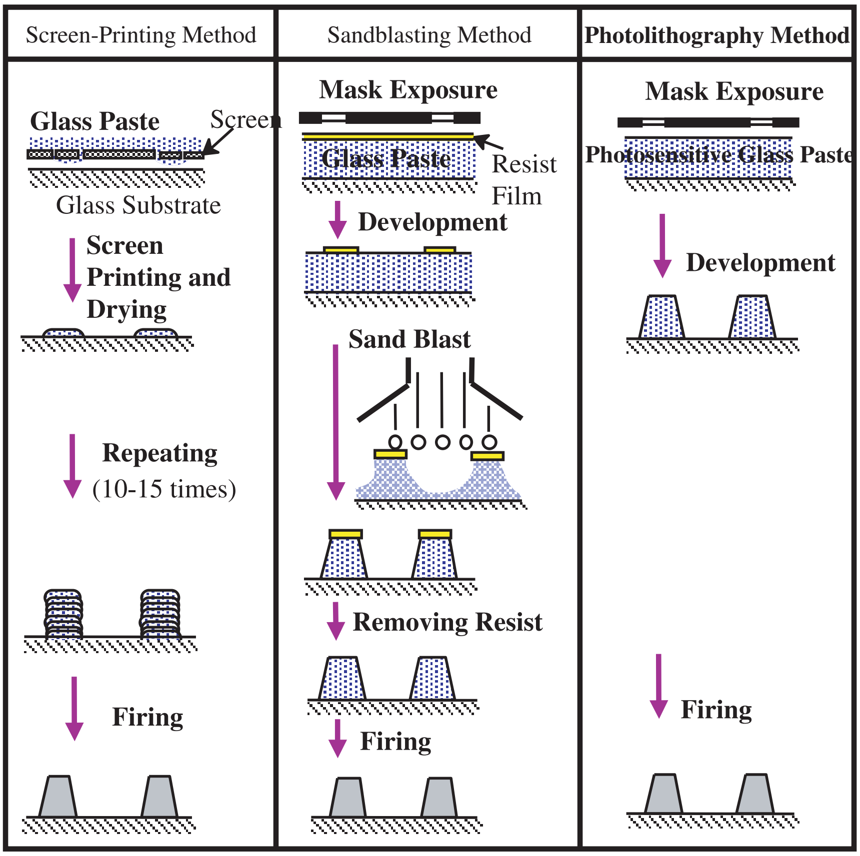

Fig. 7. Technologies for forming barrier ribs of PDP.

coated with a dry film resist, exposed, developed, and sandblasted for forming a pattern. Then, the resist is removed, and the remaining pattern is fired to form barrier ribs. Since the sandblasting method allows very high-definition processing by means of photolithography using a dry film resist, it has been used for producing PDPs. However, there are many steps, and the blasting time is as long as ten-odd minutes/panel. Furthermore, many materials such as a dry film resist and a large amount of abrasive sand must be used. These factors have curbed the cost reduction of the plasma display. In addition, there is a problem that much waste is generated. Moreover, since the barrier rib pattern before firing must endure the blasting pressure, it is difficult to narrow the width of the barrier ribs (to widen the discharge spaces). As a method for solving these problems, a photolithography method that would assure higher accuracy and a simple process had been expected, and the present technology has allowed the practical application of the photolithography method (Fig. 5).[27–29]

In the process using a photosensitive paste, a substrate is coated with the photosensitive paste and dried, being then exposed through a photomask. Water or an aqueous solution of an acid or alkali or the like is used for development, and finally the pattern is fired as an inorganic material pattern. It had been attempted to use a photosensitive paste for forming barrier ribs, but since the thickness that could be achieved by one time of exposure was only 10 to 30 μm, it was necessary to repeat the steps of coating, drying and exposure several times. We have designed a photosensitive paste material, and developed respective apparatuses suitable for the paste, to establish a technology for forming a pattern with a necessary thickness of less than 200 micrometers by one time of coating, drying and exposure. This photosensitive paste process is simple and allows cost reduction.[7] Furthermore, since the photolithography allows highly accurate processing, it is also suitable for high-definition processing. Because of these advantages, among the presently produced PDPs, the photosensitive paste technology is expanding its share.

4. Material Design of Photosensitive Paste

In the process for producing a photosensitive paste, as shown in Fig. 8, at first, organic compounds are mixed and dissolved to produce an organic solution; this is mixed with a glass powder. Then, the mixture is kneaded to produce the intended photosensitive paste. A photosensitive paste consists of an inorganic powder and organic compounds selected considering the required properties of the pattern to be formed. In the case of the photosensitive paste for PDP barrier ribs, a glass powder is used as the main compound of the inorganic powder; as required, any of various ceramic powders may be added. The glass powder is designed considering various physical and chemical properties. The main properties include shape, particle size (particle size distribution), surface condition, dispersed condition, homogeneity of chemical composition, thermal softening property, thermal expansion property, and stability. Especially a material both stable chemically and physically and suitable for the process temperature used for forming the barrier ribs must be designed. Furthermore, since the PDP is exposed to the electric discharge in a rare gas, the material de-

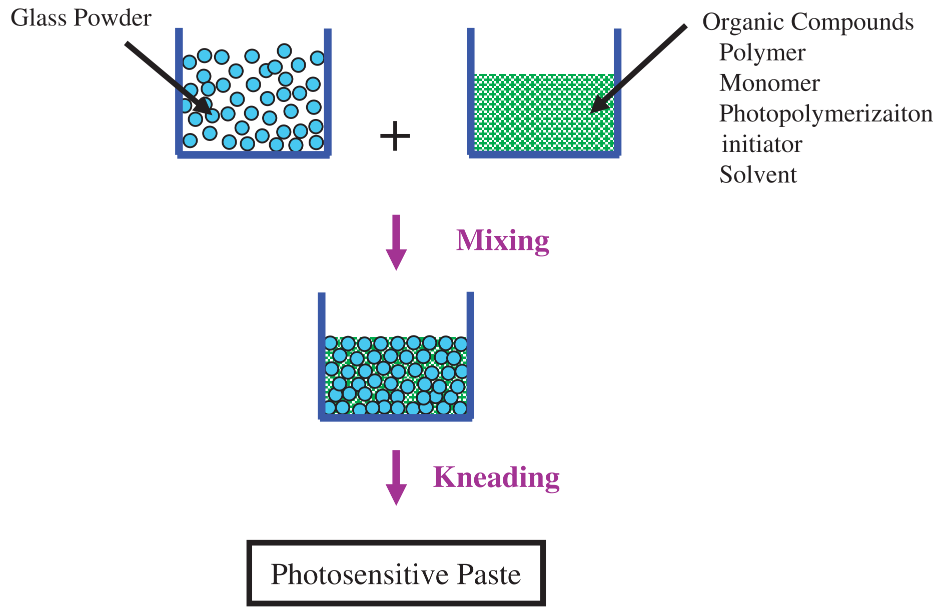

Fig. 8. Schematic diagram of producing process for photosensitive paste.

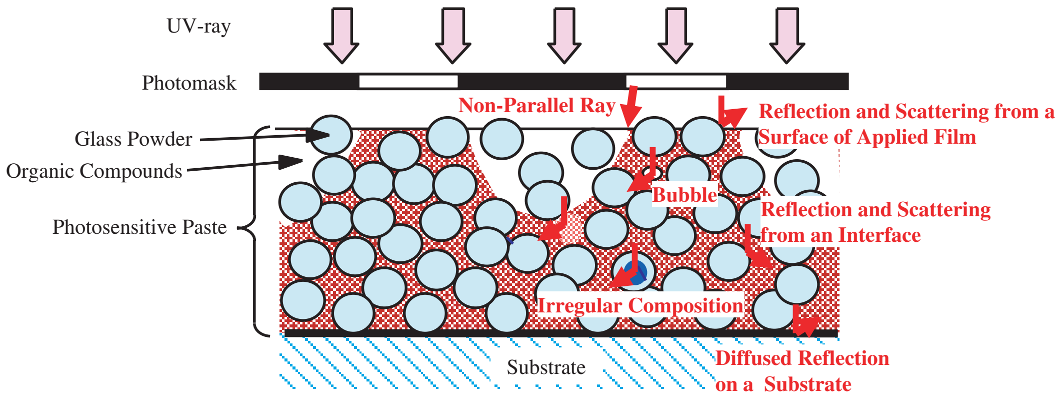

Fig. 9. Subject of photolithography method.

signed must be able to generate little impurity gas. Since the barrier ribs of PDP are fired onto a glass substrate at 500 to 600 °C, a glass with a low melting point is used. As the glass, a lead-based glass is widely used, but in view of consideration given to the environment, it is said to be necessary to use a lead-less glass. The glass used in the present technology is lead-less alumina-borosilicate glass, because of respect for the environment. On the other hand, the organic compounds include reactive ingredients peculiar to a photosensitive paste such as a binder polymer, reactive monomer and photopolymerization initiator, and further, a solvent, dispersing agent, any of various stabilizers, etc. The properties required for these organic compounds include dispersibility, stability, applicability, drying property, photoreactivity peculiar to a photosensitive paste, developability, etc. Furthermore, in the case of PDP, it is necessary to fire after forming a pattern for removing the organic compounds, so as to form a sintered compact of inorganic compounds only. So, the thermal decomposition properties of organic compounds are important. Moreover, even if the inorganic powder and organic compounds respectively have the above-mentioned properties, it occurs very often that they weaken their respective properties when and after they are mixed. Especially photosensitive organic compounds have more reactive sites than the organic binder used for the general paste and can react with the inorganic powder. This must be especially noted when the paste is designed. In addition to satisfying these properties, since an accurate pattern must be formed with one time of exposure, optical properties must also be taken into account in designing the material and selecting the members (photomask, etc.) to be used.

Problems arising in making a photosensitive thick film are typically shown in Fig. 9. It is most important to improve the straight transmission of the light transmitted through the photosensitive paste. The ratio of straight transmission can be expressed by the following formula.

$$\text{Ratio of straight transmission} = \mathrm{Lt}/(\mathrm{Lt}+\mathrm{Ls}) = (\mathrm{Lz}-\mathrm{Ls})/\mathrm{Lz} \quad (1)$$

where Lt: straight transmitted light intensity, Ls: diffuse transmitted light intensity, Lz: overall transmitted light intensity (= Lt + Ls).

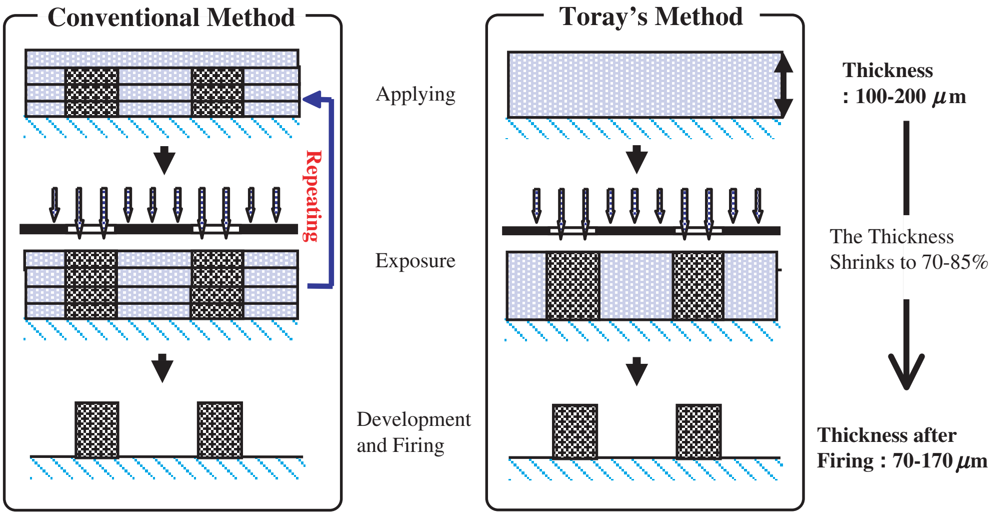

Fig. 10. Comparison between conventional and Toray's photolithography method.

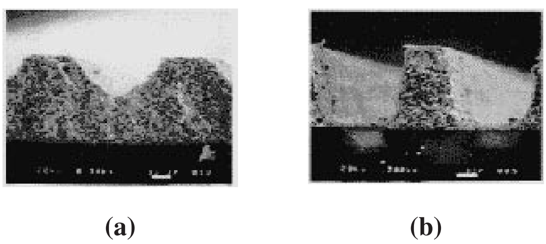

Fig. 11. Cross sectional SEM images of the shapes of barrier ribs formed before (a), and after (b) improving ratio of straight transmission.

In the conventional photolithography method, since a thick film cannot be formed at one time, the coating and exposure of a thin film are repeated, being followed by exposure, development and firing to form barrier ribs (Fig. 10). The conventional method needs a long process since exposure is repeated several times and involves difficulty in view of achieving high processing accuracy. So, we grappled with the problem of producing a film as thick as 100 to 200 μm at a time, though this was difficult to achieve by the conventional method. Factors that disturb the straight transmission of exposure light include the reflection and scattering from the surface of the coating film, the bubbles and composition irregularity inside the coating film, the reflection and scattering from the interfaces between the glass powder and organic compounds, and irregular reflection from the surface of the substrate (Fig. 9). These disturbing factors were settled one by one through material design, exposure device design, photomask design and process (gap during exposure, etc.). As a result, a ratio of straight transmission of more than 80% could be achieved, and a technology capable of accurately forming a thick film pattern with a thickness of less than 200 micrometers by one time of exposure has been established (Fig. 10).

Figure 11 shows the shapes of barrier ribs formed before and after improving the ratio of straight transmission. When the ratio of straight transmission was low, the adjacent ribs were continuous, but when the present technology was used, the ribs show a good trapezoidal to rectangular form.[30–32]

5. Process for Forming Barrier Ribs Using the Photosensitive Paste

The process for forming barrier ribs using the photosensitive paste with these properties is described below. At first, in the step of applying the photosensitive paste, since the coating thickness decides the height accuracy of the barrier ribs, a coating technique for forming a uniform thickness is necessary. We developed a slot coater system for accurate coating.[33,34] A paste suitable for slot coating was designed, and a precision stage and a precision liquid feed system were combined, to allow uniform coating. As a result, after the applying step or after forming barrier ribs, the grinding step necessary in the conventional method for making the heights of formed barrier ribs uniform could be omitted. This greatly contributed to the improvement of yield of PDPs. After completion of coating, uniform drying and exposure are carried out. The exposure is the most important step of the photosensitive paste technology. Especially if the sensitivity of the photosensitive paste is low, the exposure time becomes so long as to lower productivity. So, it is necessary to improve the sensitivity, that is, to cause a sufficient photoreaction deep inside the thick film. We designed adequate materials in photosensitivity, and succeeded in developing a highly photosensitive material requiring an exposure value of 300 mJ/cm^2 or less. Furthermore, with the cooperation of the light source maker and the exposure device maker, a 10 kW light source was developed, though a 5 kW light source only was available when the development of the exposure light source was started. Moreover, a technique of using a multi-lamp light source for improving the intensity of exposure light has also been established. As a result, even in the exposure of an area as large as a double 42-inch screen size, exposure can be accomplished in a short time of ten-odd seconds. For the exposure machine, a technique for controlling the gap uniformly when exposing the photosensitive paste and a technique of handling and positioning a large glass substrate at a high speed have been established. The exposure step is not a bottleneck step of production any more. Subsequently, development is carried out to leave necessary insoluble portions, while removing dissolved portions. For development, the materials and conditions have been optimized to secure a sufficient development margin. After development, a non-fired barrier rib pattern can be formed. The barrier rib pattern is fired at a temperature of 550 to 590 °C, to form the intended barrier rib pattern. For firing, the material was designed considering the uniform removal of binder, the uniform sintering of inorganic compounds and the matching with the thermal expansion of the glass substrate, and further, the conditions for firing at a high speed were examined to establish a highly efficient firing process technology.

6. Formation of Barrier Ribs Using the Photosensitive Paste

The barrier ribs are partitions of the respective discharge cells of RGB, and since the pixels for display are made more finely defined, high-definition processing is necessary. Since it is expected that HDTVs will be more widely used[35,36] while the information volume will increase in future, PDPs become higher in definition. The number of pixels and the screen size decide the necessary pitch of barrier ribs. The relation between screen size and cell pitch is shown in Fig. 12. If the screen size is smaller with the high definition kept constant, or if the definition is higher with the screen size kept constant, the cell pitch becomes smaller. The progress toward higher-definition versions such as the VGA widely used in industrial PDPs, W-XGA used in PDP TVs corresponding to 42-inch HD (high definition) and Full-HD (HD standard satisfying full specification) is expected to take place. A 42-inch screen as popular size of PDP requires a barrier rib pitch of 360 μm in VGA class, and a barrier rib pitch of 250 to 300 μm in W-XGA. The photosensitive paste developed by us could be used to form barrier ribs of 220 to 430 μm in pitch, 130 μm (general), 170 μm and 200 μm in height and 50 to 80 μm in width (Fig. 13). Furthermore, as a higher-definition processing tech-

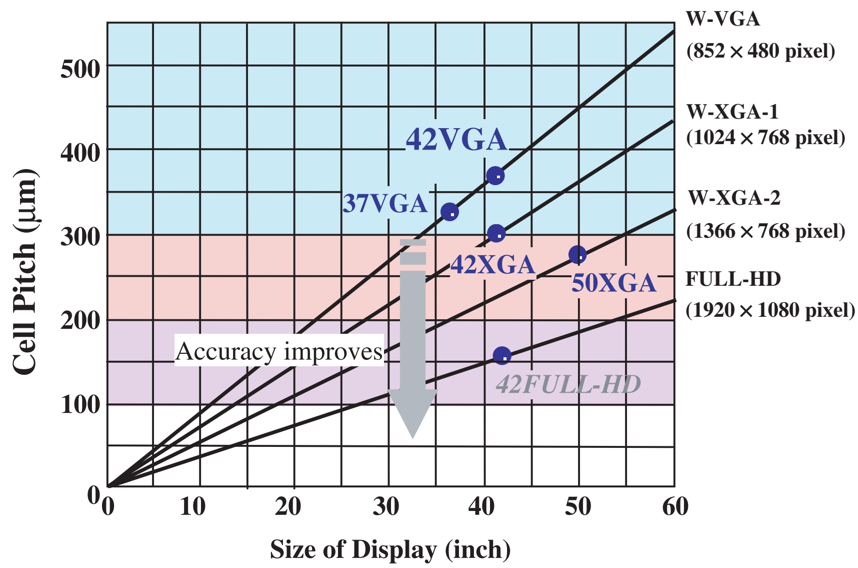

Fig. 12. Relation between size of display and cell pitch.

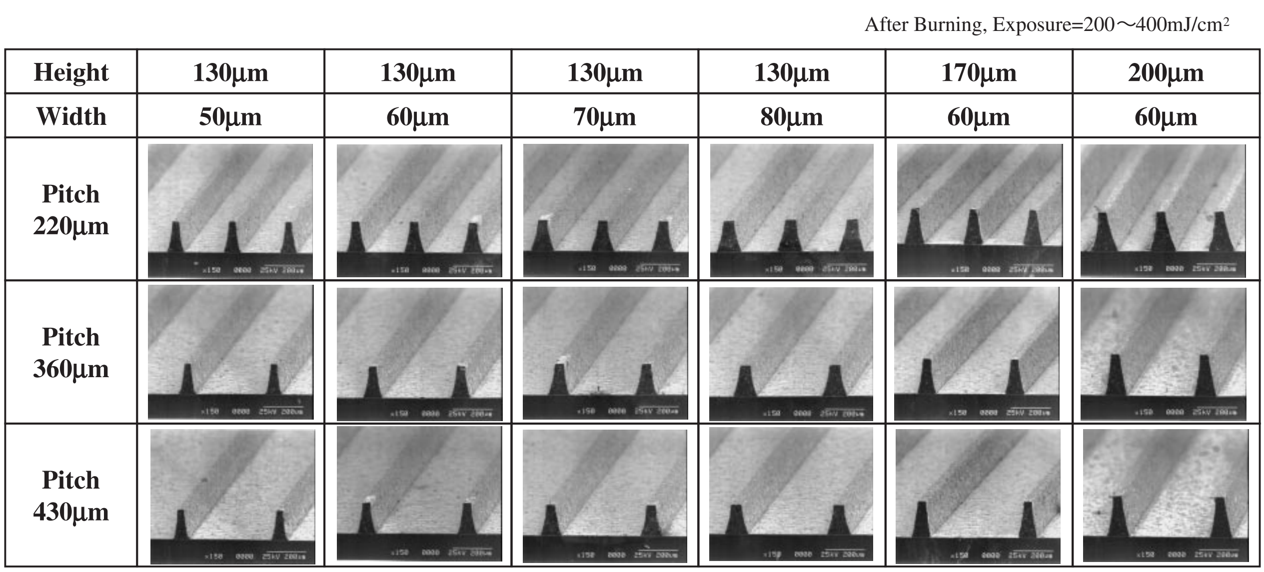

Fig. 13. Cross sectional SEM images of barrier ribs with various shapes (height, width, and pattern pitch) by using photolithography method.

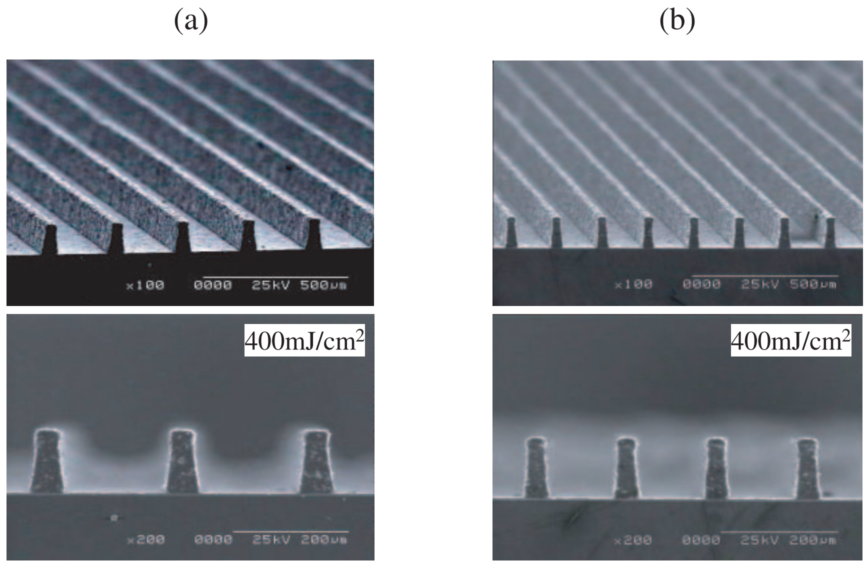

Fig. 14. Cross sectional SEM images of high-definition barrier ribs by using photolithography method. (a) Pitch 220 µm, line width 50 µm, height 150 µm, (b) pitch 150 µm, line width 30 µm, height 150 µm.

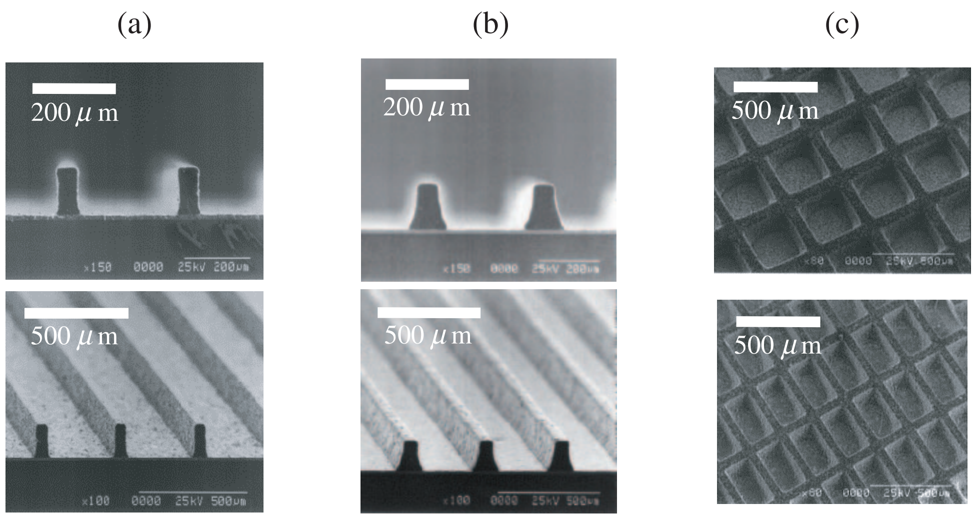

Fig. 15. Cross sectional SEM images of various shapes of barrier ribs. (a) Rectangular shape, (b) taper shape, (c) lattice shape.

nology in preparation for future, uniform barrier ribs with a pitch of 150 µm, called the ultimate high definition, can also be formed (Fig. 14).[37–45] Moreover, the sectional form can also be adjusted using a material suitable for the requirement. As shown in Fig. 15, variously formed barrier ribs such as rectangular barrier ribs, tapered barrier ribs and lattice barrier ribs can also be formed. This technology has such features that it not only allows higher-definition processing but also has dimensional flexibility (rib height, width, etc.) necessary for higher quality and less power consumption in future, allowing the formation of more complicatedly structured barrier ribs by a simple process at a high yield.

Afterword

The technique for forming a barrier rib using a photosensitive paste is more excellent than the other methods in the following:

(1) It allows highly accurate and very high-definition processing using photolithography. It will also allow production of high-definition PDPs suitable for HDTV quality images (1920 × 1080 pixels) satisfying full specification expected to come in future.
(2) It allows uniform forming and can contribute to the stabilization of electric discharge, being effective for lowering the voltage and enhancing light emission efficiency.
(3) It allows easy control of the three-dimensional structure including cross-sectionally tapered rib form and lattice structure and can respond to design of various cells, being able to contribute to enhancing the light emission efficiency and lowering the drive voltage.
(4) It is short and simple in production process and allows easy improvement of productivity. Furthermore, it allows relatively easy production of a larger-sized product or multi-screen product.

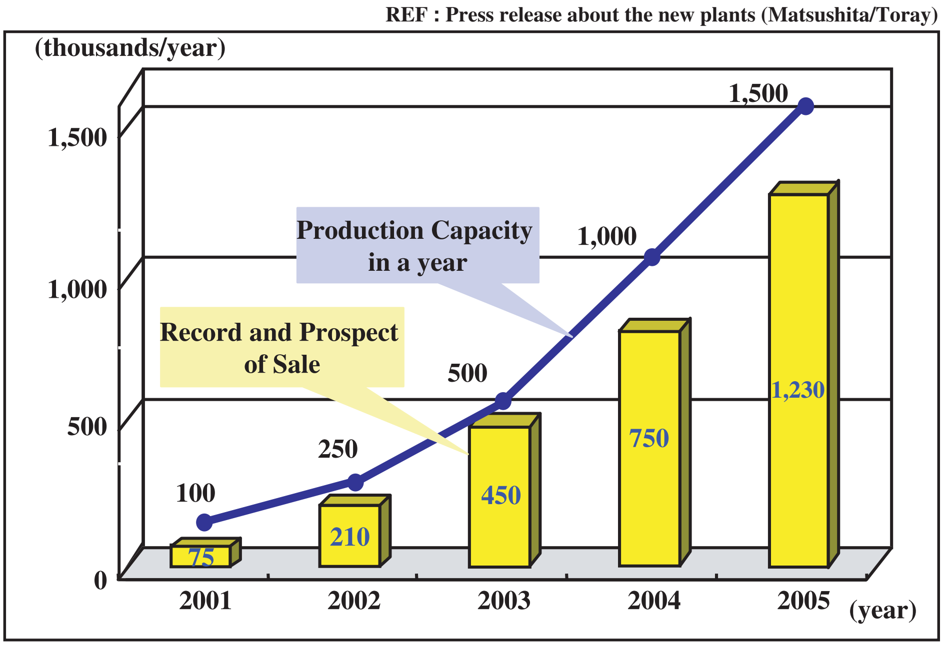

Fig. 16. Production capacity of PDP in Matsushita PDP Co., Ltd. (MPDP).

Moreover with the cooperation of a photomask maker and an exposure machine maker, a large-photomask supply capacity has been established, and in addition, a high power light source suitable for a more highly photosensitive material has been developed to allow the exposure time to be sufficiently shortened. With the efforts of the manufacturers concerned, PDPs produced by using the photosensitive paste technology are expanding their share year after year.

In addition, Toray Industries, Inc. has established Matsushita PDP Co., Ltd. (MPDP) jointly with Matsushita Electric Industrial Co., Ltd., and grants the barrier rib forming technology using a photosensitive paste, and the features of the photosensitive paste technology are used to enhance the competitiveness of PDPs in quality and cost against other large displays such as LCDs. The MPDP combines the material, process and equipment technologies owned by Toray Industries, Inc. and the image processing, driving and discharge control technologies owned by Matsushita Electric Industrial Co., Ltd., to greatly contribute to the development of the PDP industry. In 2002, the company produced more than 0.2 million PDP TVs and is establishing a capacity of supplying more than 0.5 million units in 2003 and more than 1.5 million units in 2005 (Fig. 16).

We wish to improve material design technology and process technology based on the photosensitive paste technology for producing PDPs with higher image quality at less power consumption and at lower cost in future, thereby contributing to the development of the PDP industry. Furthermore, we will apply the photosensitive paste technology to many other areas for enhancing the performance of various electronic devices demanded in relation with the widespread use of the broadband network in recent years, while fully utilizing the fundamental technologies owned by Toray Industries, Inc. such as polymer technology, photolithography and precision coating technology, for contribution to the development of the electronics industry in need of highly accurate processing.

At present, the photosensitive paste technology has been actually applied in the plasma display area; in future, the technology is expected to spread into various other areas including the electronics area, as a promising technology for processing inorganic materials.

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