Formation of Barrier ribs for PDP by Water Jet Etching of Green Tape

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Abstract

In this study, water jet etching of aqueous green tape was attempted for processing barrier rib of plasma display panel. This process combines 1) chemical etching between water and aqueous based binder in the tape and 2) mechanical erosion by water jet. Effects of etching parameters such as pressure, temperature and aqueous binder content on the morphology of barrier ribs formed were investigated. The results demonstrated a possibility of processing barrier ribs by water jet etching.

1. Introduction

Sandblasting process is currently used in manufacturing barrier ribs for PDP because of its processing capability over large area[1,2] This process, however, consisted of numerous processing steps such as thick film formation, protective layer formation, sandblasting, and sintering. Because of these numerous steps, the productivity of the process is relatively low and the morphology of the ribs produced is poorly defined. In addition, the process results in a large amount of industrial waste since more than 70% of the thick film is removed and a significant amount of sandblasting media is used with the etching process. In addition, this process has difficulties in processing closed-cell type barrier ribs.

Recently, chemical etching process of sintered thick film is being actively investigated for the processing of the barrier ribs[3,4]. In this process, a thick sintered film is etched using acid based water to form the barrier ribs. The results showed that the stripe type as well as closed-type barrier ribs are produced with an excellent morphology. This method, however, has several demerits, such as slow etching speed, environmental contamination by etching solution, limitation in the selection of materials, etc. As more than 70% of the barrier rib materials in a form of industrial waste is removed, the etching solution must be treated to prevent environmental contamination. In addition, the etching process is relatively low in productivity.

In this study, therefore, an attempt was made to develop a barrier rib processing route via etching a thick film of aqueous green tape using pure water jet. The thick film was prepared by tape casting process and patterned in a form of barrier ribs by printing an solvent based paste. The etching of the thick film was conducted by dissolving aqueous binder as well as removing debonded powders by water jet. This process, in essence, is a chemical mechanical etching (CME) process. Since the process only uses water as enchant, the powders removed can be recycled and the environmental contamination can be minimized.

The effects of etching parameters such as pressure and temperature of water jet and binder content in the tape on the morphology of barrier ribs formed were investigated.

2. Experimental procedure

Hydroxy ethyl cellulose (HEC) and acryl emulsion were used for preparation of aqueous slurry. For the raw materials of barrier rib, a mixture of glass frit and alumina powder was used at a ratio of 8:2 in weight. Average particle size of the mixed powder analyzed using a laser particle size analyzer was 1.5 μm. The slurry was prepared by mixing the powders, deionized water and dispersant using a ball mill. Subsequently, binder and plasticizer were added to the slurry and mixed.

Using the slurries prepared, thick films were formed on a glass plate using a doctor blade type tape casting machine. Thickness of the green tape obtained was approximately 200μm. A stripe pattern was then printed on the green tape with a solvent-based paste. The width of the stripe pattern was 100 μm and the pitch between the stripes was 430μm. After drying the pattern at 120°C for 20 minutes, the sample was etched using a CME apparatus as schematically illustrated in Fig. 1. For a uniform etching of the sample, the water jet nozzle traveled along the longitudinal direction, while the sample moved along the transverse direction. After the CME process, the sample was sintered at 530°C for 30 minutes. The morphology of the barrier ribs formed was examined using an optical microscopy and a scanning electron microscopy (SEM).

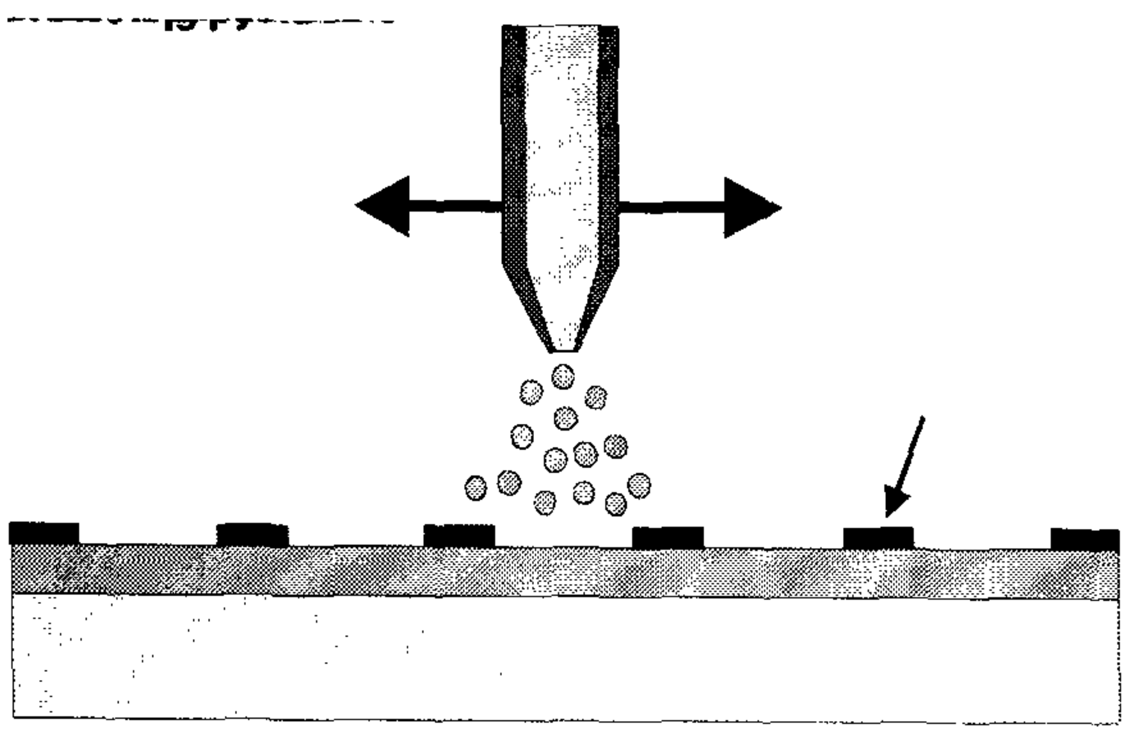


Fig. 1. Schematic illustration of CEM apparatus.

3. Results

3.1. Etching characteristics of green tape

A green tape without the barrier rib pattern was etched and measured its weight loss as a function of time. As noted in Fig. 2, the weight loss rate increased linearly with time at initial stage and exponentially at later stage of etching. The abrupt increase in the rate was observed to be caused by softening of green tape with water molecule diffusion.

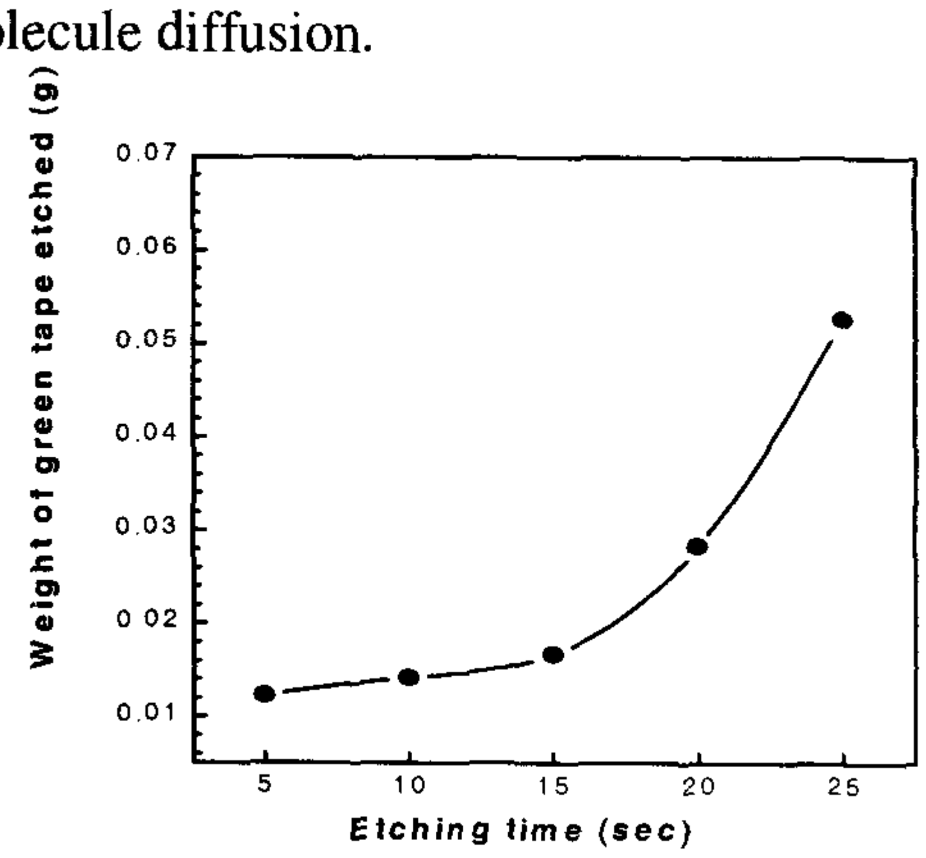


Fig. 2. Etching rate of green tape as a function of exposure time.

The effect of water jet temperature on the etching rate of green tape without pattern was examined. As the temperature is increased, the rate was increased as shown in Fig. 3. The increase in solubility of HEC and dissolution rate into water must have contributed to the increase in the etching rate.

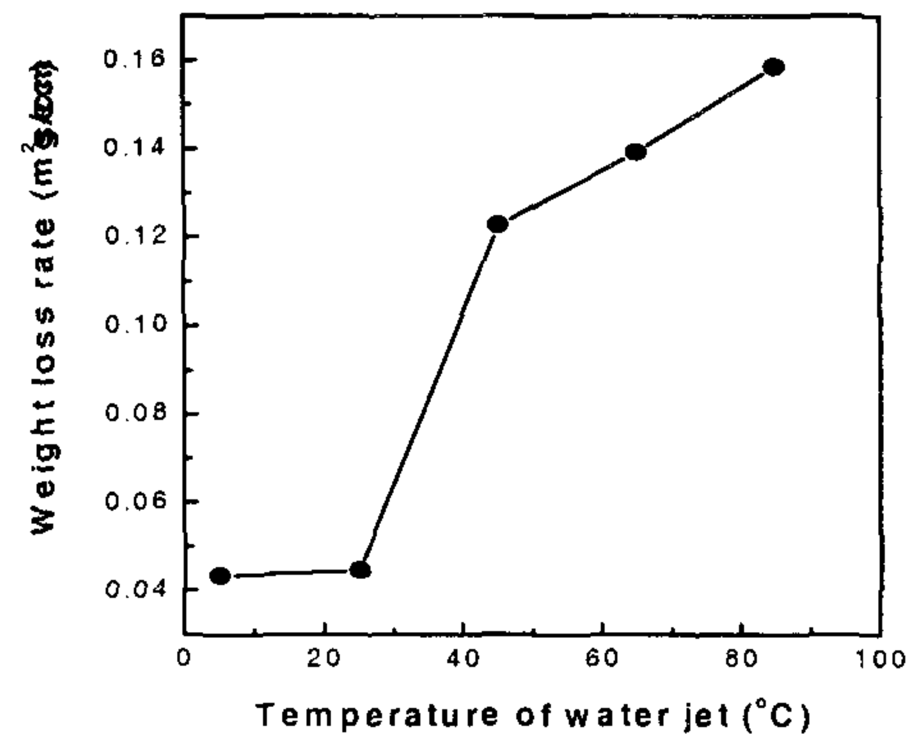


Fig. 3. Effect of water jet temperature on the etching rate of green tape.

3.2. Effects of etching parameters on morphology of barrier ribs

Figure 4 shows the effect of temperature on the height of barrier ribs etched in (a) green state and (b) in sintered state.

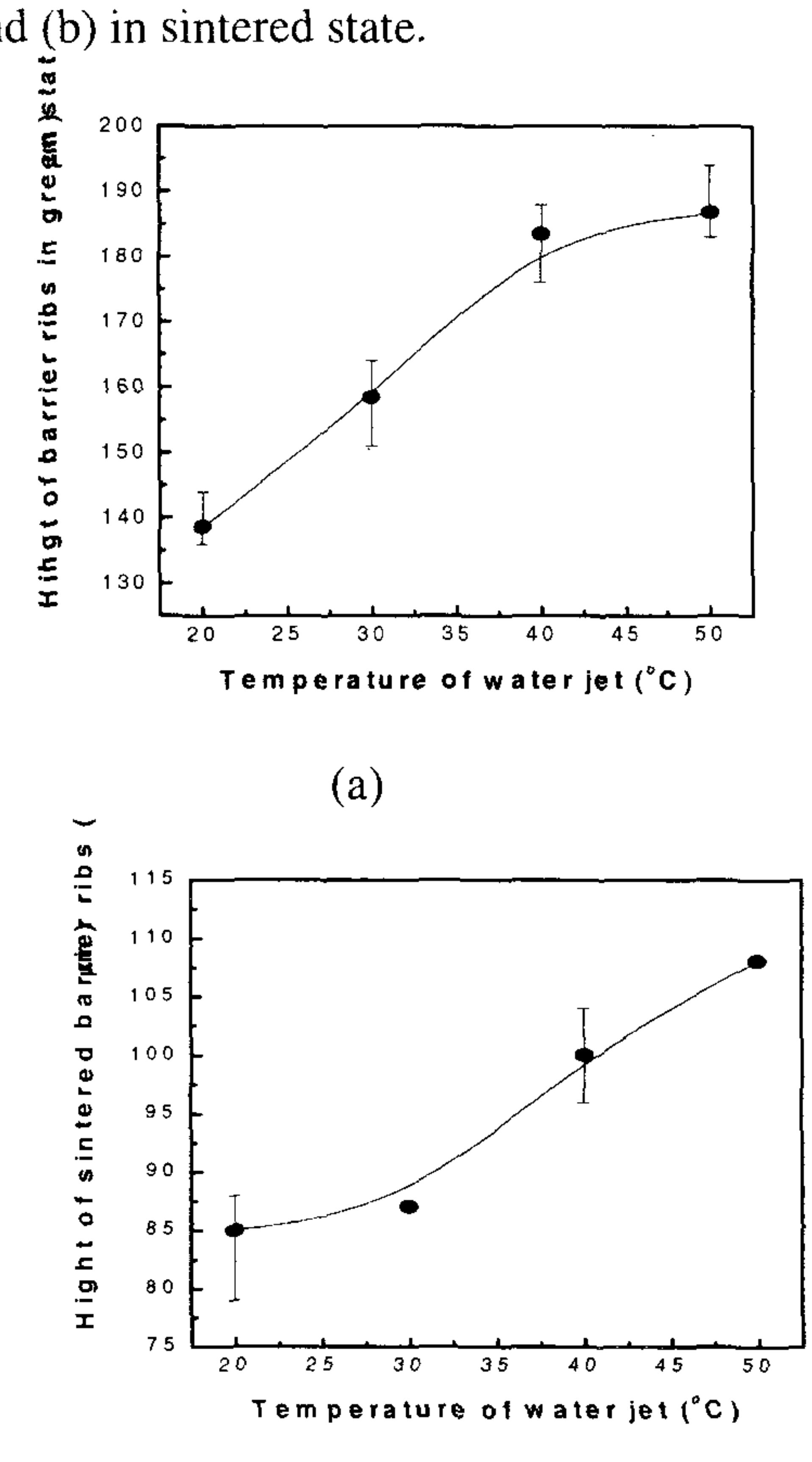
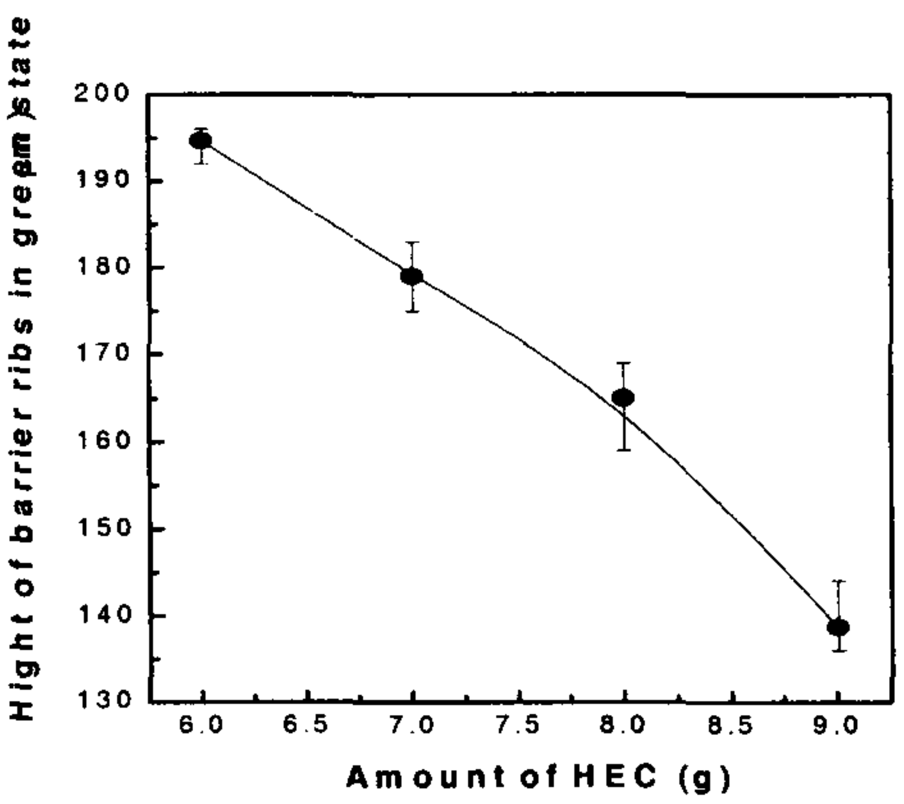


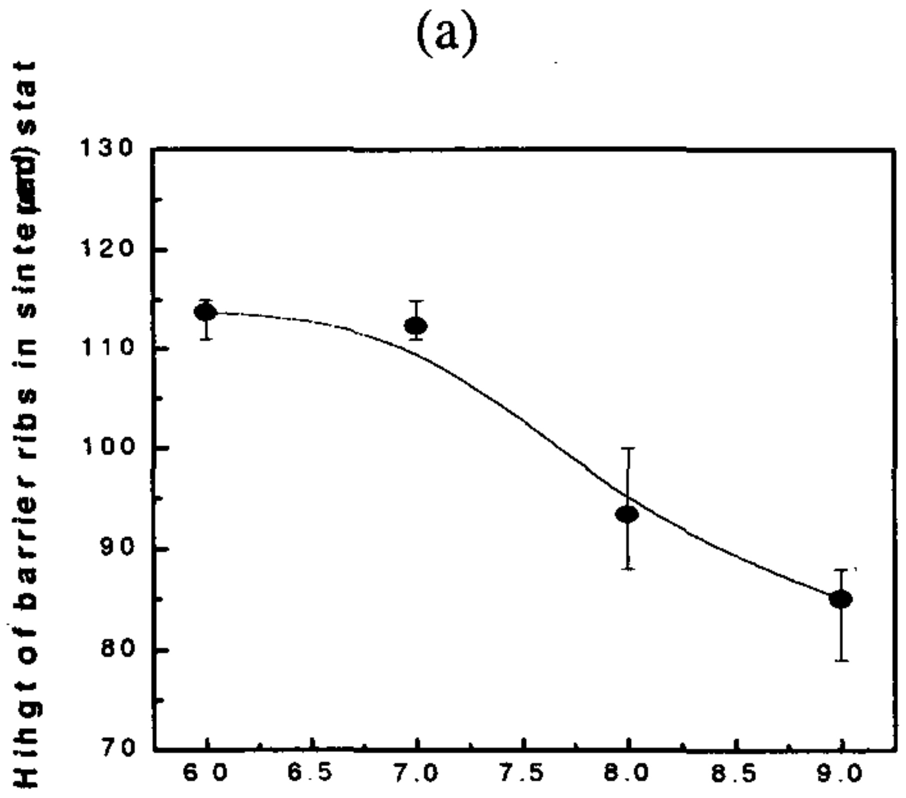
Fig. 4. Effect of water jet temperature on the height of barrier ribs formed: (a) in green state and (b) in sintered state.

As noted from Fig. 4, barrier rib heights in green state and in sintered stated increased with the water jet temperature. Higher etching rate as noted in Fig. 3 should have reduced the etching time and dissolution of binder inside the barrier ribs. As the etching time is increased, the heights of the barrier ribs were observed to decrease due to slumping of the ribs.

Effects of water soluble binder (HEC) on the heights of barrier ribs formed in green state and in sintered state are shown in Fig. 5. The height was decreased as the content of HEC binder is increased. The water soluble binder inside the barrier ribs seems to become dissolved during the etching process and that cause slumping of the barrier ribs. Therefore, the height of the barrier ribs containing higher HEC content seems to decrease.



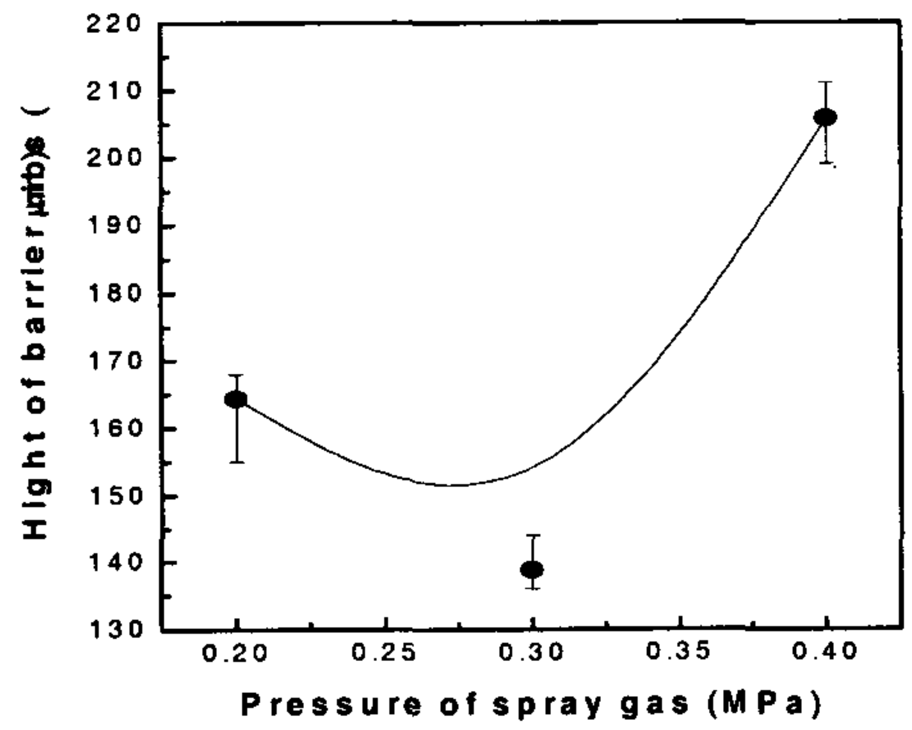
(a)



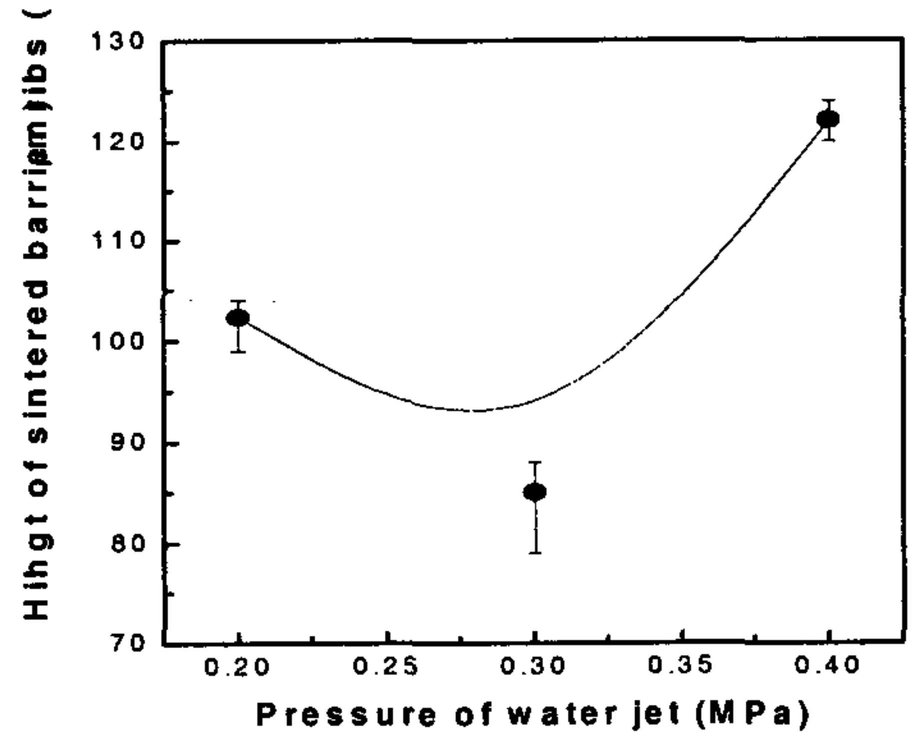
(b)

Fig. 5. Effect of water soluble binder content on the height of barrier ribs formed: (a) in green state and (b) in sintered state.

Barrier ribs formed was, in general, semi-circle in morphology. This semi-circle morphology is frequently observed when the etching characteristics of materials are isotropic. The chemical properties of green tape used were isotropic. One of the ways to induce anisotropic etching behavior on the green tape is to increase the portion of mechanical etching of the tape. The CME process consisted of chemical and mechanical etching processes. The chemical etching rate is determined by the chemical dissolution rate of binder into the water. The mechanical etching rate, on the other hand, is decided by the materials removing rate with the water jet impinging on the surface of the green tape. The momentum of water jet impinging on the green tape and the strength of the green tape exposed should determined the mechanical etching rate.



(a)

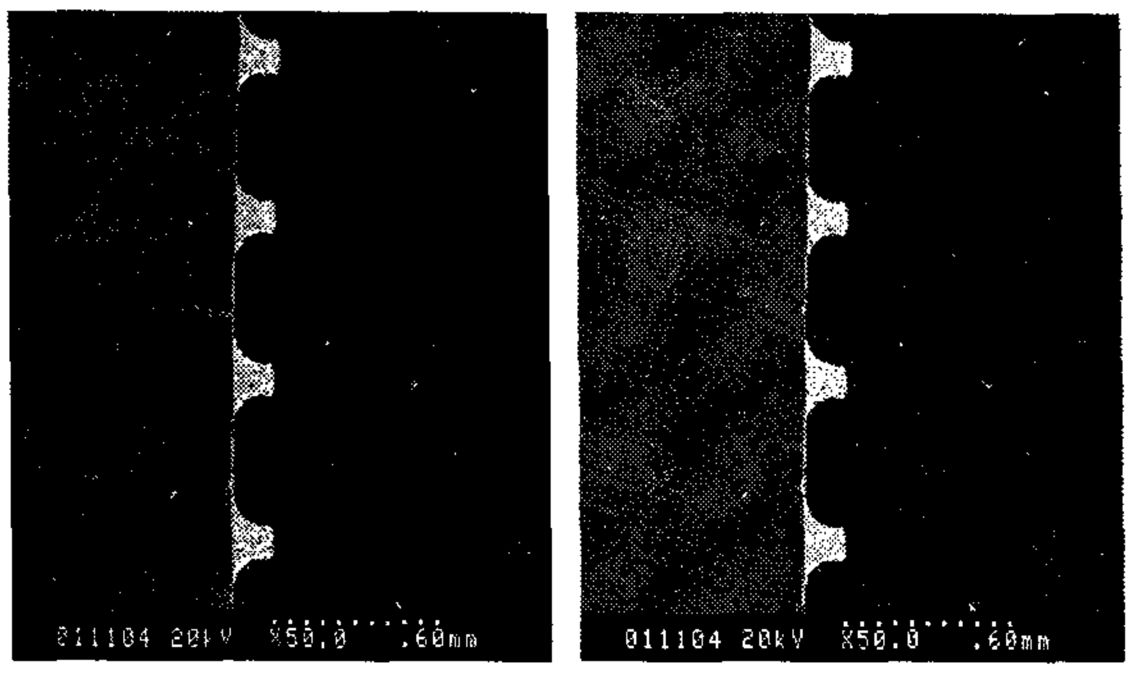


(b)

Fig. 6. Effect of water jet pressure on the height of barrier ribs formed: (a) in green state and (b) in sintered state.

Figure 6 shows the effect of water jet pressure on the height of barrier ribs formed. As noted in the figure, the height increased with the increase in the water jet pressure.

Figure 7 shows the barrier ribs formed by the water jet etching process. The morphology of the ribs formed is well-defined and was maintained during the sintering process. Barrier ribs formed was prefired at 400 °C for 1h and sintered at 530 °C for 30 min. The thickness of the ribs in sintered state was 85 μm and their height of the ribs was approximately 125 μm.



(a) (b)

Figure 7. SEM Morphologies of barrier ribs formed by water jet etching process: (a) green state and (b) sintered state.

4. Conclusions

Barrier ribs of PDP were processed by water jet etching of green tape patterned with organic based-paste. Chemical etching by dissolution of aqueous binder and mechanical etching by removal of debonded powders with water jet worked at once to form the barrier ribs. Barrier ribs having high aspect ratio and sharp etching pattern were formed via the process. A possibility of new barrier rib processing route via water etching of thick film was demonstrated.

4. Acknowledgements

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5. References

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