The formation of barrier ribs for PDP by capillary infiltration method

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Abstract

In this study, a new processing route of barrier ribs for the plasma display panels was attempted. A slurry containing ceramic powders for the barrier ribs, binder, hardener, and other additives, was molded into a PDMS mold by capillary infiltration process. The molded slurry was cured prior to mold removal. It was demonstrated that the process can fabricate successfully the cell type barrier ribs of PDP.

1. Introduction

Various manufacturing routes for the barrier ribs of plasma display panels (PDP) have been explored, which include printing [1], sand blasting [2], photo-additive method [3-4] and rolling of green tape [5-6]. Among the processes, the sand blasting process is mainly used in fabrication of the barrier ribs of PDP. This process, however, has several shortcomings. Firstly, over 70% of the paste coated on the substrate is removed by the process. Significant fraction of the paste consists of PbO-based glass frit and has a potential of environmental contamination. The loss of raw materials, in addition, significantly contributes to the increase in the cost of PDP manufacturing. Secondly, formation of the barrier ribs of width smaller than 50 μm is difficult with the process, as the strength of the unfired ribs could not withstand the impact of the sands. Ribs with finer dimensions, ~20-30 μm, are expected to be used in PDPs of higher resolution such as HDTV. Finally, the rib dimension was sometimes found to be irregular due to non-uniform impact from the sand particles.

In this study, molding of thermo-curable binder into a soft mold via capillary infiltration was attempted as an alternative manufacturing route for the barrier ribs. Formation of barrier ribs for PDP by capillary molding should alleviate the problems associated with the sandblasting process, such as low productivity, high material cost, difficulty in producing fine pitched and cellular type ribs.

When a fluid is molded into a capillary, its flow rate, $\dot{Q}$, is given by equation 1).

$$\dot{Q} = \frac{2}{3}\frac{w\delta^3}{\eta}\frac{\Delta P}{L} \qquad \text{equation 1)}$$

where, w is the capillary width, δ is the capillary thickness, η is the viscosity of the slurry, ΔP is the pressure for capillary molding, and L is the length of the capillary rise. The main parameters of capillary molding process, therefore, are the viscosity of the slurry and capillary pressure. The capillary pressure is determined by equation 2).

$$\Delta P = \frac{2\gamma Cos\theta}{\delta} \qquad \text{equation 2)}$$

where, γ is the surface tension of the slurry, θ is the wetting angle of the slurry on the mold. In this study, therefore, the effects of slurry viscosity and capillary pressure variations on the capillary molding characteristics were examined.

2. Experimental

The mold for capillary molding process was prepared by casting PDMS(Dow corning, syligad 184) on Si wafer. The wafer has barrier rib patterns formed using SU-8 thick film photoresist by lithography process. After the casting, the PDMS was baked at 70°C for 2 hours prior to removal from the Si-wafer mold. The mold was cleaned in methanol for 20minites in order to remove any contaminations remaining before the capillary molding process. The micro-structure of the PDMS soft mold has the same shape of barrier ribs for PDP and its dimension is cell pitch 360 μm, barrier ribs thickness 50 μm and height 200 μm. In addition, the soft mold with a meander type barrier rib pattern, cell pitch 430 μm, thickness 110 μm, height 200 μm, was prepared. The processing steps of the experimental procedure is schematically illustrated in Fig. 1.

The slurry for the capillary molding process was prepared using a 3-roll mill. The glass frit (DeaJu fine ceramic. Co. ltd) and alumina filler were mixed in a volume ratio of 4 : 1. Resin additives such as thermosetting binder, curing agent and diluents and

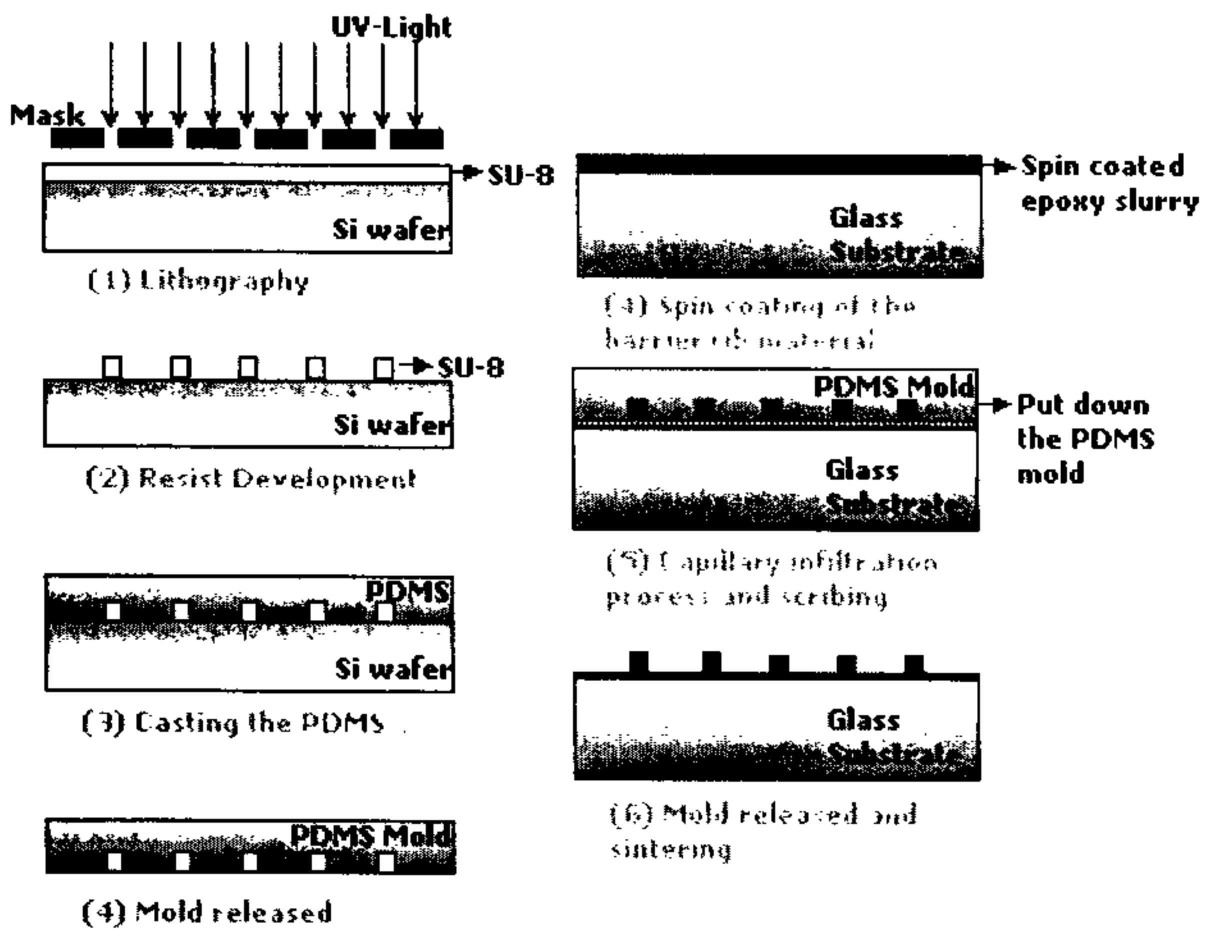

Figure 1. Processing step of barrier ribs formation

dispersant(BYK-111, BYK-chemie) were selected such that they do not react chemically with the polymeric soft mold. Epoxy resin(ERL-4221, Kukdo-chemical. Co. ltd) was selected as the binder since it has a low viscosity and fast curing characteristics. LGE was used as diluent and BF_3-monoethylamine as curing agent. Epoxy and LGE(Kukdo-chemical. Co. ltd) were mixed in ratios of 7:3 by weight.

The slurry was spin-coated on a glass substrate in 40~50□m thickness and placed under vacuum atmosphere in order to remove any pores in the film. The soft mold was then placed on the surface of the thick film and let the slurry to fill the mold by capillary pressure. In some cases, the capillary infiltration molding process was conducted at 70~80°C in order to facilitate the fluid flow into the capillary. After the slurry molding, the substrate and mold was heated to 120°C for 30 minutes in an oven for hardening and cooled to room temperature. After the removal of the PDMS mold, the sample was sintered at 570℃ for 30 minutes.

3. Results and Discussions

Fig. 2 shows a viscosity of the slurry system used in this study. As noted in the figure, the slurry shows a typical pseudo-plastic characteristic. The viscosity was affected by the content of solid, the glass frit and the filler, in the slurry. Preliminary experimental results indicated thath it is essential to have solid content higher than 50 vol%. The solid content of the slurry in this study, therefore, was selected to be 50 vol.%.

The PDMS mold produced by the PR patterning is illustrated in Fig. 3. As notes in figure 3, the side-wall of mold is very smooth and uniform.

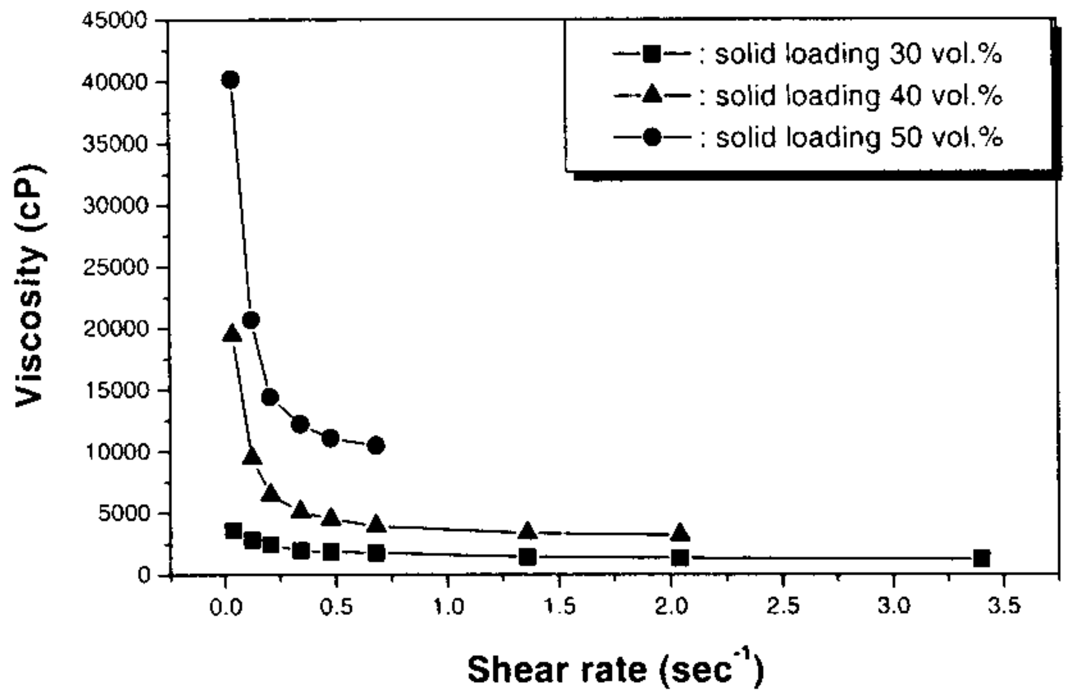

Figure 2. Effect of solid content and shear rate on the viscosity of slurry .

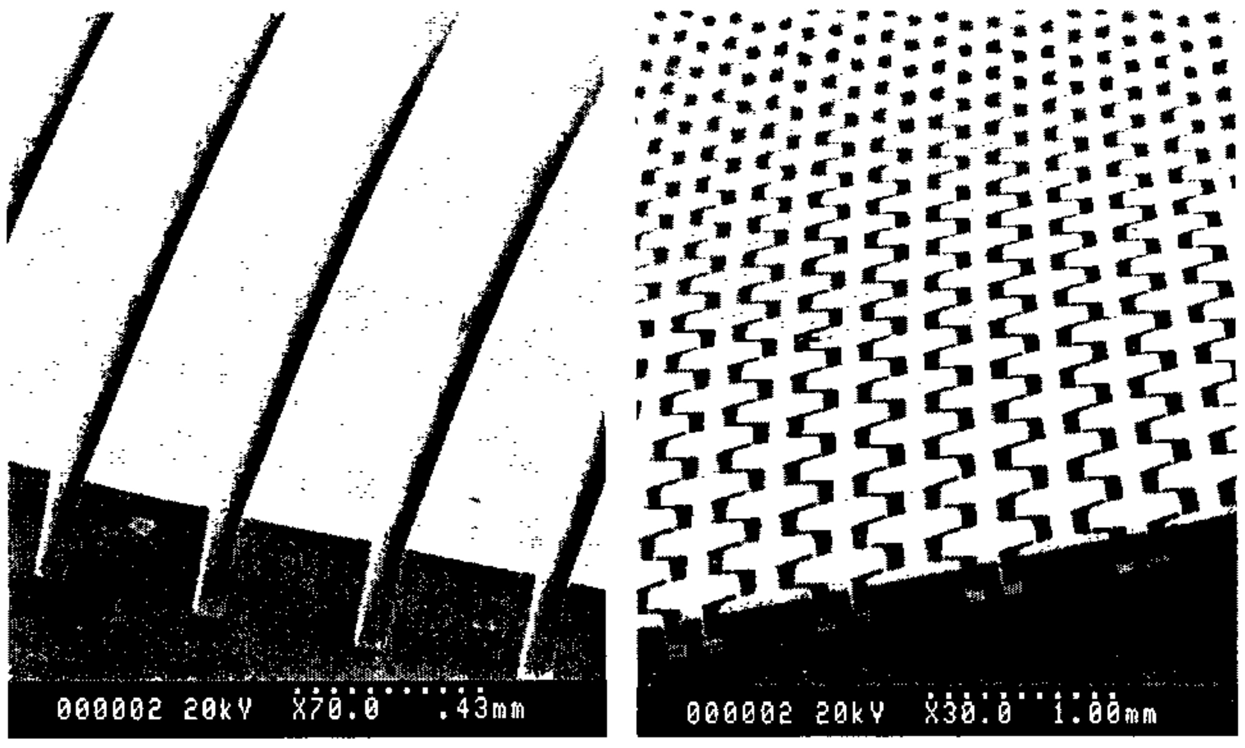

Figure 3. SEM micrographs of PDMS mold

The barrier ribs released from the polymeric mold after hardening reaction at 120°C for 30 minutes are illustrated in Fig. 4. The width of the ribs was 50μm and the height was 200μm and cell pitch was 360μm. The soft mold released from the barrier ribs cured very well and any fracturing of the ribs did not occurred due its low strength. Especially, the meander type ribs were fabricated without any defect with the process.

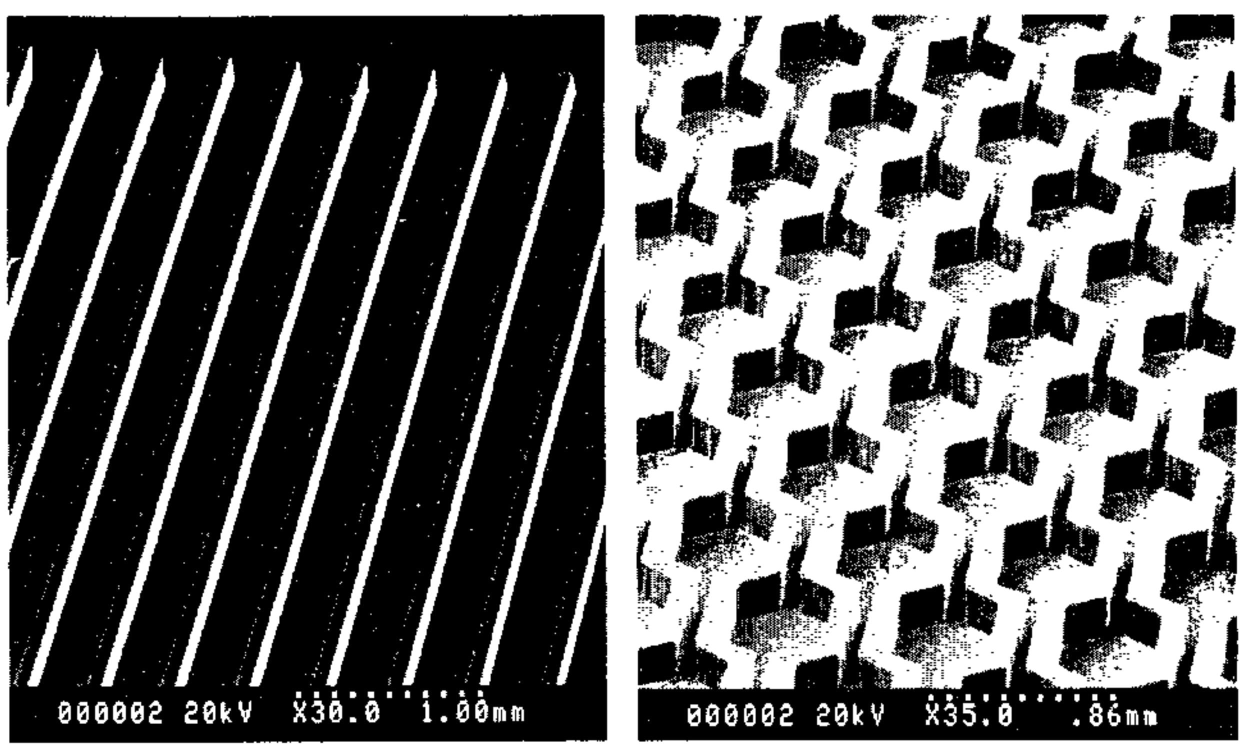

Figure 4. The barrier ribs of PDP

Fig. 5 shows SEM micrographs of the sintered barrier ribs produced by the process. As noted in the figure, very dense ribs were formed by the process. The height of the ribs was approximately 120μm and the width of the ribs was 45μm.

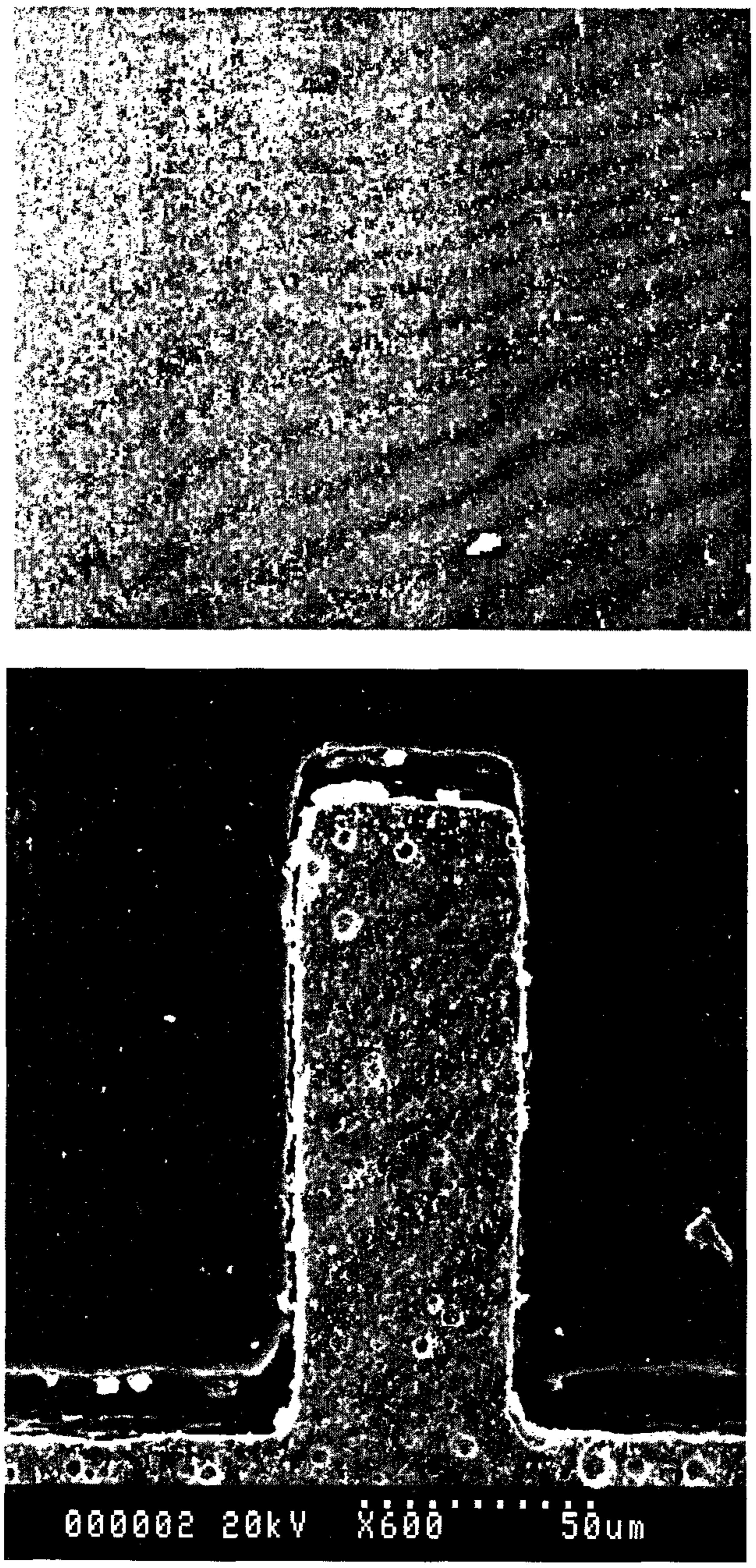

Figure 4. SEM micrographs of barrier ribs sintered.

4. Conclusions

In this study, a possibility of using capillary infiltration molding route in fabricating the barrier ribs was demonstrated. The PDMS rubber mold for the molding was prepared by replication a photo resistor via photo lithography process and the capillary molding was conducted using a low viscosity slurry of thermosetting characteristic. Well-defined and complicated structure like meander ribs were produced without any processing defects.

5. References

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