Effects of ceramic fillers on fracture resistance of barrier ribs of PDP

Se-Kyung Baek, Yong-Seog Kim
Dept. Of Materials science and Engineering, Hongik Univ., Mapoku, Seoul, Korea,
82-2-322-0644, sekyoungi@.yahoo.co.kr

Abstract

Barrier ribs of plasma display panel (PDP) are glass matrix composite reinforced with alumina particles. Mechanical properties of the ribs are very crucial for the improvement in reliability of the panel as the ribs might fracture during transportation and service. In this study, therefore, the effects of filler type and content on the mechanical properties of the ribs were investigated. The fillers used include Al_2O_3, TiO_2, ZrO_2 and fused silica. The content of the filler was changed from 0 to 40 vol.%. The mechanical properties of the ribs measured were hardness, Young's modulus, fracture toughness, and 3-point bending modulus. The fracture toughness evaluated by micro-Vicker's indentation of the composites, in general, was measured to increase with the content of the filler until the sintered density does not decrease significantly. The improvement, however, was dependent on the type of filler employed.

1. Objective and background

The barrier ribs that are currently used are glass matrix composites reinforced with ceramic fillers such as alumina and titania [1]. Within the composites, the crack may be deflected, bridged, or impeded by the ceramic fillers, resulting in increased fracture toughness. The crack defection by the fillers increases the area of fracture and reduces stress concentration at the tip to increase the energy of fracture of the sample per unit area [2]. The bridging of crack wake by the fillers should reduce stress at the tip of the crack, effectively increasing the toughness of the materials [3]. Finally, the fillers with higher Young's modulus than that of matrix may impede the propagation of the crack [4]. In addition, the fracture toughness is affected by residual stress state inside the composite. As the thermal expansion coefficients of the matrix and fillers are different each other, residual stress inside the composite may either promote or retard the crack propagation. The fracture toughness of barrier rib materials should, therefore, be affected by type and amount of fillers used.

In this study, the effects of filler type and content on the fracture toughness of barrier ribs materials were evaluated by Vicker's indentation method. For the fillers, Al_2O_3, ZrO_2, ZnO, TiO_2, and fused quartz were used. These fillers were selected based on their physical properties such as Young's modulus, thermal expansion coefficient, and dielectric constant. In addition, tensile test of the sample was conducted using sintered plates

2. Results

Vickers microhardness indentation test was conducted and the lengths of cracks generated at corners of the indentation were measured as a function of the alumina content. As noted from Fig. 1, the crack length decreased monotonically with the increase in filler content. When the content was increased from 0 to 30 vol%, the crack length decreased from 100 to less than 40μm. SEM observation of the crack revealed that the crack was deflected and bridged by Al_2O_3 fillers (Fig. 2). These actions appear to reduce the stress at the tip of the cracks and thus decrease the length of crack propagated.

Using the crack length measured, fracture toughness of the sample containing Al_2O_3 filler was calculated. When there was no fillers added, the fracture toughness of glass matrix was approximately 0.43 MPa-$m^{1/2}$. The fracture toughness increased monotonically with content of Al_2O_3 filler and reached 2.6 MPa-$m^{1/2}$ when the Al_2O_3 content is 30 vol%. Increased fracture toughness with Al_2O_3 filler may be attributed to deflection of cracks by the filler as shown in Fig. 2.

Using samples containing 10 vol% of each filler, fracture toughness was measured. As noted in Fig. 4, the fracture toughness was improved most with Al_2O_3 followed by TiO_2. With sample containing ZnO filler, the crack propagation was not affected by the presence of the filler (Fig. 5). The crack propagated straight through the sample.

3.Impact

Effects of filler type and content on the fracture toughness of barrier rib materials were evaluated using Vicker's indentation method. The results indicated that crack length decreased with the addition of Al_2O_3 and quartz fillers, but the fracture toughness behaves differently. Improvement in fracture toughness was the highest with Al_2O_3 filler followed by TiO_2. The main mechanism of toughness improvement was observed to be crack deflection. This basic understanding of fracture mechanism of barrier ribs should provide an efficient way of improving reliability of PDP.

5.Reference

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Figures

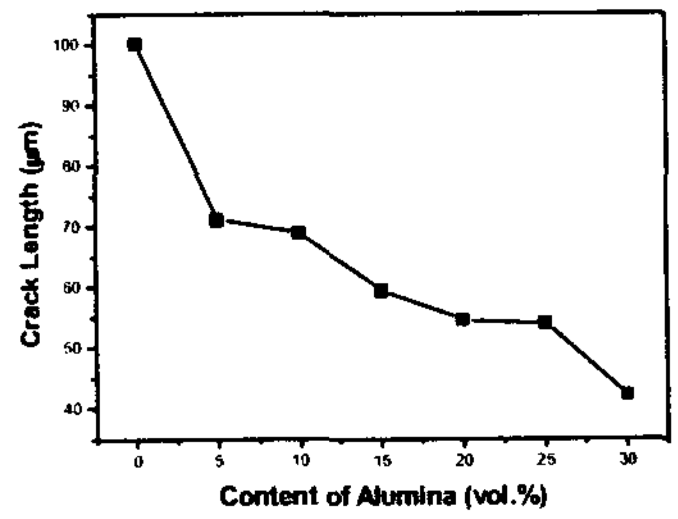

Fig. 1. Crack length measured as a function of filler content

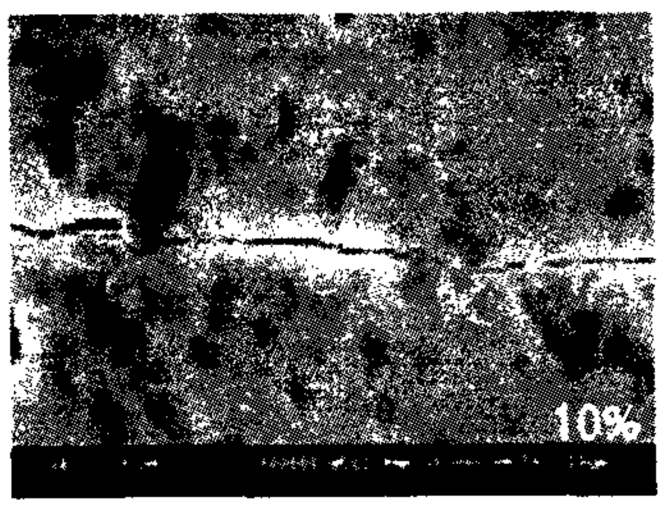

Fig. 2. SEM micrograph of crack propagation

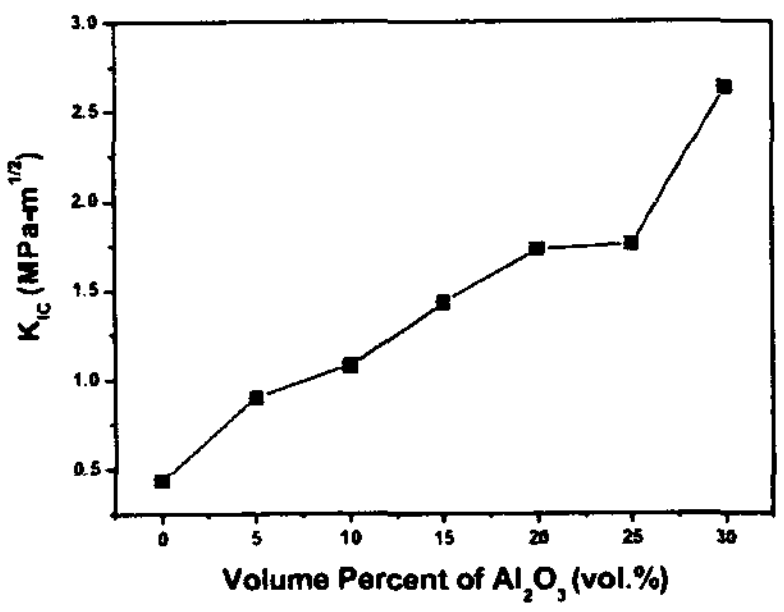

Fig. 3. Fracture toughness of sample with Al_2O_3 in a sample with alumina filler.

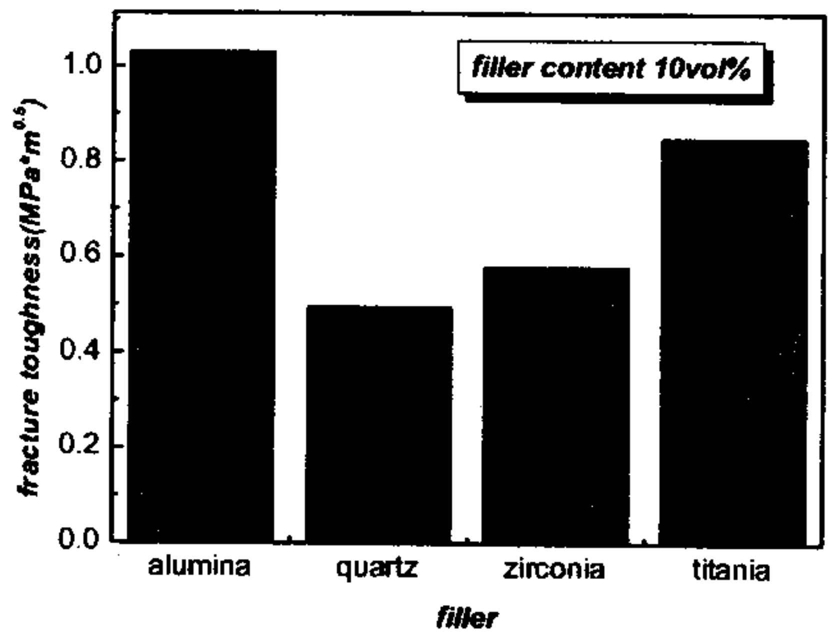

Fig. 4. Fracture toughness of sample with various filler types

Fig. 5. Morphology of crack propagation in sample with ZrO_2 filler..