Introduction

What is the deformation mechanism of brittle material, such as glass, especially at room temperature? It has been a controversial problem from the 1970s.

Although the deformation mechanism is surely related with cracking, or brittle behaviors of glass even in sub-micro scales, only a few reports focus on deformation of glass beneath an indenter.

The purpose of this study is:
1. To propose a separation method of the permanent densification part from the total indentation volume.
2. To clarify the effects of glass composition on densification.
3. To evaluate relationship between densification and indenter geometries or indentation conditions.

Results and Discussion

Effect of glass composition (Vickers indenter):

1. Various kinds of glasses except for BMG experience densification beneath a Vickers indenter.
2. Densification contribution for silica glass is > 90%!
3. Densification contribution decreases with increasing Poisson's ratio, or free volume in glass.

Effect of indenter geometry (Trihedral pyramids):

1. A Sharper indenter results in plastic flow, while a blunter indenter causes densification.
2. Higher Sneddon's pressure is the origin of smaller densification contribution beneath a Cube-corner indenter.
3. Similar to phase transformation of crystal, glass changes its structure depending on pressure.

Effect of indentation load (Trihedral pyramids):

1. Indentation volume increases with increasing holding time in any environment. (Indentation Creep!)
2. Densification contribution is almost constant (63% for 1 sec in water, 67% for 1000 sec in water).

Conclusion

- Inelastic deformation of glass was investigated using some types of diamond indenters.
- Densified volume can be estimated from AFM measurements before and after annealing.
- Densification is a major mechanism of indentation deformation in oxide glass, and depends on glass composition, indenter geometry, and indentation conditions.