Polishing-induced Generation of Intrinsic Defect of Fused Silica

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Fused silica optics are widely used in high-power laser applications, and polishing-induced intrinsic defects have become the key reason for the degradation of optical performance. Although intrinsic defects could be removed by wet etching and other methods, they also cause the deterioration of surface roughness. Thus, it is significant to understand the generation mechanism of intrinsic defects during the polishing process. In this paper, taking E' center and non-bridging oxygen hole center (NBOHC) as examples, polishing experiments and molecular dynamics simulations were performed to analyze the influencing factor and generation mechanism. By comparing the effect of different polishing pads, particles, and polishing parameters on the population of intrinsic defects, it is found that the population of intrinsic defects increases as a function of the load on the single particle. The growth rate of E' center is much higher than NBOHC, which cannot be explained by the mechanism of the breakage of strained Si-O-Si bonds. Thus, a new generation mechanism was proposed based on the intermediate of overcoordinated atoms. The reaction barrier of the generation of E' center is higher than that of NBOHC, indicating the reliability of the generation mechanism. The results provide valuable insights into the generation of intrinsic defects and guide the precision manufacturing of fused silica.