A New Magnetic Enhanced Chemical Mechanical Polishing Method for Quartz Glass Slender Holes

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Due to the limitations of tool size, field assisted polishing methods are often employed for polishing the internal surfaces of slender holes with large aspect ratios. However, in existing polishing methods, fields are often applied in isolation, which limits the ability to obtain high surface quality. Therefore, developing a polishing method that harnesses the synergistic interaction of multiple fields, and revealing the polishing mechanism, is crucial for achieving high-quality internal surfaces of quartz slender holes. To address this problem, a novel magnetic enhanced chemical mechanical polishing method was proposed in this paper and a systematic process study was carried out to analyze the synergistic effects of magnetic and chemical fields. To evaluate the effects of process parameters on material removal and forecast MRR, the material removal process was modeled and validated based on the consistency between experimental and theoretical values. Suitable process parameters are determined through experiments and analysis on magnetic field distribution and process parameters. By conducting EDS mapping and XPS analyses on the reaction product, the enhancement mechanism of magnetic field on material removal in the chemical mechanical polishing process was identified. Under the assistance of a magnetic field, the magnetic abrasive particles encircle the CeO_2 particles to fully contact the workpiece surface. The contact force between the polishing tool and the workpiece surface increase. Both of the effects promote the chemical reaction and enable the reaction layer on the surface to be removed in time to obtain higher surface quality. As a result, this method achieves high-efficiency and high-quality polishing, significantly reducing the surface roughness Sa of slender holes from 0.3 μm to 77 nm, with a material removal rate of 141 μm/h.

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