A new glycerol-based polishing slurry for Cs_2LiYCl_6 crystal

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Scintillation crystals are widely used in various fields, including homeland security, medical diagnostic imaging, space exploration, and high-energy physics, due to their capacity to generate light or flash when exposed to high-energy rays or particles. Among them, the potassium cryolite scintillating crystal Cs_2LiYCl_6 (CLYC) offers more light output and energy resolution, demonstrating excellent neutron/gamma-ray dual detection performance. However, due to the softness, brittleness, and easy deliquescence of CLYC crystals, the processing poses significant challenges. Currently, CLYC crystals are usually ground and polished using fine sandpaper or diamond slurry with the aid of mineral oil. However, this method demonstrates limited machining effectiveness and is prone to causing abrasive embedding and surface scratches. To address this issue, a new glycerol-based polishing slurry containing glycerol, ethanol, deionized water, and SiO_2 abrasives was formulated. The CLYC crystal ingot was cut into 7×7×2.5 mm^3 samples, and 1000 mesh sandpaper was used for pre-grinding to remove impurities and debris attached to the sample surface, obtaining a flat surface. Prior to polishing, liquid paraffin was applied as a protective oil to the pre-ground surface to prevent deliquescence from damaging the flat surface. The conventional water-based polishing slurry, known to cause severe deliquescence in CLYC crystals, was eschewed in favor of glycerin as the base fluid. To reduce the viscosity of glycerin, ethanol was incorporated as a diluent. Additionally, a minimal quantity of deionized water, coupled with low-hardness spherical hydrophilic SiO_2 abrasives, was utilized to facilitate material removal. In this paper, the viscosity and zeta potential of different proportion mixtures of glycerol and ethanol were tested to assess their liquidity, dispersibility, and stability. Through process optimization experiments, the optimal slurry formula was determined. X-ray photoelectron spectroscopy (XPS) experiments were conducted to elucidate the material removal mechanism of the new slurry. During the polishing process, the paraffin oil layer coated on the surface of the crystal will be removed. Due to the gravity and the frictional interaction between the crystal and the polishing pad, the roughness micro-peaks are exposed first. These micro-peaks will interact with the deionized water in the slurry, forming a soft layer on the micro-peaks, which could further ionize. While deliquescence occurs, the SiO_2 abrasives in the slurry also engage in mechanical action to remove the soft layer; moreover, they play a role in eliminating the fresh micro-peaks generated by deliquescence, inhibiting the deterioration of surface quality. Due to the residual liquid paraffin in the micro-valleys, the deliquescent actions of the crystal surface roughness valleys are relatively weak. In this way, the roughness peaks of the crystal surface are gradually removed, and the processing surface tends to become smooth and uniform. Finally, using the new polishing slurry, the surface roughness Ra of the CLYC crystal was reduced from 894 nm to 85 nm, and the energy resolution reached 5.73% in the absence of Ce^{3+} or other dopant elements.