Mechanical Surface Treatment of Water-sensitive Perovskite Scintillator Crystals via Hydrophobic Solvents

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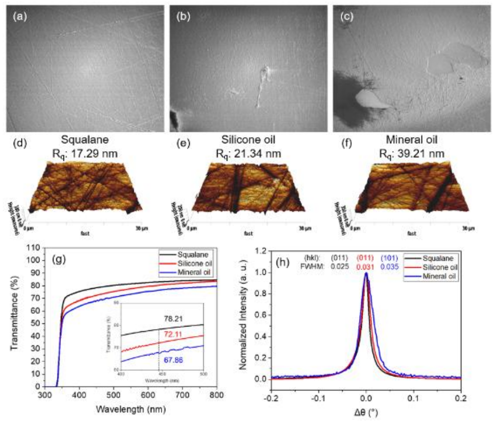
Recently, halide perovskites have been studied in various fields such as solar cells, optoelectronics, radiation detection, and medical imaging owing to their tunable bandgap, optical properties, and high effective atomic number. They have been studied to achieve the growth of large single crystal with high crystallinity by optimizing growth conditions such as the temperature gradient, molar ratio, and compositional engineering for high-performance devices.

Regardless of growth method, as-grown crystals require post-processing such as cutting, lapping, and polishing. Among them, polishing must be performed for using crystal as a device because of improvement performance by reducing mechanical damage on the surface or flattening irregular shapes such as hopper-like morphology. However, most halide perovskites suffer from poor stability, especially against moisture and water. In the case of 0D halide perovskite, $Cs_3Cu_2I_5$(CCI), is relatively stable in ambient condition, however, it dissolves when it contacts with water. Therefore, polishing abrasive for water-sensitive halide perovskite should be hydrophobic to prevent degradation of the crystal.



SEM and AFM images of Polished CCI with (a), (d) Squalane, (b), (e) silicone oil and (c), (f) mineral oil. (g) Transmittance curves and rocking curves with polished each solvent.

In this study, three hydrophobic solvents with different molecular characteristics were selected as polishing solvents: a single molecule (squalane), a polymer (silicone oil), and a multicomponent mixture (mineral oil). Polishing abrasive was prepared by dispersing 10 g of alumina powder (Al_2O_3, 1 μm) in 100 mL of each solvent. The polished samples were rinsed with toluene, which has a nonpolar character, to prevent moisture-induced degradation of the samples. To confirm the surface roughness of polished CCIs with each solvent, Scanning Electron Microscope, Atomic Force Microscope and X-ray Diffractometer rocking curve measurements were conducted. Also, UV-Vis transmittance was measured to evaluate optical properties influenced by surface roughness.

As shown in SEM images, CCI polished with squalane showed an absence of residue on surface. To quantify surface roughness, AFM measurement was conducted. RMS roughness of polished CCIs with squalane, silicone oil and mineral oil were measured to be 17.29 nm, 21.34 nm and 39.21 nm, respectively. These results suggest that the single-molecule character of squalane allows more efficient polishing compared to solvents with more strongly interacting molecular structures. As a result, the improved surface flatness leads to higher optical transmittance (78.21%) and a reduced rocking-curve FWHM (0.025°), indicative of suppressed surface roughness–induced broadening.

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