Research Abstract

This research aims to develop nanomaterial-based abrasives that can improve the efficiency and effectiveness of the chemical-mechanical optical polishing process for superfinish surfaces. The focus is on overcoming the limitations of the conventional abrasive particle by producing nano-sized abrasive particles with required features such as fine particles, narrow particle size distribution, high surface area, and high zeta potential. This allowed for more efficient cutting and polishing of the glass surface, resulting in a smoother and more uniform surface finish. The research involves the development and characterization of the nanoabrasives and investigating their polishing efficiency by varying the different polishing parameters, such as pH, concentration, and polishing time. The research also investigated the impact of the chemical and mechanical action of the CMP by the nanoabrasive particles on the polishing performance.

A dual nature magnetic-nanoparticle-based abrasive was also developed for the magnetic field-assisted polishing process. The magnetic field-based polishing techniques, such as MRF, BEMRF, and their variations, rely on two essential factors: the finishing abrasive and the magnetic particles. However, the presence of magnetic particles can impede the direct contact of non-magnetic abrasive particles with the surface to be polished, leading to a decrease in the overall polishing efficiency. Therefore, the effectiveness of magnetic-assisted finishing depends on the ability of the active abrasive particles to interact with the surface being polished. Additionally, the optical and semiconductor industries use a significant amount of commercial abrasives for polishing, which cannot be recycled or reused, resulting in significant waste. This research addresses this issue by introducing an abrasive system that can provide Angstrom-level surface roughness in a sustainable and reusable manner for both magnetic and non-magnetic optical fabrication processes.

Research outcomes

- A magnetic nanoparticle-based abrasive was developed to fabricate superfinish surfaces via a conventional chemical mechanical polishing process
- To further resolve the limitation of the bared magnetic nanoparticle-based abrasive, a functionalization process was utilized to alter the bared-nanoparticle’s physical and chemical features, such as particle size and its distribution, high surface area, and high zeta potential. This allowed us to lower the surface roughness of the polished surface to one Angstrom

- First time, different surface modifiers such as Cysteine, Malic acid, and Glutamine were explored to investigate the effect of different end-functional groups on the chemical mechanical polishing performance of magnetic nanoparticles for superfinish surfaces
- To eliminate the need for two types of particles, such as magnetic and abrasive particles (non-magnetic), a dual features magnetic nanoparticle was developed and utilized for BEMRF polishing for the MR-based finishing process.
- A hybrid core-shell-based nanoabrasive was developed for both magnetic and non-magnetic polishing processes to enhance further the finishing efficiency of dual-nature magnetic nanoparticle-based MR fluid