Material removal behavior and model for chemically enhanced high-shear and low-pressure grinding of lithium niobate crystals

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Lithium niobate crystals possess unique electro-optic, acousto-optic, elasto-optic, piezoelectric, pyroelectric, and nonlinear optical properties. They are widely employed in 5G communications, micro-nano photonics, integrated photonics, and quantum optics domain. However, lithium niobate crystals suffer serious surface/sub-surface damage, unclear material removal mechanism, low material removal rate, and other scientific and technological challenges during ultra-precision machining due to their low hardness, large brittle, and strong anisotropic. To address the above challenges, this study proposed a novel method of chemically enhanced high-shear and low-pressure grinding. This method employs a body-armor-like abrasive tool with soft abrasives to achieve high-efficiency, ultra-smooth, and damage-free removal of lithium niobate crystals. The mechanisms of elastomeric fluid film formation and material removal behavior in the contact region are investigated using the theories of contact mechanics, non-Newtonian fluid kinematics, and elastohydrodynamic lubrication. A material removal model for chemically enhanced high-shear and low-pressure grinding of lithium niobate was established based on the theory of material removal from a single abrasive grit, supplemented by a statistical model of active abrasives. The experimental results demonstrated that the chemically enhanced high-shear and low-pressure grinding method held great promise for high-efficiency and high-quality machining of lithium niobate crystals.