Featured Material – Lithium Niobate ($LiNbO_3$)

Lithium niobate ($LiNbO_3$) is the embodiment of human ingenuity. It is a manmade crystal of niobium, oxygen, and lithium (Figure 1). Remeika is often credited with growing the first large $LiNbO_3$ single crystal around 1949 (1). $LiNbO_3$ crystal has a high melting point, 1,257 °C, to be exact and is colorless. Its high transparency window, non-centrosymmetric property, high Curie temperature (~1200 °C), and acoustic property make $LiNbO_3$ crystal a great candidate for applications in photonics. As a matter of fact, $LiNbO_3$ modulators are widely used in fiberoptic communications.

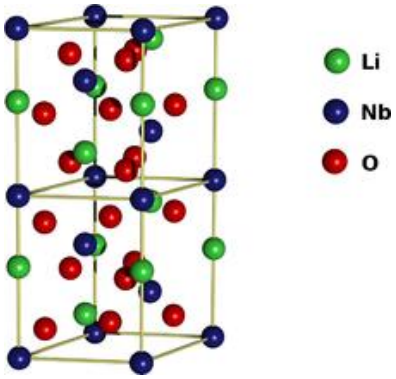

Figure 1. Crystal structure of $LiNbO_3$ (credit Wikipedia).

Thin-Film Lithium Niobate and Bottlenecks

Despite its remarkable characteristics, $LiNbO_3$ remained a material found in bulky devices due to its difficulties in processing and integration in the decades following Remeika's crystal growth. Thin-film $LiNbO_3$ with ridge waveguides, on the other hand, can achieve large index contrast and superb mode confinement, and at the same time, making miniaturization of host devices possible. For example, the acoustic index of the speed of sound inside thin-film $LiNbO_3$ is higher than that of sapphire and radio frequency filtering in cell phones becomes possible. However, the fabrication of thin-film $LiNbO_3$ and its ridge waveguides had been plagued with technical difficulties and inconsistencies in quality - until the dawn of the 21st century and now.

"Smart-Cut" and Dynaqual™

Rabiei of Partow Technologies was among the first few to produce high-quality $LiNbO_3$ thin film with the use of crystal ion slicing and direct bonding in early 2000s (2). The "Smart-Cut"

technology eliminates the inconsistencies of making $LiNbO_3$ thin films with deposit or growth methods. After the $LiNbO_3$ thin film is created by splitting with thermal annealing, polishing is needed to smooth out the thin-film surface. At the Lapping and Polishing Lab at Qual Diamond, we are able to achieve roughness of 0.5 nm in a one-step polishing procedure on thin-film $LiNbO_3$ using Dynaqual™ polycrystalline diamond slurry with particle size of 1 µm and Qual Diamond QDTXD polishing pad (Figure 2).

Ridge waveguides can also be achieved by mechanical means (3). Can Dynaqual™ diamond slurry generate functional ridge waveguides? One way to find out is to contact sales@qualdiamond.com for a free sample!

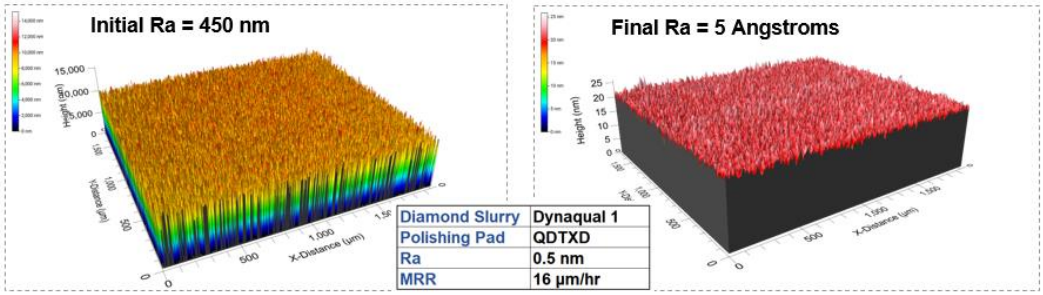

Figure 2. Results of 1-step polishing procedure of $LiNbO_3$ thin film.

References:

1. Matthias, B.T.; Remeika, J.P. Ferroelectricity in the Ilmenite Structure. Phys. Rev. 1949, 76, 1886–1887.
2. P. Rabiei and P. Gunter, "Optical and electro-optical properties of submicrometer lithium niobate slab waveguides prepared by crystal ion slicing and wafer bonding," Appl. Phys. Lett. 85, 4603–4605 (2004).
3. M. F. Volk, S. Suntsov, C. E. Rüter, and D. Kip, "Low loss ridge waveguides in lithium niobate thin films by optical grade diamond blade dicing," Opt. Express 24, 1386–1391 (2016).