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## Lithium Niobate Material Quality Classification

Crystal Technology, Inc. currently specifies three grades of crystal quality. As a general rule, crystal quality is continuously improved as the processes are improved. However, there are often trade-offs between improving quality and reducing costs. Our technical staff regularly meets with the leading customers in each industry in order to find the best compromise between quality improvements and cost reduction. The following material grades are in order from the least critical (and lowest cost) to the most demanding:

- SAW Grade
- Refractive Grade
- Optical Grade

### SAW Grade

This is the most commonly produced grade and is used for making surface acoustic wave devices. This is a non-optical applications and the least demanding in terms of impurities and crystalline perfection. Reduced material ("black LN") is often adequate or even preferred for its lack of pyro-electric charging. Inclusions can be tolerated to some extent as long as they are small enough not to interfere with the excitation or propagation of the SAW waves. Crystal growth for SAW material is generally optimized for high efficiency. The crystals are grown quite long, converting a large fraction of the melt into crystal material.

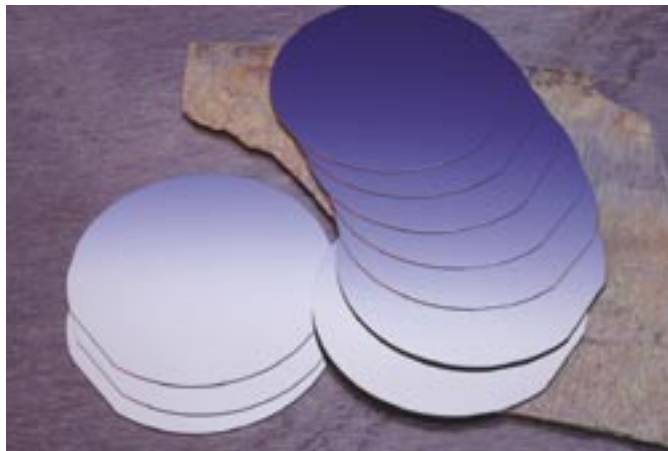
CTI rejects material that is excessively colored (excessive contamination), cracked, or shows signs of twinning or large angle grain boundaries ( $>0.2^\circ$ ). Material with large inclusions or a high density of smaller inclusions is also rejected.

### Refractive Grade

This is material used for lower demanding optical applications such as Wollaston prisms for DVD heads and blur-filters for digital still cameras. Strain (dislocations) are tolerable, but inclusions are not. The crystals are grown at similar lengths to SAW grade material, but inspected and screened to avoid even low densities of inclusions.

### Optical Grade

This material is used for the most demanding optical applications such as high speed modulators and polarization-controlling devices. Optical material is low strain with no inclusions. To avoid grain boundaries and strain build-up, the crystals are grown shorter (typically less than half the SAW grade crystal length). The growth environment (furnace construction) as well as growth parameters (pull rate, rotation) are optimized for low strain, not high throughput. To minimize effects of non-congruency and impurities, a smaller fraction of the melt (~50%) is converted into crystal than for the other two grades. A proprietary inspection method is used to visualize strain before the crystal is sliced. Only the best of these crystals are further processed, with the others either graded as refractive or recycled.



Chemically reduced (black) lithium niobate SAW wafers.