Nd:YLF as an Alternative to Nd:YAG

Advantages and Disadvantages

Nd:YLF often is proposed as an alternative lasing medium to Nd:YAG. Their emission wavelengths are nearly the same (1047 nm and 1053 nm for Nd:YLF vs 1064 nm for Nd:YAG). However, there are a number of deficiencies in the inherent performance of Nd:YLF that make it difficult for industrial use.

1. **Pulse Energy:** The sole benefit of Nd:YLF is its greater pulse energy performance at low Q-switch frequencies < 2 kHz, up to 2 times the pulse energy capability of Nd:YAG. However, at pulse rates > 2 kHz, the pulse energy (and average power) performance of Nd:YLF decreases significantly.

2. **Beam Roundness:** The output beam profile of a Nd:YLF laser tends to be oval, not circular. It may be possible to use external optics to correct the oval beam profile and make it circular, but this will be effective for only one output power level. If the laser is operated at a different power level, the beam will again become oval.

3. **Performance Uniformity:** Nd:YLF laser rods exhibit a significant level on non-uniformity from one crystal to another. This means that uniform performance from one laser to another will be difficult to achieve without laser rod selection, which will be costly.

   This also means that when a Nd:YLF laser rod must be replace, the new crystal may not exhibit the same performance as the original crystal.

   Lee Laser's experience with Nd:YAG shows highly repeatable performance from one crystal to another inside the same optical resonator.

4. **Crystal Solubility:** Nd:YLF material is slightly soluble in water. The outside surface of the Nd:YLF crystal will slowly dissolve in the cooling water, which can cause water seal problems. The crystal eventually must be replaced. Nd:YLF crystal lifetime is 1-2 years.

   Nd:YAG exhibits no such solubility deficiency.

5. **Thermal Focusing:** Nd:YLF material exhibits completely different thermal focusing characteristics than Nd:YAG. A laser designed for Nd:YAG cannot simply accept a Nd:YLF laser rod of the same dimensions. The performance will be totally different. Therefore, it will be necessary to design a new laser optical resonator for use with a Nd:YLF crystal.

6. **Crystal Hardness:** Nd:YLF is considerably softer and more brittle than is Nd:YAG. Nd:YLF laser crystals are highly vulnerable to fracture. The technique that Lee Laser uses to grasp Nd:YAG rods cannot be used for Nd:YLF, at the risk of breaking the ends of the Nd:YLF laser rod.

   One of the major reasons that Nd:YAG has remained the crystal of choice for industrial use for more than 30 years is its high durability in an industrial operating environment.

7. **Thermal Shock Resistance:** Nd:YLF exhibits five times (5X) the thermal expansion of Nd:YAG. As such, it is more sensitive to thermal shock and fracture such as might occur if an arc lamp were to suddenly fail.

8. **Self Polarization:** Nd:YLF crystals that are used inside a laser optical resonator are self polarizing. This means that the output beam is inherently polarized. This can be a clear benefit when generating the fundamental output wavelengths of 1047 and 1053 nm. However, when used with a second harmonic generator to produce the half wavelengths of 523 and 526 nm, the planes of polarization must be exactly matched to extract maximum output power.

   Nd:YAG is not self-polarizing. It is common to use a Brewster or other intracavity polarizer inside the optical resonator of an Nd:YAG laser for TEMoo-mode generation. However, for multimode generation, polarization of a Nd:YAG laser results in significant (up to 50 %) loss of output power.

In summary, Nd:YLF offers some interesting performance benefits, especially for scientific investigations where high pulse energy at low pulse rate is desirable. Nd:YLF requires more care and supervision which generally is not a problem in a laboratory environment. However, for industrial use, Nd:YLF will be more problematic and requires frequent attention to maintain its performance edge.

Lee Laser believes that it is not in our best interest to pursue the use of Nd:YLF for most industrial applications.