

Scientists demonstrate a high-efficiency ceramic laser

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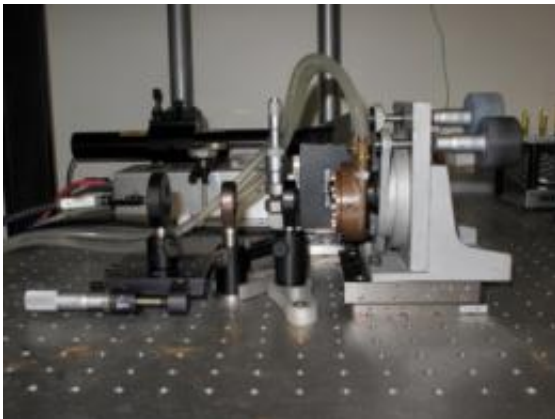
A sample of a transparent laser (left) and a vial containing nano-powder used to make it.

(PhysOrg.com) -- Scientists in the Optical Sciences Division at the Naval Research Laboratory, report a successful demonstration of a novel high-efficiency ceramic laser that is both, light-weight and compact for use in both military and civilian applications.

According to Dr. Jas Sanghera, a senior scientist on the program, "Solid-state crystal lasers are ideal for applications where light-weight and

compact [laser applications](#) are important. But, these are difficult to grow due to high-temperature growth issues, which limit size and quality. However, researchers in our Optical Materials and Devices branch, have overcome these challenges by developing a low-temperature ceramization process to fabricate these hard-to-grow materials resulting in high optical quality."

This new process enables the densification or sintering of high-purity nano-powder at ~65 percent of the melting temperature. This avoids the traditional high-temperature problems associated with crucible reactions, volatilization and [phase transitions](#), enabling the fabrication of a fully-dense and transparent ceramics material with optical-quality similar to single-crystals. This process has been applied to YAG, a hard synthetic yttrium aluminum garnet, used in [laser](#) technology, which is the workhorse of the solid-state laser community.



The test-bed used for demonstration of lasing with powder ceramic sample.

Scaling to significantly higher powers with good beam quality in YAG has its limitations, mainly due to its limited [thermal conductivity](#) and its sudden drop with increasing rare earth ion dopant concentration. A

better solution is to use materials with higher thermal conductivity such as the sesquioxides Y_2O_3 , Sc_2O_3 , and Lu_2O_3 . Of the three, the most important is Lu_2O_3 , since its thermal conductivity is almost insensitive to the rare earth ion-dopant concentration due to the similarity of their phonon energies. For certain laser configurations requiring high-dopant concentration, such as thin-disk geometries, Lu_2O_3 , has shown excellent promise for high-power scaling. Although, single-crystal Lu_2O_3 is difficult to make by traditional high-temperature crystal growing at $>2400^\circ\text{C}$, the NRL research team has successfully fabricated laser quality rare earth doped Lu_2O_3 ceramics using the low-temperature sintering route.

The resultant ceramics were obtained by the synthesis of ultra-high purity Yb^{3+} doped Lu_2O_3 nano-powders, which were then hot-pressed to make a highly transparent $\text{Yb}^{3+}:\text{Lu}_2\text{O}_3$ ceramic. The ceramics demonstrated lasing at 1080 nm with a world record [high efficiency](#) of 74 percent. "This result is remarkable considering the high doping level of 10 percent Yb^{3+} . It paves the way forward for thin disk lasers, such as those based on Yb^{3+} at $1\mu\text{m}$, that would have small path-lengths (100's μm), high-dopant concentrations ($\sim 10\%$), and the potential for TW high peak power short pulse lasers and multi-KW high average power lasers, both being pertinent to very high power laser applications on-board military platforms as well as commercial cutting and welding," concludes Sanghera.

Provided by Naval Research Laboratory

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