Lawrence Livermore National Laboratory

PROGRAM UPDATE - JULY 2003

Laser Science & Technology

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First Light with Turnkey Fiber-Based Guide Star System

Under the support of the Laboratory Directed Research & Development Program (LDRD) and the NSF Center for Adaptive Optics (CFAO), we are developing sources of high-power visible light via frequency mixing of fiber lasers. Since their "rediscovery" by the University of Southampton in 1985, fiber lasers and amplifiers have steadily increased in importance and output power. They are popular solutions to many problems because they typically have high wall-plug efficiency and are easy to package into robust, reliable, turnkey devices that virtually anyone can operate.

An all-fiber-based laser guide star will benefit the astronomy community by providing a safe, reliable, and turnkey system to replace the existing guide star dye laser systems. Furthermore, it will provide a compact, cost-effective system to meet the needs of the next generation of ELTs (extremely large telescopes) that demand multiple laser beacons. Our fiber laser design consists of a ~10-W, 1583-nm EDFA (erbium-doped fiber amplifier) sum-frequency mixed with a 15-W, 938-nm NDFA (neodymium-doped fiber amplifier) in a periodically poled potassium titanyl phosphate (PPKTP), a nonlinear material, to produce 5 to 10 W of 589-nm light (Figure 1).

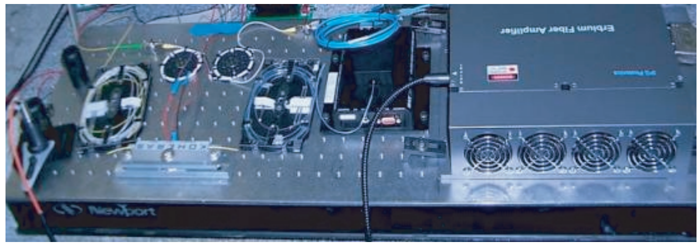

Figure 2. The LS&T's 1583-nm fiber laser system assembled from commercial components fits easily on a 2 ft x 1 ft breadboard.

The 1583-nm EDFA subsystem is composed of commercially available components and has already been demonstrated at 10 W in a robust configuration (Figure 2). To date, our NDFA has generated a record 2 W using a 200-mW seed input. Previously reported results for a NDFA indicated <100 mW could be generated at 938 nm. The most significant challenge has been eliminating a strong gain competition from the 1088-nm laser transition in the medium. Initially, this issue was addressed by cooling the laser to 77 K to make the 3-level laser transition at 938-nm competitive with the 4-level transition at 1088 nm. However, through careful study and analysis of a prototype NDFA conducted over the past year, we have been able to develop a fiber design that permits the NDFA to operate as a 938-nm amplifier at room temperature using conventional amplifier design techniques. The NDFA is now in the process of being scaled to 10 W of output power via the creation of additional amplifier stages, which will add additional pump power to the system. At this time, there are no expected barriers to 10-W operation beyond coupled pump power.

A system integration test has successfully produced 589-nm light by frequency mixing the 1583-nm EDFA and 938-nm NDFA in periodically poled lithium niobate (PPLN). First light of low-power output is shown in Figure 3. We have also begun a study of the lifetime performance of PPLN and PPKTP that will allow us to evaluate the reliability of the 589-nm system. We anticipate achieving our goal of 5 W of 589-nm light this year, followed by field-hardening the system next year, with the goal of eventual deployment at an observatory.

—J. Dawson, A. Drobshoff, Z. Liao, D. Pennington, L. Taylor, R. Beach,

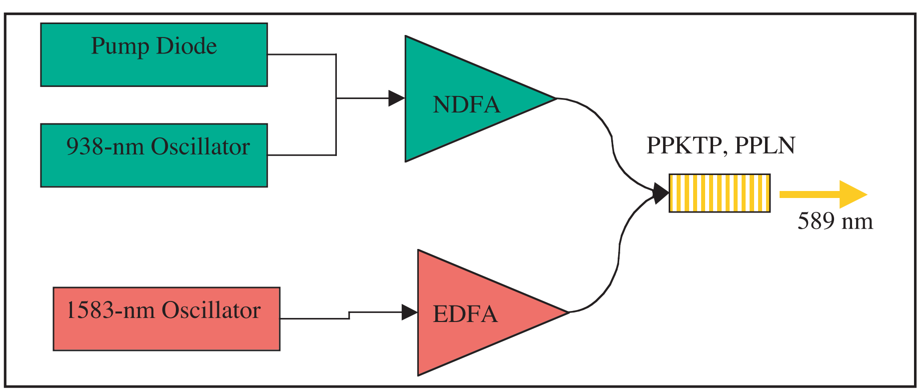

Figure 1. Schematic of the all-fiber-based guide star laser.

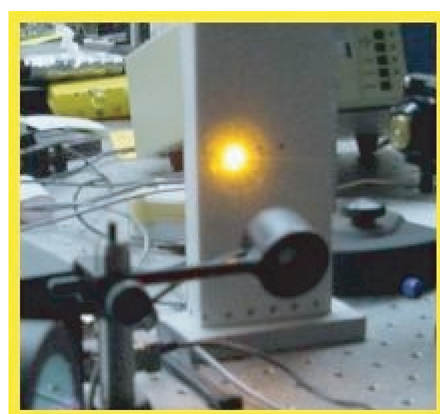

Figure 3. First-light result from system integration test. The 589-nm laser light was generated by sum-frequency mixing the 1583-nm and 938-nm fiber lasers in PPLN.

For comments about content of the *LS&T Program Update*, contact Dr. Hao-Lin Chen (925) 422-6198.
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