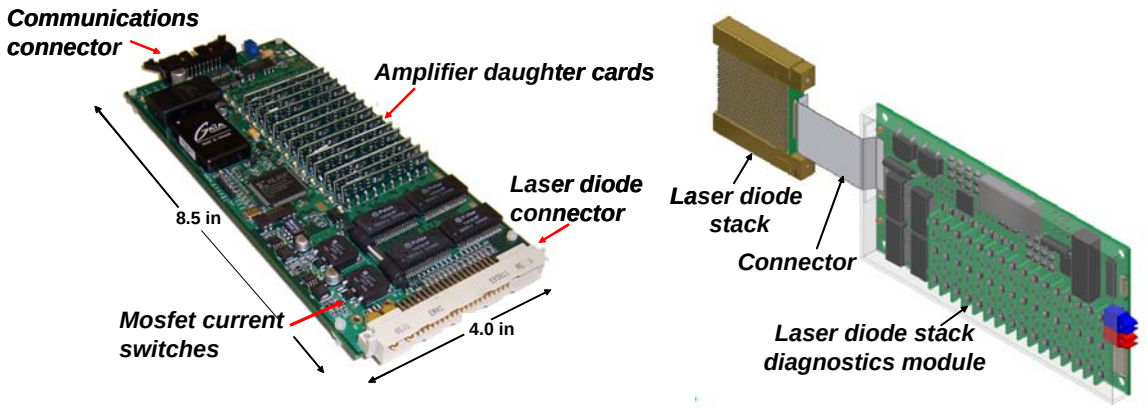
Air Force Research Laboratory AFRL

Science and Technology for Tomorrow's Aerospace Forces

Success Story

INTELLIGENT DRIVERS FOR IMPROVING THE RELIABILITY OF HIGH POWER LASER DIODE ARRAYS



(a) **(b)**

Fig 1. (a). SRL fault protection module for laser diode stacks that is installed on a DoD laser, and (b) illustration how the SRL protection module integrates with a laser diode stack.

Payoff

Science Research Laboratory (SRL) has developed intelligent laser diode drivers under an Air Force/MDA SBIR that has improved the lifetime of high power laser diode bars by more than factors-of-5. This is important because large laser diode arrays (LDAs) for pumping High Energy Lasers (HELs) will be required to produce up to 150 W/bar-cm at high efficiency (> 60%) in order to meet stringent size and weight requirements for military systems. A key issue with operating LDAs at high power is that performance and reliability degrade rapidly at optical power levels exceeding 100 W/bar-cm. SRL has developed diagnostics that monitor laser diode characteristics, and provide early indication that diode emitters are approaching damage threshold that will decrease their lifetime and performance. Fault-mode protection electronics have demonstrated increased LDA lifetime in on-going accelerated life testing.

Accomplishment

SRL has developed laser diode diagnostics that monitor laser diode bars and arrays to detect optical emitter anomalies during operation. For example, small perturbations in diode optical mode instabilities can result in higher junction temperatures, which can result in accelerated aging, optical facet damage and eventual emitter failure. These instabilities can be

further exasperated by solder migration and degradation in overall thermal management, which will limit diode lifetime, performance and reliability. SRL's technology can monitor a full spectrum of LDA characteristics, from single emitters to large laser diode arrays, and it provides information on the performance of diodes in real time. Modulating the power to the LDA when instabilities are detected can reduce the probability of catastrophic damage and failure. In this manner, SRL has demonstrated lifetime improvements of factors-of-5 in laser diode bars operating at 120W/bar.

As an outgrowth of this SBIR, SRL has received non-SBIR Phase 3 funding to develop laser diode diagnostics and fault protection for LDA stacks. Fig. 1 shows a photograph of SRL's diode stack protection module, and illustrates how the module integrates with a diode stack. We are presently monitoring 26 bars simultaneously in a diode stack, which can be scaled to many more diode bars, as needed. SRL's stack diagnostics technology has been successfully integrated and tested with a DoD HEL system.

Background

HELs will become increasingly important to the military services, as interest in developing high power lasers for tactical and strategic missions continues to grow. Many scenarios call for 100 kW-class HELs that will require large laser diode pump modules that cost several million dollars. This is a significant cost item in a weapons system, and it is critical that diagnostics and protection circuitry be implemented to improve LDA lifetime and reliability, and reduce the cost-of-ownership. SRL has demonstrated fault protection with 26 diode bar arrays, and our scaling analysis predicts this technology can be eventually integrated onto LDAs. Thus SRL's diode protection technology can play an important role in improving laser diode array performance and lifetime while significantly reducing the size and weight of HELs.