Thursday, September 26, 2019

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White Paper:

Contrasting the Photodigm DBR Laser Diode Architecture with Competing Single Frequency Laser Diodes

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Abstract

The Photodigm family of high-power edge-emitting **Distributed Bragg Reflector** (DBR) laser diodes is based on Photodigm's **proprietary single epi growth DBR laser** architecture.[1] The Photodigm DBR laser architecture consists of an electrically pumped gain region and a separate passive DBR grating region, monolithically fabricated over a continuous ridge waveguide. This design has resulted in the world's highest power commercially available, single-frequency, monolithic laser diodes with performance specifications that rival bench-top research lasers. Over the years, Photodigm DBR lasers have proven themselves to be ideally suited for applications requiring high-power single-frequency performance within a well-defined operating range. Photodigm has worked with its customers to develop a family of laser products unmatched in the industry. Optimized for stability, reliability, and power efficiency, these devices have opened up opportunities for an emerging class of cost-effective precision mobile instruments for applications in spectroscopy, atomic physics, non-linear optics, and quantum information.

The DBR laser is often compared to the distributed feedback, or DFB, laser, which is the established architecture for low power telecommunications lasers. While both the DFB and the DBR use the common elements of a Bragg grating and a ridge waveguide to produce a diffraction-limited, single frequency output beam, their architectures and fabrication techniques are quite different. The DBR employs a relatively short, highly reflective, unpumped Bragg reflector to select a single longitudinal mode, whereas the DFB uses a weakly reflective grating running the full length of the gain ridge to select the mode. These characteristics define the architectures and lead to their practical differentiation.

1. Product Evolution

DBR lasers were among the first single frequency laser diodes, with development beginning in the 1970's. They were commercially produced in limited quantities by several manufacturers through the 1990's, including SDL and Yokogawa. They were used for research applications requiring resonance with atomic transitions at 780 nm (R_b), 852 nm (C_s), and 1083 nm (He^*). However, the market was limited, and the telecom boom in the late 1990's to early 2000's forced laser manufacturers to focus their capacity to meet the explosive demand in telecom applications. The needs of low power signal lasers for wavelength division multiplexing were best met by DFB lasers, and DBR lasers for instrumentation and metrology disappeared from the market by the early 2000's. The limited market demand was primarily met by either existing stock from last-time buys, or by complex research lasers, including Ti:sapphire or external cavity diode lasers (ECDLs). Furthermore the 1300 and 1550 nm lasers required for telecom were produced from InP, which has a favorable processing chemistry for DFB fabrication.

Several manufacturers stepped in to fill the SDL void by 2002, using the DFB architecture so successful in telecom. These devices had typical characteristic of DFB lasers, including random, indeterminate mode hops, low power, and a difficult process flow due to the need for epi regrowth.

By the mid-2000's, Photodigm was approached by several customers who had either exhausted their existing stocks or who had new needs driven by the emerging fields of cold atom physics. They were also concerned by the poor reliability exhibited by DFB lasers when operated at their required powers. We examined their needs carefully and concluded that our unique combination of proprietary laser diode technology, dedicated wafer fab, and knowledgeable customer base would allow us to successfully enter this market. Shortly thereafter, we introduced our first Spectroscopy Certified™ DBR laser products at 1083 nm and 780 nm. Photodigm Spectroscopy Certified DBR lasers offered the industry products that could operate at higher power and with better reliability than the DFB. We quickly realized that fully meeting our customers' expectations would require our offering a complete product lineup, including the Dx and Dy lines of R_b, C_s, and K, as well as metastable helium, He^*. Because we owned our own wafer fab, we could respond to custom orders, and we expanded our product line over the next 2-3 years. Photodigm's DBR lasers offered a distinct technology choice for users of instrumentation lasers in the near IR band. Users soon came to value the higher

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DBR vs DFB

The Photodigm family of high-power edge-emitting Distributed Bragg Reflector (DBR) laser diodes is based on Photodigm's proprietary single epi growth DBR laser architecture. The Photodigm DBR laser architecture consists of an electrically pumped gain region and a separate passive DBR grating region, monolithically fabricated over a continuous ridge waveguide. This design has resulted in the world's highest power commercially available, single-frequency, monolithic laser diodes with performance specifications that rival bench-top research lasers. Over the years, Photodigm DBR lasers have proven themselves to be ideally suited for applications requiring high-power single-frequency performance within a well-defined operating range. Photodigm has worked with its customers to develop a family of laser products unmatched in the industry. Optimized for stability, reliability, and power efficiency, these devices have opened up opportunities for an emerging class of cost-effective precision mobile instruments for applications in spectroscopy, atomic physics, non-linear optics, and quantum information. The DBR laser is often compared to the distributed feedback, or DFB laser diodes.

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