Recent advances in tunable lasers *

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Divalent transition-metal-doped solid state lasers are now emerging as important sources of tunable radiation in the 1–2 μm wavelength region. We report here on recent results with Ni: MgF_2, V: MgF_2, Co: MgF_2 and Ni: MgO lasers. These lasers are being considered for use as fusion drivers because of their large energy storage times (several millisecs), large optical damage thresholds, and efficient operation capability.

All of these lasers have used cw Nd: YAG lasers to longitudinally optically pump crystals conduction-cooled to cryogenic temperatures, typically 77 K. The Ni: MgF_2 laser has been operated with 100 mW of cw, TEM_{00} polarized output power over a tuning range of 1.61–1.74 μm and Q-switched to yield 140 W of peak power in a 500–ns pulse, for an energy extraction of 1 J/cm^3. The Co: MgF_2 laser, which, like all the transition-metal ion lasers, operates on a combination of vibronic and purely electronic transitions has been tuned from 1.63 to 2.08 μm with up to 100 mW of output power and it is possible that the long-wavelength limit can be extended beyond 2.2 μm. Recent success in growing doped MgF_2 crystals 3.7 cm in diameter by 7.5 cm long indicate that the Ni: MgF_2 and Co: MgF_2 lasers can be scaled up to power outputs of 100 W CW and 1 J pulsed.

The Ni: MgO laser has produced 9 W of cw output power at 1.32 μm, with 6.5 W of TEM_{00}, polarized power at a crystal temperature of $\sim$ 80 K. Quasi-cw operation up to 235 K has been observed at an output wavelength of 1.41 μm. Pulsed operation of this device may be achieved at 300 K since fluorescence from Ni: MgO is not quenched at room temperature.

A continuously operating room-temperature double-heterostructure $Ga_xAl_{1-x}As$ diode laser has been operated in a stable external cavity. When this device was operated in a single spatial mode, the total laser output (several milliwatts) occurred in a single frequency. The laser could be tuned over a spectral range of 200 cm^{-1}, which was nearly equal to the spontaneous linewidth. The external-cavity configuration retained nearly all the double-ended multi-mode power of the same diode when operated without an external cavity and without anti-reflection coatings at the same injection level. Several diode lasers were tested with similar results. Long-term ($\sim$ 1 hr.) frequency drift was less than 1 MHz/min. with no external feedback stabilization and the line-width was less than 500 kHz. Single-frequency operation would be expected for a homogeneously broadened line without spatial burning. Such devices are ideally suited for experiments on optical communications.

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可调谐激光器的最新进展

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掺入二价过渡金属的固体激光器现已成为波长范围在1～2微米的可调谐辐射的重要光源。本文报告了 Ni:MgF_2、V:MgF_2、Co:MgF_2 和 Ni:MgO 激光器的最新结果。由于这些激光器贮能时间长(几个微秒),光损伤阈值高和运转效率高,因而考虑用它们作聚变驱动器。

所有这些激光器都是采用连续 Nd: YAG 激光器来纵向光泵靠传导冷却到低温的晶体,典型的温度为77K。Ni:MgF_2 激光器已工作在调谐范围为1.61～1.74微米,能输出100毫瓦的 TEM_{00} 偏振功率,在Q开关情况下产生100瓦峰值功率,脉冲宽度500毫微秒,对应能量输出为1焦耳/厘米^3。Co:MgF_2 激光器,就象所有过渡金属离子激光器一样,是工作在既有电子振动又有纯电子跃迁的联合态之下,其调谐范围1.63～2.08微米,输出功率可高达100毫瓦,且长波极限还可延伸到2.2微米。最近成功地生长了直径为3.7厘米、长7.5厘米的 MgF_2 晶体,这表明 Ni:MgF_2 和 Co:MgF_2 激光器可提高到输出100瓦的连续波功率和1焦耳的脉冲能量。

在晶体温度 80K左右时 Ni:MgO 激光器已在1.32微米的波长处产生 9 瓦的连续波输出功率,其中 TEM_{00} 模偏振功率为6.5瓦。当运转温度高达 235K时,在输出波长1.41微米处观察到了准连续输出。此器件的脉冲运转温度可能达 300K,因为 Ni:MgO 发出的荧光在室温下还没有猝灭。

室温连续工作的双异质结 $Ga_xAl_{1-x}As$ 二极管激光器已在稳定的外腔结构中运转。当它工作在单一空间模时,其全部激光输出(几个毫瓦)为单一频率。此激光器能在几乎等于自发谱宽 200 厘米$^{-1}$ 的光谱范围内调谐。外腔型结构基本能保持同一二极管在同样注入水平下,以无外腔及无增透膜工作时双端多模输出的全部功率。试验了几个二极管激光器都获得类似的结果。在无外反馈稳定时,长时间(约一小时)的频率漂移小于每分钟1兆赫,线宽小于500千赫。

预计可能实现没有空间烧孔的均匀加宽线的单频输出。这样的装置对光通讯实验是很理想的。