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现代应用光学

纳米半导体复合薄膜的非线性光学性质及其在激光器中的应用

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摘要： 采用射频磁控溅射技术制备了Ge掺二氧化硅（Ge-SiO_2）和Ge，Al共掺二氧化硅（Ge/Al-SiO_2）两种复合薄膜，并进行了热退火处理形成了纳米Ge镶嵌结构。通过紫外-可见吸收谱测量，确定了两种薄膜中纳米Ge的光学带隙，并采用皮秒激光*Z*-扫描技术研究了薄膜的非线性光学性质。测试结果显示，在1 064 nm激发下得到的Ge-SiO_2和Ge/Al-SiO_2薄膜的非线性吸收系数分别为-1.23×10^{-7} m/V和4.35×10^{-8} m/W，前者为饱和吸收，而后者为双光子吸收。把两种薄膜作为可饱和吸收体均可实现1.06 μm激光的被动调*Q*和被动锁模运转。与Ge-SiO_2薄膜比较，采用Ge/Al-SiO2薄膜可以获得较窄的调*Q*脉冲和锁模脉冲。最后，理论分析和实验比较了两种薄膜实现被动调*Q*和锁模的机理。

关键词： 半导体复合膜 Ge-SiO2薄膜 Ge/Al-SiO2 薄膜 非线性吸收 被动调Q 被动锁模

Nonlinear optical properties of nanometer semiconductor compound films and their applications to lasers

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Abstract: The Ge-SiO_2 and Ge/Al-SiO_2 compound films were prepared by Radio-Frequency (RF) magnetron sputtering technique, and then Ge nanocrystals were obtained in the films by a thermal annealing treatment. The optical bandgaps of the Ge nanocrystals in the two films were calculated by measured UV-visible absorption spectral data, and the nonlinear optical properties of the two compound films were investigated by using picosecond laser *Z*-scan technique. Experiments show that the nonlinear absorption coefficients of Ge-SiO_2 and Ge/Al-SiO_2 films at 1 064 nm lasing are -1.23×10^{-7} m/V and 4.35×10^{-8} m/W, respectively. The former corresponds to the saturable absorption, while the latter corresponds to the two-photon absorption. Furthermore, both the Ge SiO_2 and Ge/Al-SiO_2 films can be as the saturable absorbers to implement the passive *Q*-switching and mode-locking operation for a 1.06 μm laser. Obtained experimental results demonstrate that Ge/Al-SiO_2 film could achieve narrower *Q*-switched pulse and mode-locked pulse than that of the Ge-SiO_2 film. Finally, it discusses the mechanisms of passive *Q*-switching and passive mode-locking with the two films.

Keywords: semiconductor film Ge-SiO2 film Ge/Al-SiO2 film Nonlinear absorption Q-switched mode-locking

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