光学 精密工程
OPTICS AND PRECISION ENGINEERING
核心期刊
主管：中国科学院
主办：中国科学院长春光学精密机械与物理研究所
中国仪器仪表学会
主编：曹健林

光学精密工程 2013, 21(9) 2209-2216 ISSN: 1004-924X CN: 22-1198/TH

现代应用光学

纳秒级脉冲型群红外量子级联激光器驱动电源

党敬民[1]，翟冰[1]，高宗丽[1]，陈晨[2]，王一丁[1*]

1.吉林大学 电子科学与工程学院 集成光电子学国家重点联合实验室，吉林 长春 130012;
2.吉林大学 仪器科学与电气工程学院， 吉林 长春 130026

摘要： 由于红外混合气体的检测方法要求电源具有驱动群红外量子级联激光器 (QCL) 的能力，本文设计并研制了一种新型群QCL驱动电源。为了避免驱动电流多路输出的交叉影响，该电源采用了时分复用控制方案，并结合高速模拟比例-积分(PI) 反馈, 实现了每一条输出支路电流的独立调节。系统采用脉冲频率调制(PFM)与脉冲宽度调制(PWM)相结合的方法，改善了驱动脉冲的频率及脉宽特性，确保了各支路激光器均工作在最佳状态。利用该驱动电源对中国科学院半导体所研制的中心波长分别为4.8，7.49，7.71 和10.7 μm的4种QCL进行了驱动测试。结果表明：在长时间 (220 h) 运行中，系统驱动电流长期稳定度为4.62×10-6，线性度为0.029 1%，满足驱动群量子级联激光器的要求，为红外混合气体的检测提供了可靠的保障。

关键词： 红外混合气体检测 群红外量子级联激光器(QCL) 驱动电源 时分复用(TDM)

Nanosecond driver for multiple pulse-modulated Infrared quantum cascade lasers

DANG Jing-min[1], ZHAI Bing[1], GAO Zong-li[1], CHEN Chen[2], WANG Yi-ding[1*]

1.State Key Laboratory on Optoelectronics, College of Electronic Science and Engineering,
Jilin University, Changchun 130012, China;
2.College of Instrumentation and Electrical Engineering, Jilin University, Changchu 130026, China

Abstract: A driving generator to drive multiple infrared Quantum Cascade Lasers (QCLs) was designed under an experimental validation for detection of mixed infrared gases. To avoid the cross-influence of the driving currents among multi-channels, the Time Division Multiplexing (TDM) method integrating with the fast analog proportional-integral (PI) control theory was used to adjust the regulating output currents in each branch independently. A control method combined pulse frequency modulation (PFM) and Pulse Width Modulation (PWM) was proposed to improve the characteristics of the operating frequency and the pulse width of driving pulse and to guarantee the lasers of each branch to operate in an optimum condition. By utilizing the illustrated driver, a driving test was performed on four QCLs with center wavelengths at 4.8, 7.49, 7.71 and 10.7 μm respectively fabricated by Institute of Semiconductor, Chinese Academy of Sciences. Experimental results demonstrate that the stability of driving current is 4.62×10-6 and the linearity of power system is 0.029 1% during a long-term operation (220 h), which meets the requirements of driving multiple QCLs and provides a strong guarantee for mixed infrared gas detection.

Keywords: infrared multi-gas detection multiple infrared quantum cascade lasers (QCL) driving generator time division multiplexing

收稿日期 2013-01-04 修回日期 2013-03-11 网络版发布日期 2013-09-30

基金项目:

“863”国家高技术研究发展计划项目;“863”国家高技术研究发展计划项目;“863”国家高技术研究发展计划项目;吉林省科技厅项目

通讯作者: 王一丁

作者简介: 党敬民(1987-)，男，天津人，博士研究生，主要从事光电检测、嵌入式系统方面的研究。

作者Email: wangyiding48@yahoo.com.cn

参考文献：

[1]NAMJOU K, CAI S, WHITTAKER E A, et al.. Sensitive absorption spectroscopy with a room-temperature distributed-feedback quantum-cascade laser [J].Optics Letters， 1998, 23(3):219-221. [2]KOSTEREV A A, CURL R F, TITTEL F K. Methane concentration and isotopic composition measurements with a mid-infrared quantum-cascade laser [J]. Optics Letters，1999, 24(23):1762-1764. [3]MCMANUS J B, ZAHNISER M S, NELSON D D. Dual quantum cascade laser trace gas instrument with astigmatic Herriott cell at high pass number[J].Applied Optics， 2011, 50(4):74-85. [4]TUZSON B, ZEEMAN M J, ZAHNISER M S. Quantum cascade laser based spectrometer for in situ stable carbon dioxide isotope measurements[J].Infrared Physics & Technology，2008, 51(3):198-206. [5]ROLLER C, KOSTEREV A A, TITTEL F K, et al.. Carbonyl sulfide detection with a thermoelectrically cooled midinfrared quantum cascade laser [J]. Optics Letters，2003, 28(21): 2052-2054. [6]陈晨，黄渐强，吕默，等. 高精度纳秒级红外量子级联激光器驱动电源的研制[J].吉林大学学报（工学版）,2011, 41(6): 1739-1740. CHEN CH, HUANG J Q, L M, et al.. High-precision narrow pulse drive power for infrared quantum cascade laser[J]. Journal of Jilin University (Engineering and Technology Edition),2011, 41(6):1739-1740. (in Chinese) [7]GE P, JOUANEH M. Tracking control of a piezoceramic actuator[J]. Transactions on Control Systems Technology,1996, 4(3):213-214. [8]丛梦龙，李黎，崔艳松，等. 控制半导体激光器的高稳定度数字化驱动电源的设计[J].光学 精密工程,2010, 18(7):1633-1634. CONG M L, LI L, CUI Y S, et al.. Design of high stability digital control driving system for semiconductor laser[J]. Opt. Precision Eng.,2010, 18(7):1633-1634. (in Chinese) [9]陈霄，隋青美，苗飞，等. 应用单一超窄线宽激光器的多气体检测[J].光学 精密工程,2011, 19(7):1498-1499. CHEN X, SUI Q M, MIAO F, et al.. Design of detecting system for multi-component gases based on single ultra-narrow-linewidth laser [J].Opt. Precision Eng.,2011, 19(7):1498-1499. (in Chinese) [10]IYENGAR P, FLETCHER J E, BITTLESTONE D J. Enhanced mosfet gate driver for pulsed

power IVA module[C]. Pulsed Power Conference (PPC), Chicago:IEEE，2011：1479-1480. [11]邓军. 半导体激光器驱动模式与可靠性研究[D].长春:吉林大学电子科学与工程学院,2008. DENG J. Study of Drive Modes and Reliability on Semiconductor Laser[D]. Changchun:College of Electronic Science and Engineering, Jilin University, 2008. (in Chinese) [12]THOMPSON M T, SCHLECHT M F. High power laser diode driver based on power converter technology [J]. IEEE Transactions on Power Electronics,1997, 12(1):46-52. [13]SACKINGER E, OTA Y, GABARA T. A 15-mW, 155-Mb/s CMOS burst-mode laser driver with automatic power control and end-of-life detection [J].IEEE Journal of Solid-State Circuit,1999, 34(12):1994-1950. [14]LU J F. Piecewise nonlinear fitting method of tunnel surrounding rock displacement and its application [C].International Conference on Multimedia Technology (ICMT), Hangzhou, 2011：1148-1151. [15]王敏，张玉钧，汤媛媛，等. 基于室温脉冲工作量子级联激光器的脉间光谱技术研究[J].光学技术,2010, 36(3):325-326. WANG M, ZHANG Y J, TANG Y Y, et al.. Inter-pulse spectroscopy based on room-temperature pulsed quantum-cascade laser [J]. Optical Technique, 2010,36(3):325-326. (in Chinese) [16]黄向东，刘立丰，谭久彬，等. 调幅式电容位移传感器的峰值检波电路设计[J].光学 精密工程,2012, 20(11):2447-2448. HUANG X D, LIU L F, TAN J B, et al.. Design of peak detector circuit for AM capacitive displacement sensor [J]. Opt. Precision Eng.,2012, 20(11):2447-2448. (in Chinese)

本刊中的类似文章

1．孙业明 曾平 程光明 郭抗.单振子二自由度超声电机驱动电源[J]. 光学精密工程, 2013,21(9): 2279-2286

2．刘向东, 傅强, 赖志林.多单元浮地级联式压电陶瓷执行器高压驱动电源[J]. 光学精密工程, 2012,20(3): 597-606

3．丛梦龙, 李 黎, 崔艳松, 张真骞, 王一丁.控制半导体激光器的高稳定度数字化驱动电源的设计[J]. 光学精密工程, 2010,18(7): 1629-1636