

论文

激光诱导间质热疗中生物组织的温度场研究

包美芳¹, 钱志余¹, 李赓韬¹, 肖笛¹, 王晋阳¹, 钱露²

(1 南京航空航天大学 自动化学院 生物医学工程系, 南京 210016)

(2 南京邮电大学 通信与信息工程学院, 南京 210046)

摘要:

激光诱导间质热疗疗效评估的前提是必须获得准确的激光在不同功率、不同照射时间的生物组织温度场分布. 利用多物理场直接耦合分析软件COMSOL Multiphysics构建了在组织光学参量不变情况下的三维有限元传热模型. 该模型基于Pennes生物传热方程和轴对称高斯形状的激光光束热源方程, 参量针对离体猪肝组织, 考虑到了生物组织热物性密度、比热和热导率随温度变化的情况. 仿真获得激光功率为0.77 W、0.95 W、1.23 W, 照射时间为10~90 s, 径向距离0~2 mm范围和轴向距离0~4 mm范围的温度场数据集. 利用拟合算法, 获得了自变量为激光功率、照射时间、径向距离和轴向距离的生物组织温度场分布模型. 将功率为0.88 W和1.05 W时的结果与Pennes方程结果相比较, 两者误差在5%以内.

关键词: 激光诱导间质热疗 温度场 有限元 Pennes生物传热方程

Biological Tissue's Temperature Field During the Laser-Induced Interstitial Thermo-therapy

BAO Mei-fang¹, QIAN Zhi-yu¹, LI Wei-Tao¹, XIAO Di¹, WANG Jin-yang¹, QIAN Lu²

(1 Biomedical Engineering Department, College of Automation Engineering, Nanjing University of Aeronautics and Astronautics, Nanjing 210016, China)

(2 Communication and Information Engineering, Nanjing University of Posts and Telecommunications, Nanjing, 210046, China)

Abstract:

The temperature distribution of the accurate biological tissues in different powers and different irradiation times is the premise of efficacy of laser-induced interstitial thermo-therapy assessment. A three-dimensional finite element heat transfer model was constructed by multi-physical field conductive coupling analysis software COMSOL Multiphysics in the invariable tissue optics parameters situation. The model was based on Pennes bio-heat transfer equation and axisymmetric Gaussian shape of the laser beam heat equation. In this model, the parameters were for the liver tissue in vitro, and the thermal properties of biological tissue density, specific heat and thermal conductivity with temperature variations were considered. The temperature field data sets were obtained by simulation under the laser power for 0.77 W, 0.95 W, 1.23 W, irradiation time for 10~90 s, radial distance range 0~2 mm and axial distance range 0~4 mm. Fitting algorithm was used to obtain the tissue's temperature distribution model related to the laser power, irradiation time, radial and axial distance. The results of 0.88 W and 1.05 W were compared with the Pennes equation, and the error between them was within 5%.

Keywords: Laser-induced interstitial thermo-therapy Temperature distribution Finite element Pennes bio-heat transfer equation

收稿日期 2010-12-30 修回日期 2011-03-02 网络版发布日期 2011-05-25

DOI: 10.3788/gzxb20114005.0718

基金项目:

江苏省自然科学基金 (No. BK2009371) 和国家高技术研究发展计划 (No. 2008AA02Z438) 资助

通讯作者: 钱志余 (1964-), 男, 教授, 主要研究方向为生物医学光子学. Email: zhiyu@nuaa.edu.cn

作者简介:

扩展功能

本文信息

- Supporting info
- PDF (492KB)
- HTML
- 参考文献

服务与反馈

- 把本文推荐给朋友
- 加入我的书架
- 加入引用管理器
- 引用本文
- Email Alert
- 文章反馈
- 浏览反馈信息

本文关键词相关文章

- 激光诱导间质热疗
- 温度场
- 有限元
- Pennes生物传热方程

本文作者相关文章

- 包美芳
- 李赓韬
- 钱志余
- 肖笛
- 王晋阳

参考文献:

- [1]EYRICH G, SAILER H, MORITZ M N, et al. Laser induced interstitial thermotherapy [J]. International Journal of Oral and Maxillofacial Surgery, 1999, 28(1): 49.
- [2]BOWN S G. Phototherapy of tumors [J]. World Journal of Surgery, 1983, 7(6): 700-709.
- [3]PUCCINI S, BAR N K, BUBLAT M, et al. Simulations of thermal tissue coagulation and their value for the planning and monitoring of laser-induced interstitial thermotherapy (LITT) [J]. Magnetic Resonance in Medicine, 2003, 49(2): 351-362.
- [4]OLSRUD J, WIRESTAM R, PERSSON B R, et al. Simplified treatment planning for interstitial laser thermotherapy by disregarding light transport: A numerical study [J]. Lasers in Surgery and Medicine, 1999, 25(4): 304-314.
- [5]MOLS A M, KNAPPE V, BUHR H J, et al. Laser induced Thermotherapy (LITT): dose-effect relation on lung tissue [J]. Medical Laser Application, 2004, 19(3): 160-166.
- [6]XIE Shu-sen, YANG Hong-qin, LI Bu-hong. Laser and skin layer organization solar-thermal function and heat transfer model [J]. Journal of Optoelectronics Laser, 2001, 12(7): 746-750.
- 谢树森, 杨洪钦, 李步洪. 激光与皮肤层状组织的光热作用及其传热模型[J]. 光电子-激光, 2001, 12(7): 746-750.
- [7]LI He-jie, ZHANG Xue-xue, LIU Jing. Laser and biological tissues hot interaction of multi-layer structure model [J]. Chinese Journal of Lasers, 2002, 29(5): 465-470.
- 李和杰, 张学学, 刘静. 激光与生物组织热相互作用的多层结构模型[J]. 中国激光, 2002, 29(5): 465-470.
- [8]LI Zhong-ming, ZHANG Zhen-xi. Thermal effects of photodynamic therapy in the theoretical analysis and calculation [J]. Acta Photonica Sinica, 2006, 35(2): 269-273.
- 李忠明, 张镇西. 光动力治疗中热效应的理论分析与计算[J]. 光子学报, 2006, 35(2): 269-273.
- [9]JING Shi-chen, MA Ning, ZHANG Xue-xue. Method of laser-induced interstitial thermotherapy of in vitro simulation [J]. Laser Journal, 2004, 25(2): 21-22.
- 江世臣, 马宁, 张学学. 激光诱导间质热疗方法的离体模拟实验研究 [J]. 激光杂志, 2004, 25(2): 21-22.
- [10]MA Ning, LI He-jie, JIANG Shi-chen, et al. Laser-induced interstitial thermotherapy of biological tissue layer structure model [J]. Journal of Optoelectronics Laser, 2003, 30(4): 380-384.
- 马宁, 李和杰, 江世臣, 等. 激光诱导间质肿瘤热疗的生物组织双层结构模型[J]. 中国激光, 2003, 30(4): 380-384.
- [11]TIAN Xiao-ming, FENG Yong-zhen. Influence of laser interstitial heat damage to the liver area shape factor of experimental observation and discussed [J]. Chinese Journal of Medical Physics, 2006, 23(2): 108-110.
- 田晓明, 冯永振. 影响激光间质热毁损肝脏区域形状因素的实验观察与讨论[J]. 中国医学物理学杂志, 2006, 23(2): 108-110.
- [12]MCKENZIE A L. Physics of thermal processes in laser-tissue interaction [J]. Physics in Medicine and Biology, 1990, 35(9): 1175-1209.
- [13]JIANG Shi-chen, ZHANG Xue-xue. Optical-thermal interaction of biological tissue subjected to the surface applied laser irradiation [J]. Journal of Optoelectronics Laser, 2005, 16(6): 752-756.
- 江世臣, 张学学. 表面照射下激光与生物组织的光热作用分析[J]. 光电子-激光, 2005, 16(6): 752-756.

本刊中的类似文章

1. 朱海永 张戈 黄呈辉 魏勇 黄凌雄 陈静 陈玮冬. 双端抽运热容激光器温度特性分析[J]. 光子学报, 2007, 36(5): 773-776
2. 米红林 方如华 朱启荣 陆荣林. 云纹干涉系统及其在金瓷双材料中的应用[J]. 光子学报, 2007, 36(5): 894-898
3. 黄虹宾 孙凤山 李景镇 龚向东 艾月霞. 超高速摄影仪中铝转镜的模式分析[J]. 光子学报, 2007, 36(4): 746-749
4. 王富国 张景旭 杨飞 吴小霞. 四翼梁式次镜支撑结构的研究[J]. 光子学报, 2009, 38(3): 674-676
5. 高益庆; 金瑜; 邢键; 罗宁宁*. 用光谱层析技术重建等离子束射流场[J]. 光子学报, 2006, 35(8): 1156-1161
6. 何忠蛟. 硅基二氧化硅波导和SOI脊型波导应力双折射研究[J]. 光子学报, 2006, 35(2): 201-204
7. 楼歆晔; 吴兴坤. 光子器件激光封装中热致角度偏移的降低[J]. 光子学报, 2006, 35(11): 1680-1685
8. 李九生. Si₂N₂O基体铌酸锂调制器有限元法研究[J]. 光子学报, 2006, 35(1): 37-40
9. 李安虎; 孙建锋; 朱勇建; 徐荣伟; 刘立人. 精密光束偏离装置棱镜组件的光机热分析[J]. 光子学报, 2006, 35(7): 1107-1112
10. 惠彬; 李景镇; 裴云天; 龚向东. 大口径折反射式光学系统的光机结合分析[J]. 光子学报, 2006, 35(7): 1117-1120
11. 李隆; 史彭; 陈浩伟; 贾森; 白晋涛. 非线性晶体内腔倍频的温度模式分布[J]. 光子学报, 2005, 34(10): 1441-1444
12. 刘小毅; 张方迪; 张民; 余重秀; 张磊; 吕召彪; 叶培大. 椭圆形高折射率芯Bragg光纤的偏振和色散特性[J]. 光子学报, 2006, 35(10): 1529-1533
13. 张德江; 刘立人; 孙建锋; 徐荣伟; 李大汕. 棱镜自重变形对波面影响的研究[J]. 光子学报, 2006, 35(4): 618-621
14. 李福; 阮萍; 赵葆童. 重力作用下平面反射镜变形研究[J]. 光子学报, 2005, 34(2): 272-275
15. 关建飞; 沈中华; 许伯强; 倪晓武; 陆建. 激光激发声表面波在缺陷板材中散射过程的有限元分析[J]. 光子学报,

文章评论 (请注意:本站实行文责自负, 请不要发表与学术无关的内容!评论内容不代表本站观点.)

反馈人	<input type="text"/>	邮箱地址	<input type="text"/>
反馈标题	<input type="text"/>	验证码	<input type="text" value="7235"/>
<input type="text"/>			