目录(Contents)

复旦大学光科学与工程系
上海市邯郸路220号
邮政编码：200433
电话：86-21-65643791/65649001
传真：86-21-65641344

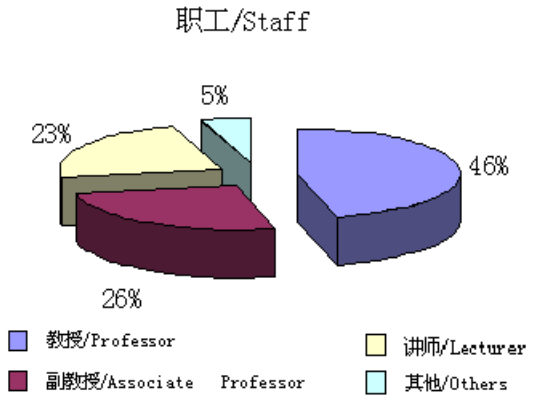
Department of Optical Science & Engineering
Fudan University
Shanghai 200433, China
Tel.：86-21-65643791/65649001
Fax：86-21-65641344

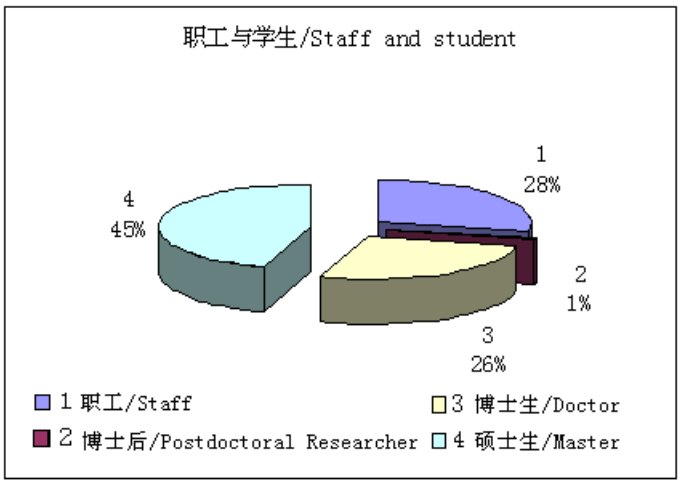
实验室概况/Overview of the Department of Optical Science& Engineering

光科学与工程系有教授 18 名，副教授 10 名。教授中包括 2 名院士、1 名长江特聘教授及国家杰出青年基金获得者、2 名国家杰出青年基金获得者、3 名跨世纪人才基金获得者。我系拥有光学国家重点学科，在“211”、“985”等高校重点学科建设中获得近 2000 万元的建设经费。在科研方面，以信息光子学领域具有重要意义和应用价值的新型光子学材料与器件作为主攻方向，侧重于基础光子学以及微光子学与纳米光子学材料和器件的研究，并适当重视光子学在交叉学科中的应用。近 5 年来，获得各类科研经费总额达 2700 多万元。我系拥有多台进口激光器、光子学器件制备系统、薄膜制备系统以及分析测试系统等设备，研究条件优越。

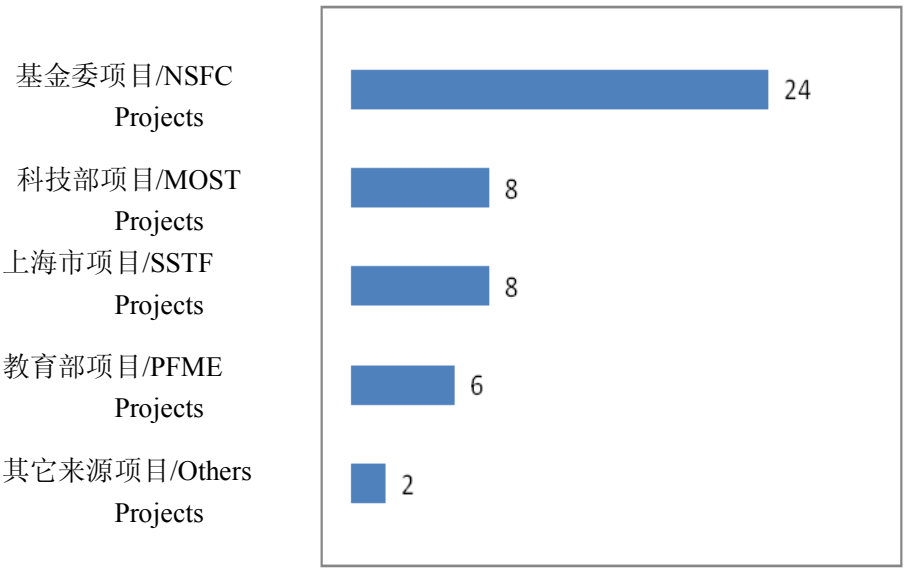
The Department of Optical Science & Engineering has 34 highly qualified faculty members, including 18 professors and 10 associate professors. Among the professors, there are one academician of the Chinese Academy of Sciences, one academician of the Chinese Academy of Engineering, one professor of “Cheungkong Scholars Program” of the ministry of education and the winner of the national distinguished youth science fund, two winners of the national distinguished youth science fund, three winners of “cross-century talent cultivation plan fund” of the ministry of education. The department boasts one national key discipline of optics, which is included in the “211 Plan” and “985 Plan” of the ministry of education and has acquired finance allocation of about 20 million yuan for constructing the discipline in the past years. The research in the department focuses on the novel photonic materials and devices of great importance and promising application in the field of information photonics, emphasizing particularly on the study for fundamental photonics, new materials and devices of micro-photonics and nano-photonics, and also paying attention to the interdisciplinary studies concerning photonics. In the past 5 years, the research fund from various programs added up to 27 million yuan. The department has a very good research environment，and is in possession of many lasers of high performance, fabricating system for photonic devices, thin film deposition system and testing and analyzing system, etc.

人事概况/General View of Personnel





在研项目概况/General View on Projects under Researching



人员结构/Organization

光科系主任/ Director

钱列加 教 授 Qian Liejia, Professor

光科系副主任/ Deputy Directors

吴嘉达 教 授，Wu Jiada, Professor

郑玉祥 教 授，Zheng Yuxiang, Professor

我系聘请的名誉教授和顾问教授/Honorary and advisory professors

N. Bloembergen Professor (美国哈佛大学，诺贝尔物理学奖获得者， Harvard University, USA)

沈元壤 院士 Y. R.Shen Academician (美国加州大学, University of California, Berkerley USA)

张国龑 教授 R. K. Chang Professor (美国耶鲁大学, Yale University, USA)

厉鼎毅 教授 T. Y. Li Professor (美国 AT&T 公司及 Bell 实验室, AT&T Bell Lab, USA)

唐孝威 院士 Xiaowei Tang Academician (北京高能所， Institute of High Energy Physics, CAS)

徐至展 院士 Zhizhan Xu, Academician (上海光机所, Shanghai Institute of Optics & Fine Mechanics, CAS)

杨国桢 院士 Guozhen Yang, Academician (北京物理所, Institute of Physics, CAS)

侯 洵 院士 Xun Hou, Academician (西安光机所，Xian Institute of Optics & Fine Mechanics, CAS)

钟业华 教授 Yip-Wah Chung, Professor (美国西北大学, North-West University, USA)

杰出人才/ Intelligent Staff

中国科学院院士/ Academician, CAS

1980　干福熹　Gan Fuxi

中国工程院院士/ Academician, CAE

1995　范滇元　Fan Dianyuan

国家杰出青年基金获得者/National Science Fund for Distinguished Young Scholars

1994　陈良尧　Chen Liangyao

2000　金庆原　Jin Qingyuan

2007　钱列加　Qian Liejia

国家教育部“长江学者”荣誉称号获得者

1999　陈良尧　Chen Liangyao

国家教委跨世纪（新世纪）优秀人才基金获得者

1997　徐　雷　Xu Lei

2000　吴嘉达　Wu Jiada

2006　郑玉祥　Zheng Yuxiang

光科学与工程系人员名录/Name List

研究人员/Scientific

陈良尧	Chen Liangyao	王松有	Wang Songyou
戴海涛	Dai Haitao	韦　玮	Wei Wei
范滇元	Fan Dianyuan	吴嘉达	Wu Jiada
干福熹	Gan Fuxi	吴　翔	Wu Xiang
金庆原	Jin Qingyuan	徐　雷	Xu Lei
李　晶	Li Jing	徐　敏	Xu Min
刘建华	Liu Jianhua	许　宁	Xu Ning
刘丽英	Liu Liying	应质峰	Ying Zhifeng
陆　明	Lu Ming	袁　鹏	Yuan Peng
马　斌	Ma Bin	张　浩	Zhang Hao
糜　岚	Mi Lan	张荣君	Zhang Rongjun
倪　刚	Ni Gang	张文献	Zhang Wenxian
彭　波	Peng Bo	张相启	Zhang Xiangqi
钱列加	Qian Liejia	张宗芝	Zhang Zongzhi
沈德元	Shen Deyuan	郑玉祥	Zheng Yuxiang
孙　剑	Sun Jian	朱鹤元	Zhu Heyuan
王培南	Wang Peinan	庄　军	Zhuang Jun

技术人员/Technical Staff

戴祝萍	Dai Zhuping	杨月梅	Yang Yuemei
胡谊梅	Hu Yimei	张敏毅	Zhang Minyi
徐新民	Xu Xinmin		

博士后/Postdoctoral fellows

高洪跃	Gao Hongyue

博士生/ Ph.D Students

廖嘉霖	Liao Jialin	张启明	Zhang Qiming

李晓凡	Li Xiaofan	尚　磊	Shang Lei
魏小红	Wei Xiaohong	杨　佩	Yang Pei
刘　伟	Liu Wei	胡婧婷	Hu Jngting
王　科	Wang Ke	沈轶群	Shen Yiqun
张艳武	Zhang Yanwu	胡　巍	Hu Wei
周薇溪	Zhou Weixi	李　皓	Li Hao
周　靖	Zhou Jing	赵　源	Zhao Yuan
张　鹏	Zhang Peng	邱　娉	Qiu Ping
张　尉	Zhang Wei	李颖峰	Li Yingfeng
毛鹏辉	Mao Penghui	陈　英	Chen Ying
魏慎金	Wei Shenjin	涂　鑫	Tu Xin
邱静燕	Qiu Jingyan	单　炯	Shan Jiong
任红艳	Ren Hongyan	蔡清元	Cai Qingyuan
张　弛	Zhang Chi	赵　坤	Zhao Kun
刘明辉	Liu Minghui	周恩宇	Zhou Enyu
钟亥哲	Zhong Haizhe	干　洁	Gan Jie
李　征	Li Zheng		

硕士生/ Master Students

唐隽逸	Tang Juanyi	戴仲鸿	Dai Zhonghong
赵佳琦	Zhao Jiaqi	方　芳	Fang Fang
张东方	Zhang Dongfang	李　喧	Li Xuan
陈一鸣	Chen Yiming	李锦江	Li Jinjiang
刘燕妮	Liu Yaini	尹德全	Yin Dequan
陶光明	Tao Guangming	冯　雷	Feng Lei
许晓锋	Xu Xiaofeng	王　娜	Wang Na
张　淼	Zhang Miao	朱　江	Zhu Jiang
冯　亮	Feng Liang	冯　慧	Feng Hui
王骁栋	Wang Xiaodong	吴　松	Wu Song
滕雪雷	Teng Xuelei	唐　佳	Tang Jia

马鎏学	Ma Liuxue	张　岩	Zhang Yan
唐文涛	Tang Wentao	黄丽媛	Huang Liyuan
张旭辉	Zhang Xuhui	王　刚	Wang Gang
沈　彦	Shen Yan	周信传	Zhou Xinchuan
熊蓉玲	Xiong Rongling	陈舒拉	Chen Shula
耿昭华	Geng Zhaohua	陈永彬	Chen Yongbin
徐吉鹏	Xu Jipeng	高　昆	Gao Kun
陆卫杰	Lu Weijie	贺　赫	He He
徐　岫	Xu Xiu	任　勇	Ren Yong
陈剑波	Chen Jianbo	陈珊珊	Chen Shanshan
李　倩	Li Qian	朱焕锋	Zhu Huanfeng
崔伯寅	Cui Boyin	王绍军	Wang Shaojun

光学工程/Optical Engineering

顾培培	Gu Peipei	裴　斐	Pei Fei
段朝阳	Duan Chaoyang	刘　磊	Liu Lei
邱永成	Qiu Yongcheng	李振亚	Li Zhenya
蒲海辉	Pu Haihui	李双柱	Li Shuangzhu
王治国	Wang Zhiguo	赖菊水	Lai Jushui
高　斌	Gao Bin	伍经纬	Wu Jingwei
孙　涛	Sun Tao		
邢美术	Xing Meishu	赵二刚	Zhao Ergang

承担课题/Projects under Researching

序号	项目来源	课题名称（编号）	负责人	起止时间
1	973子项目	光参量放大过程中位相传递及其控制 2007CB815104-1	钱列加	2007.1-2009.12
2	863项目	高增益低噪声放大技术研究 2007AAXXX507	钱列加	2007.1-2010.12
3	863项目	纳秒级激光脉冲的高分辨单次测量及实验研究 2008AAXXX0011	袁　鹏	2008.7-2009.6
4	国家杰出青年基金	基于光学二阶非线性的超快激光技术研究 60725418	钱列加	2008.1-2011.12
5	基金重大项目	超高密度、高速光-磁混合数字信息存储研究 60490290	金庆原	2004.7-2008.6
6	基金重点项目	新型纳米微结构光电子材料及微腔光子器件特性研究 60638010	徐　雷	2007.1-2010.12
7	基金重点项目	1μm波段全系列宽带激光技术研究 60538010	范滇元	2006.1-2009.12
8	基金重点项目	无机基有机杂化非线性光学材料的基础研究（分课题）50532030	刘丽英	2006.1-2009.12
9	基金面上项目	超短脉冲信噪比测量方法研究10576009	朱鹤元	2006.1-2008.12
10	基金面上项目	共振激励研究全息聚合物分散液晶的相分离 10574031	刘建华	2006.1-2008.12,
11	基金面上项目	DNA杂交的光学性质及其温度特性的椭圆偏振光谱分析研究 60578047	李　晶	2006.1-2008.12
12	基金面上项目	纳光子薄膜器件制备的原位光谱快速获取和特性分析研究 60578046	王松有	2006.1-2008.12
13	基金面上项目	基于回廊耳语模式的非圆对称光学微谐振腔的发光特性及传感性能研究 10574032	刘丽英	2006.1-2008.12
14	基金面上项目	共轭聚合物固体激光材料及光特性研究 60578039	韦　玮	2006.1-2008.12
15	基金面上项目	磁性复合有机半导体中的自旋注入、输运以及自旋相关效应 60501002	倪　刚	2006.1-2008.12
16	基金面上项目	垂直高矫顽力记录介质的自旋超快过程研究 60678008	金庆原	2007.1-2009.12
17	基金面上项目	巨磁电阻器件中极化电流激发的自旋波效应研究 10604016	张宗芝	2007.1-2009.12
18	基金面上项目	易轴垂直取向巨磁电阻器件中电流驱动的磁矩翻转效应 50771033	张宗芝	2008.1-2010.12

19	基金面上项目	纳米模板辅助FePt有序合金阵列的制备研究 50771032	金庆原	2008.1-2010.12
20	国家联合基金	基于分层部分氘化KDP晶体的宽带激光三倍频技术研究 10776005	钱列加	2008.1-2010.12
21	基金面上项目	纳米信息功能薄膜的变温快速椭圆偏振特性分析和研究 60778028	郑玉祥	2008.1-2010.12
22	基金面上项目	基于离子束刻蚀法的宽带连续可调谐半导体量子点光源 60776038	陆 明	2008.1-2008.12
23	上海市重大项目	激光辅助混合磁存储的基础研究 06DJ14007	金庆原	2006.11-2008.10
24	上海市重点项目	新构型量子点微腔激光器 06JC14010	徐 雷	2006.9-2008.9
25	上海市重点（子项目）	人工微纳结构中的红外光电转换过程 07JC14058	徐 雷 陈良尧	2007.12-2009.11
26	上海市优秀学科带头人计划（A类）	微控光子学材料与器件 08XD14006	徐 雷	2008.1-2009.12
27	上海市曙光计划	飞秒脉冲光参量放大的激光物理问题研究与新技术发展 05SG02	钱列加	2006.1-2008.12
28	教育部新世纪优秀人才	快速光谱获取技术及其在环境科学中的应用 NCET-06-0365	郑玉祥	2007.1-2009.12
29	博士点基金	发光增强型多层硅纳米晶的制备及其发光特性 20060246028	陆 明	2007.1-2009.12
30	上海市晨光计划	搀杂氧化钛在可见光诱导杀伤癌细胞中的应用	糜 岚	2008.11-2010.12
31	上海市AM基金	硅表面高K金属氧化	吴嘉达	2007.12-2009.6
32	基金面上项目	ECR-PLA等离子体的时空运动、激发增强和气相反应 10875029	吴嘉达	2009.1-2011.12
33	基金面上项目	直流等离子体反应沉积法合成氮碳纳米锥阵列及其场致发射特性研究10875030	许 宁	2009.1-2011.12
34	基金面上项目	硅纳米晶光频转换增强及晶体硅电池光电转换效率的提高 60878044	陆 明	2009.1-2011.12
35	基金面上项目	中红外光纤激光器用材料及其光纤的研究 10876009	彭 波	2009.1-2011.12
36	基金面上项目	高光学非线性介质微腔中的光学参量过程与实时调控技术研究 10874033	徐 雷	2009.1-2011.12
37	基金重大项目的课题	高峰功率可调谐中红外激光技术的基础问题研究 60890202	钱列加	2009.1-2012.12
38	上海市教委人才基金	垂直磁化自旋阀中巨磁电阻力和自旋转矩效应研究 09ZZ03	张宗芝	2009.1-2011.12

仪器设备/Facilities

序号	设备名称	型号	性能	用途
1	分子束外延设备(超高真空系统)	定制	极限真空: 1.5E-11 mbar	磁性超薄膜生长和性能测试
2	光刻机	SUSS MJB3 UV400	光刻基板最大尺寸：3英寸。样品台移动范围：X轴±3mm, Y轴3mm转角±3度。光刻分辨率0.6微米，套刻精度0.5微米，光强均匀性5%。汞灯350W。	用于各种器件图形的制备
3	扫描干涉显微镜（表面轮廓仪）	NV200HR	横向分辨率最大为0.22微米，纵向测量精度为0.1nm。	测表面粗糙度
4	掺钛蓝宝石飞秒激光器	MIRA BASIC	脉宽: 100fs； 输出功率: 振荡级 490mW 放大级 800mW OPA 30uj @ 606nm 调谐性:振荡级 750-850nm OPA 450-750nm	测量磁性薄膜材料的自旋超快动力学过程
5	锁模Nd:YAG激光器（皮秒）	PY61C-10	能量（with #9740Dye) 30mJ@1064nm, 15mJ@532nm, 5mJ@355nm, 3mJ@266nm; 脉宽40ps@1064 nm; 稳定性5%@1064nm; 7%@532 nm	皮秒脉冲光源
6	微波ECR实验装置+YAG激光器	自制	极限真空: 2 10-4Pa 工作气体: N2,O2, Ar, He, etc. 工作气压: 9 10-3Pa ~ 110-1Pa 微波频率: 2.45GHz 微波功率: 300-1000W 激光系统: 调Q-Nd: YAG (Continuum 公司) 波 长: 266nm, 355nm, 532nm, 1064nm 激光脉宽: 5ns 激光能量: 600 mJ/ pulse pu重复频率：1Hz ~10Hz	可以产生ECR等离子体、PLA等离子体ECR-PLA等离子体，用于ECR微波放电和脉冲激光烧蚀联合作用过程和ECR-PLA等离子体特性研究以及等离子体和激光束联合材料处理和制备技术探索和应用。
7	皮秒宽光谱扫描激光器	PL2143A	波长：220-2000nm, 脉宽：30ps, 重复频率 10Hz, 单脉冲能量 0.01-1mJ	材料的物性研究，微光学器件性能研究

8	多光子/共焦荧光显微镜	FV300-1X71/81	分辨率：1微米；激发波长：405和514nm;荧光探测波长：可见光	三维高分辨荧光图像和光谱分析
9	多功能扫描探针显微镜	XE-100	扫描范围100x100微米，精度0.1nm	测量固体表面形貌
10	高真空多靶磁控溅射仪	KJLC CMS-18	极限真空: 2E-8 mbar；6靶；共溅射；附带传样室。	磁性薄膜和器件的生长
11	ND:YFL激光器	EVOLUTLONXX	脉宽: 200ns 中心波长:527nm 输出功率: 5w	纳秒光源
12	飞秒激光器系统	SPIT FIRE 速率70	脉宽: 50fs 中心波长:800nm 输出功率: 振荡级 350mW 放大级 500mW	飞秒光源

研究工作报告/Scientific Report

超快非线性光学的应用研究 / Applications of Ultrafast Quadratic Nonlinear Optics

成员：钱列加　朱鹤元　范滇元　袁　鹏　　Group members: Qian Liejia, Zhu Heyuan, Fan Dianyuan, Yuan Peng

课题组以发展超高功率短脉冲(PW)等大型激光装置为牵引目标，从事高功率激光技术和二阶非线性光学的研究工作。在基础性研究方面，着重开展超快非线性光学的科学研究工作，探索新的时空非线性光学现象和效应，拓展非线性光学的新应用，并发展形成新的光学技术和测量方法。在工程性激光技术研究方面，将超快非线性光学的科学研究结果作为基础和创新源泉，驱动高功率激光技术的发展，解决大型激光工程中的关键技术难题。本年度取得的主要进展包括：

1. 基于光纤列阵/光电倍增管探测系统的单脉冲信噪比诊断。Fiber-array-based detection scheme for single-shot pulse contrast characterization

信噪比是高功率激光脉冲质量的重要指标之一。随着大型高功率激光装置的发展，对具有高动态范围的、单脉冲方式的诊断技术提出了更高的要求。我们提出并实验演示了创新的基于光纤列阵/光电倍增管探测系统的单脉冲信噪比诊断方案，它去除了传统的外部中性衰减片并引入了高灵敏度的光电倍增管，将并行测量转化为串行测量，较大地提高了测量的动态范围，演示性实验显示了 2×10^7:1 的动态范围。该新方案可以容易地应用于现有的单脉冲信噪比诊断仪器中，对皮秒脉冲，如果结合脉冲倾斜技术，将可以进一步增大诊断的时间窗口。

Contrast is one of the most important parameters of a high-power laser pulse. With the development of high-power laser facilities, diagnostic techniques with high dynamic range in single-shot mode are highly demanded. We have proposed and demonstrated a fiber-array-based detection scheme for single-shot pulse contrast characterization. The parallel to serial mapping using the fiber array allows the use of a high-sensitivity photomultiplier tube and eliminates the external neutral density filter, both resulting in significantly improved dynamic range. The proof-of-principle experiments show a dynamic range of 2×10^7:1. The demonstrated technique can be readily applied to existing instruments for single-shot pulse characterization. The temporal window for characterization may be expanded via pulse tilting for picosecond pulses.

2. 相位畸变光束泵浦的光学参量放大特性研究。Optical parametric amplification by a phase-aberrated beam

高能量激光系统输出的光束通常伴有较大的相位畸变，即非衍射极限光束，当以这类激光作为泵浦源进行光学参量放大（OPA）时，由于空间走离(walk-off)效应的存在，泵浦光束的相位畸变将一定程度上转移给信号光(signal)和闲频光(idler)，从而影响它们的光束质量。数值计算结果表明，OPA 的放大特性综合地依赖于泵浦光强度及其光束质量和空间走离量的大小等因素，对弱泵浦（小信号放大）和强泵浦（饱和放大）两种情形，我们系统地研究了信号光放大增益（效率）及光束质量随空间走离量和泵浦光光束质量的变化规律。我们提出了一种改善信号光光束质量的方案，即采用两级放大构型，其中两块晶体的光轴被设置成所谓的反平行构型，从而使两者的 walk-off 方向相反。如果两块晶体有相同的长度及泵浦光

强，则能最优化地减小泵浦光向信号光的相位转移。

We have theoretically studied the spatial characteristics of optical parametric amplification (OPA) or chirped pulse OPA (OPCPA) pumped with a phase-aberrated beam. Due to the fact that pump-to-signal phase transfer caused by walk-off effect is highly gain-dependent, in a high gain OPA system the signal beam-quality will be significantly degraded even for a weak walk-off, accompanied with beam tilting and converging or diverging. It is demonstrated that an OPA configuration with walkoff-compensated crystal pair is capable of blocking the phase transfer and hence ensuring signal beam-quality unaffected by the pump beam, which may be of importance for designing high-energy OPCPA systems.

3. 基于差频过程级联非线性的孤子脉冲压缩。Soliton pulse compression through cascaded quadratic nonlinearity in difference-frequency generation

研究了飞秒脉冲差频过程中基于级联非线性的孤子压缩效应。在相位失配量较大且泵浦光与信号光之间群速度匹配的条件下，给出了耦合波方程的简化形式，揭示了该类孤子压缩的物理机制。数值模拟计算表明，在等效互相位调制和材料色散的共同作用下，可以同时对泵浦光和信号光脉冲进行较高倍数的压缩。

Cascaded nonlinearity based soliton pulse compression in the process of femtosecond difference frequency generation is studied theoretically. A set of simplified coupled wave equations under the conditions of large phase mismatch and matched group velocities is obtained, which reveals the physical mechanism of soliton compression in this process. Numerical simulations demonstrate that in the presence of group velocity dispersion and equivalent cross phase modulation, both the pump and the signal pulses can be compressed with a high compression ratio.

本年度共发表 SCIE 文章 13 篇，被授权发明专利 3 项。

13 papers were published in SCIE journals and three patents were approved in 2008.

微光子学材料与器件 / Micro-Photonic Materials and Devices

成员：徐雷　刘丽英　吴翔　　Group members：Xu Lei，Liu Liying，Wu Xiang

微光子学以光波导、光学微腔等具有一定功能的微小光学光路为研究对象，不同功能的微小光学光路的集成（称为集成光学，或集成光子学）是取代体光学光路的必由之路，也是人们所追求的终极目标。本课题组的工作集中于探索功能玻璃材料作为光子芯片应用的可能性，研究涉及材料的性能、微结构和微图形及光子学器件。

Micro-photonic chips are miniature optical circuits of waveguides and microcavities. Integration of circuits that have different functions will eventually replace bulk optical components, just like integrated circuits of microelectronics replaced discrete electronic components and changed our normal life. Our group focused on functional glassy materials, exploring the possibility of using these materials as part of photonic chips. Our research covers material characterization, micro-patterning technique and prototype photonic chip devices.

1. 单频回音壁模式微腔激光器。Single-frequency coupled asymmetric microcavity laser

回音壁模式微腔激光器的优点是高 Q、低损耗。但模式间隔小是致命的缺点。通过巧妙地采用非对称耦合微腔结构，我们成功地制备出高 Q 单频微腔激光器。我们首先在经过腐蚀的两根尺寸稍有不同的光纤(125 μm 和 115μm)上制备了光学微环，将两个微腔耦合在一起，获得激光。通过模式竞争效应，可将小间隔的微腔模式扩展成大间隔，结合有效泵浦，成功地抑制住旁模的激光振荡，从而获得单频激光，激光的 Q 值近 30000。激光仅在 4 个方向输出，发射角为 6.6 度。而且该单频耦合微腔激光还可通过平面光波导耦合输出。采用耦合腔方法获得单频微腔激光，提供了一种简便通用的高效率单频激光产生技术。在上述工作基础上，制作出硅基板上单频、单方向的回廊耳语模式微腔激光器。结合硅基底上制备有机/无机复合材料新型光学微盘微腔的工作和上述单频耦合微腔激光器工作，我们在硅基底上制备了两个相接触的微环微腔与螺旋微腔。利用螺旋微腔的单方向出射特性，将微环微腔与螺旋微腔耦合，成功获得单方向、单频回廊耳语模式的激光输出。其中比螺旋微腔尺寸略小的环形共振器(80-100 μm 直径)作为激光谐振腔，而螺旋微腔则起到了模式选择和单方向出射的作用。同时，该耦合微腔激光器的激光产生阈值 (48 μJ/cm^2) 远低于单个螺旋微腔激光器的阈值 (130 μJ/cm^2)。实验还发现该耦合微腔激光器的特性和微环微腔与螺旋微腔的耦合区直接相关，当改变耦合区域时，该单频单方向回廊耳语模式微腔激光器的激光产生阈值会明显变化。相关工作分别发表在 Optics Letters 33, 1050 (2008)，Applied Physics Letters 93, 081105 (2008)，并在 2008 Photonics West（美国）及 2008 APLS（日本）国际会议上作了邀请报告。

Single-mode lasing from a coupled asymmetric microcavity is achieved. By coupling two size mismatched circular microrings to form a coupled asymmetric microcavity, multi-whispering-gallery modes are successfully suppressed and single-frequency laser emission is robustly obtained. Moreover, the laser emits in four directions, and each beam has a divergence of only 6.6°. It is demonstrated further that this single-frequency coupled microcavity laser can be easily integrated with planar lightwave circuits. We provide an easily accessible approach to achieve a single-frequency laser from microcavity lasers operating on whisperinggallery modes.

A ring-spiral coupled microcavity laser on Si wafer is also fabricated. The ring resonator

works as an oscillator and has a diameter that is slightly less than that of the spiral cavity. The spiral provides wavelength selective feedback and emits light out from the notch. As a result, the coupled cavity generates unidirectional single-frequency laser emission. Its lasing threshold is also significantly lower than a single spiral-shaped microcavity laser.

The above results were published in Applied Physics Letters and Optics Letters, also presented at Photonics West and APLS as invited talks.

2. 溶胶-凝胶技术制备掺镱光纤预制棒及掺镱光纤激光器性质研究。Optical Properties and Laser Output of Heavily Yb-Doped Fiber Prepared by Sol-Gel Method and DC-RTA Technique

高掺Yb光纤激光器是一种应用范围非常广泛的高功率光纤激光器。但高掺Yb技术条件苛刻，成本高是待解决的问题。溶胶－凝胶技术虽然可以提供一种低成本高掺杂的可能，但如何稳定沉积足够厚度光学质量高的薄膜仍未解决。我们采用独创的的DC-RTA(dip coating and rapid thermal annealing)溶胶凝胶技术，即拉膜－快速致密化技术来在石英管内壁沉积出具有足够厚度而且具有很好光学质量的掺镱玻璃薄膜解决这一问题。即在石英管内壁一次拉制一层约300 nm厚的凝胶薄膜，并在1000°C左右的高温下迅速致密化。在此基础上继续拉下一层薄膜，如此往复循环。经过几十次沉积之后，石英管内壁上的掺镱凝胶薄膜达到一定厚度，并在氢氧焰高温下收棒，形成光纤预制棒。掺镱凝胶薄膜在预制棒中心成为光纤芯层，石英管成为纤芯外面的包覆层。成功制备出了多根掺镱光纤预制棒，并拉制出高掺镱单模光纤。该光纤实测得到的主要指标为：纤芯掺镱浓度14300 ppm；纤芯中镱离子荧光寿命0.84 ms；光纤在976 nm处的镱离子吸收为827 dB/m；光纤在1310 nm处的传输损耗为2.43 dB/m，在1550 nm处的传输损耗为1.78 dB/m。与目前商售的掺镱光纤比较，本项目所研制的单模掺镱光纤已属于很高的掺杂浓度。测量了使用该方法制得的预制棒样品芯层中的折射率分布和镱离子分布，结果表明使用该方案后预制棒样品的芯层掺杂具有非常好的均匀性。利用本项目制得的高掺镱单模光纤，成功地实现了1053 nm的光纤激光输出，斜效率高达88.4%。这是目前世界上利用溶胶凝胶法制备的掺镱光纤所取得的最好结果，与传统方法制备的掺镱光纤也基本相当。论文发表于IEEE J.Lightwave Technology 26(18) 3256-3260 (2008)。

Heavily Yb-doped (14300 ppm) preforms and fibers are prepared by the sol-gel method and dip coating-rapid thermal annealing (DC-RTA) technique. Optical properties of these performs and fibers are measured and discussed. The concentration of Yb in fiber is 14300ppm, optical loss at 1310nm is 2.43dB/m. A fiber laser at a 1053-nm wavelength is realized and its slope efficiency is measured to be 88.4% which is among the highest in Yb fiber lasers. The excellent performance of the fiber laser and repeatability show that the novel approach described in this paper is capable of providing low-cost high-level rare earth-doped fibers for amplifiers and fiber lasers.

3. 将离子交换技术和溶胶-凝胶技术相结合，实现了低损耗硅基二氧化硅光波导和掺铒光波导放大器件。Low-loss channel waveguides and Y-splitter formed by ion-exchange in silica-on-silicon

将离子交换技术和溶胶-凝胶技术相结合，实现了低损耗硅基二氧化硅光波导和光波导分束器件，条波导的传输损耗为 0.5 dB/cm，与标准 1550 nm 单模光纤的耦合损耗为 0.76 dB/端面。这项工作使离子交换技术应用在硅基光波导器件的制备上成为可能，突破了传统离子交换技术只能依靠玻璃体材料的局限性，大大增强了用离子交换技术制备更复杂功能的集成光波导器件的可能性，为离子交换技术在集成光学研究中的进一步应用和发展提供了基础。

在此基础上，采用稀土掺杂可离子交换的硅基二氧化硅薄膜和离子交换技术制备了铒镱共掺的硅基波导光放大器件，在 1558 nm 波长处实现了净增益。对器件的增益特性进行了分析。这种全新的掺铒波导放大器制备方法一方面利用了溶胶-凝胶技术可以制备高浓度稀土离子掺杂的硅基二氧化硅薄膜的特点；另一方面也发挥了离子交换技术制备条波导器件低成本且方便可行的优势。从而为掺铒波导光放大器件的制备指出了一条新的可行的工艺路线。部分结果发表于 Optics Express16(5), 3172-3177, (2008)。

Low-loss channel waveguide devices on silicon substrate are prepared by a combination of ion-exchange and sol-gel techniques. The transmission loss of the channel waveguide is 0.5 dB/cm and the coupling loss with the standard single-mode fiber is 0.76 dB/facet. This work makes the ion-exchange technique possible in preparing SOS waveguide devices and largely enhances the probability of fabricating more complex devices by ion-exchange technique. Er^{3+}/Yb^{3+} co-doped waveguide amplifier (EYDWA) with net gain of wavelength 1558 nm are formed by ion-exchange on rare-earth doped ion-exchangeable SOS film. Gain characteristic of the EYDWA was numerically modeled. This novel route takes the advantages of both sol-gel and ion-exchange techniques, as silica glass film with high rare-earth doping level can be prepared by sol-gel method on silicon substrate and channel waveguides can be formed by the simple and low-cost ion-exchange process. The achievement provides a new way in preparing EDWA.

4. 新构型掺铒波导光放大器的研制。A semi-weakly confined erbium-doped waveguide amplifier with double-layered buffer/cladding

制备了利用倏逝波泵浦的掺铒光波导放大器。该波导尺寸在纵向上（波导高度）为亚微米量级（350 nm）从而具有弱束缚波导特性，而横向尺寸（波导宽度）则在微米量级（5 μm）。这种结构的波导易于制备，可以沿用传统的光刻加工工艺，且由于波导高度只有百纳米量级，刻蚀要求极低。条波导结构的模场分布仍能和光纤很好地匹配。通过铒离子在包层内的掺杂，掺铒光波导放大器在1550 nm处获得了1.9 dB的内增益。论文发表于Optics Express 16(13), 9844-9849, (2008)。

A semi-weakly confined waveguide structure was designed and fabricated. This waveguide structure has a 350 nm thin core layer. Its optical mode field is weakly confined in vertical direction but is strongly confined laterally. The waveguide can support a nearly circular optical field distribution that matches well with a single-mode fiber. An erbium-doped waveguide amplifier (EDWA) with the new waveguide structure was fabricated by sol-gel method. The EDWA has a passive core and doublelayered buffer/cladding. A small coupling loss of 0.4 dB/facet and an internal gain of 1.9 dB via evanescent wave amplification near 1550 nm were obtained.

2008年度本课题组完成国家自然科学基金项目1项，完成上海市科委基础性研究计划连续支持项目1项，另有1项国家自然科学基金重点项目通过中期检查，被评为优秀。2008年申请到上海市科委优秀学科带头人计划项目1项，国家自然科学基金项目1项。2008年度课题组发表SCI文章11篇，发表在包括Opt. Lett., Appl. Phys. Lett., IEEE J. Lightwave Technol.和Opt. Express等期刊上，与其他课题组合作文章5篇，发表在Opt. Lett.和Chem. Mater. 等期刊上；在国际会议上报告7次，其中会议邀请报告2次；在国内会议上报告2次；申请国家发明专利3项。

Si 纳米晶的光辐射应用及 $SrTiO_3$ 的可见光催化/ Application of light-emission of Si nanocrystals and Visible-light photocatalysis of $SrTiO_3$

成员：陆明 赵有源 Group Members: Lu Ming，Zhao Youyuan

本年度主要开展了以下 3 方面工作：1）镶嵌于 SiO_2 基体中 Si 纳米晶的受激辐射研究。基于我们以往的高发光 Si 纳米晶工作，获得了低激发功率密度阈值的 Si 受激辐射，该阈值比国外的要低 1 个数量级；同时获得了增益系数，也较国外报导的高近 1 倍，目前正在研究一演示型的 Si 激光器。2）晶体硅太阳电池效率提高研究。利用我们研究的高光致发光 Si 纳米晶，将太阳光谱中的蓝紫光高效地转换为晶体硅电池最易吸收的红光及近红外光，预期提高光电转化效率 10%。3）$SrTiO_3$（STO）的可见光催化研究。发现结果 Ar 离子束轰击，STO 原有的紫外光催化能力显著增强，且存在一种新的可见光催化机制，和传统的相比，它的作用主要在于延长光载流子寿命而不是增加其数量，同时，该可见光催化具有广谱特性。

Our research covers three subjects. 1) Stimulated emission of Si nanocrystals embedded in SiO2 matrix. Based on our previous work on high PL efficiency of Si nanocrystals, we obtained Si stimulated emission with threshold of power density lower than the precedingly reported by one magnitude of order; further, the optical gain was acquired, which is two times that precedingly reported. Our work underway aims at a prototype Si laser for demonstration; 2) Improvement of the conversion efficiency of single crystalline Si solar cell. By using our high PL efficiency of Si nanocrystal films, we were trying to convert the violet/blue lights in the solar emission spectrum into red/near infrared ones that are mostly absorbed by single crystalline solar cells. The conversion efficiency could be enhanced by about 10% as expected, 3) Visible-light photocatalysis of $SrTiO_3$ (STO). We found that the UV photocatalytic ability of STO was enhanced after Ar ion bombardment of STO. Further, a new-type of visible-light photocatalysis in ion-bombarded STO was found. As compared to the usual visible photocatalysis, the new type focuses on the extension of electron/hole pair lifetime rather than the generation of new electron/hole pairs. Meanwhile, the new type visible photocatalysis posesses the broad-spectrum nature.

本年度发表 SCI 论文 2 篇。获得 NSFC 项目 1 个。

金属表面吸附原子及团簇的扩散动力学研究 / Studies on self-diffusion of adatoms and adatom clusters on metal sufaces

成员：庄军 Group member：Zhuang Jun

1. 基于半经验和第一性原理模拟，研究了利用单原子、双原子和三原子探针对吸附在Cu(111)表面单个 Cu 原子进行横向操纵的可靠性。获得了操纵可靠性随探针高度的变化规律。对于单原子探针操纵可靠性随探针高度的下降而提高。与单原子探针相比，双原子和三原子探针能够在一定高度范围内明显提高操纵可靠性，原因在于两种机制的作用。一种是“增强的相互作用机制”：探针和吸附原子在操纵方向上具有较强的相互作用。另一种是“原子悬浮机制”：由于探针对吸附原子具有较强的纵向吸引力而使得其横向捕获能力变强。在三原子探针的横向操纵中两种机制都起作用，而对于双原子探针则只有第一种机制起作用。此外，基于三原子探针较好的纵向和横向捕获能力，我们还提出了利用三原子探针对 Cu(111)表面单个 Cu 吸附原子进行可逆纵向操纵的新方法.

We study the reliability of the lateral manipulation of a single Cu adatom on a Cu(111) surface with single-atom, dimer and trimer apex tips using both semiempirical and first-principles simulations. The dependence of the manipulation reliability on tip height is investigated. For the single-atom apex tip the manipulation reliability increases monotonically with decreasing tip height. For the dimer and trimer apex tips the manipulation reliability is greatly improved compared to that for the single-atom apex tip over a certain tip-height range. Two kinds of mechanism are found responsible for this improvement. One is the so-called enhanced interaction mechanism in which the lateral tip–adatom interaction in the manipulation direction is improved. The other is the suspended atom mechanism in which the relative lateral trapping ability of the tip is improved due to the strong vertical attraction of the tip on the adatom. Both mechanisms occur in the manipulations with the trimer apex tip, while in those with the dimer apex tip only the former is effective. Moreover, we present a method to realize reversible vertical manipulation of a single atom on a Cu(111) surface with the trimer apex tip, based on its strong vertical and lateral attraction on the adatom.

2. 用分子动力学方法研究了小团簇 Pt6 和 Cu6 分别在 Pt(111)和 Cu(111)表面上的扩散。原子的相互作用由半经验势来描述。模拟的结果显示两个不同的系统中，团簇扩散的过程差异较大。 例如，在 Pt(111)表面六聚物的单原子跳跃和双原子剪切过程只发生于吸附在 B-边的原子，而在 Cu(111)表面它们既可以发生在 B-边吸附原子上也可以在 A-边吸附原子上。对于平行四边形结构的六聚物，观察到了合作迁移在扩散路径上各向异性的现象。在两个系统中这种现象的机制以及优先的扩散途径完全不同。最后我们讨论了这些扩散特点和差异的原因。

Diffusions of small cluster Pt6 on Pt(1 1 1) surface and Cu6 on Cu(1 1 1) are studied by molecular dynamics simulation, respectively. The atomic interaction is modeled by the semiempirical potential. The results show that the diffusion processes in the two systems are far different. For example, on Pt(1 1 1) surface, the hopping of single atom and the shearing of two atoms of hexamer only occur on the adatom(s) adsorbed at B-step, while on Cu(1 1 1) surface they can appear on the adatom(s) either at A-step or B-step. To the concerted translation of the parallelogram hexamer, the anisotropy in the diffusion path is observed in the two systems, the mechanisms and then the preferential paths, however, are completely different. The reasons for these diffusion characteristics and differences are discussed.

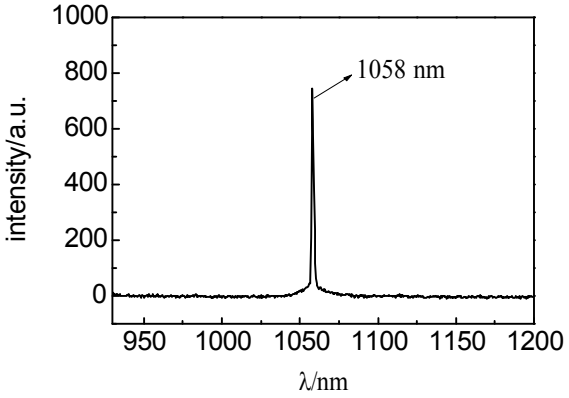
有机光电功能材料及器件 / Organic Optoelectronic Functional Materials and Device

成员：彭波 韦玮 Group Members: Peng Bo，Wei Wei

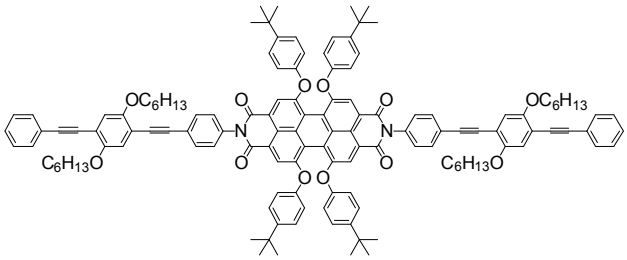
- 新型流体激光材料与性能
- 有机光电材料
- Novel liquid laser media and optical feature
- Organic functional Materials

1.新型流体激光介质与性能的研究取得突破性进展。采用波长为 808 nm，脉宽为 200 us，功率 1.7 kW 的半导体阵列，对流体激光谐振腔（反射镜 R_1 = 100%, R_2 = 90%）进行了激光侧泵发振，在实验室首次观察到激光动态输出。最大输出功率达 1.59 mJ，激光阈值为 116 mJ。

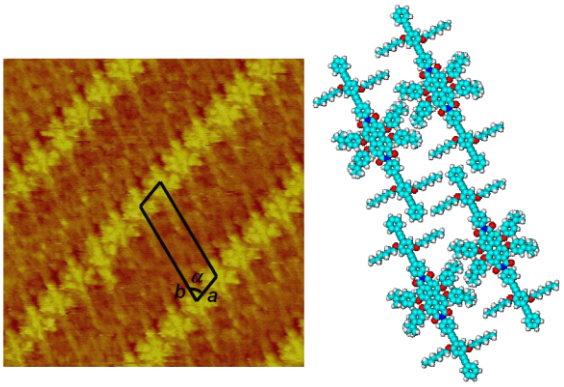
2.设计/制备了给体-受体-给体(D-A-D)结构寡聚物。研究发现：溶液态中溶剂极性越弱，寡聚物越易发生聚集；光激发诱导下存在分子内的能量和电子转移；能在 HOPG 和辛基苯固液界面自组装,分子平铺在石墨上,沿长轴方向上平行排列。



流体激光器的发射光谱



给体-受体-给体(D-A-D)结构寡聚物



STM 图像和结构模型

1. A great progress has been made in the novel liquid lasers materials. Through a lot of theories and experiments, we firstly observed dynamic laser output of the flow laser. The maximum laser output reaches to 1.59 mJ and the threshold energy is 116 mJ. The flow laser was pumped by a semiconductor diode from side, 808 nm of wavelength, 200 us of pulse width and 1.7kW of power, R_1 and R_2 of the laser cavity reflector were 100% and 90%.

2. Design and preparation a novel oligomer based on donor-acceptor-donor (D-A-D) structure. It was found that strong aggregation of the oligomer took place in low-polarity environments. And there existed intramolecular energy and electron transfer. The oligomer formed well-ordered two-dimensional patterns from 1-phenyloctane on graphite (HOPG) at the solid-liquid interface. The molecule lay with its molecular axes parallel to the graphite plane. Along the molecule's long axis, the adjacent molecules stacked with parallel model.

氮氢共掺杂氧化钛纳米材料的可见光催化研究 / Study on the visible-light photocatalytic abilities of N:H-codoped TiO_2 nanoparticulate films

成员：王培南 糜岚 Group members: Wang Peinan, Mi Lan

1. 氮掺杂和氮氢共掺杂氧化钛纳米材料的可见光催化研究。Study on visible-light photocatalytic abilities of N-doped and N:H-codoped TiO_2 nanoparticulate films

锐钛矿相的纳米氧化钛在环保和能源领域有广泛的应用。但氧化钛的光催化必须使用紫外光，使应用成本非常高，极大阻碍了它们的应用推广。通过掺氮可以将氧化钛的光学吸收边从紫外区移到可见光区，将可以利用廉价的太阳光做能源进行光催化反应。因此研究掺氮氧化钛的合成和催化效率的提高具有重要的应用前景。我们合成了掺氮和氮氢共掺杂的氧化钛纳米薄膜，研究了他们的可见光催化性能，并对掺杂机理进行了理论研究。

我们采用在流动氮气和氨气中煅烧 TiO_2 纳米颗粒膜的方法制备了掺氮和氮氢共掺杂的 TiO_2 膜。在煅烧过程中先在高温下短时间煅烧，后在较低温下长时间煅烧，既减少了锐钛矿相向金红石相的转化，又得到了较高的掺氮量。通过对薄膜的表征，发现在氨气中煅烧比在氮气中煅烧有更好的掺杂效率；在掺氮量一样的情况下，氮氢共掺杂与掺氮相比有明显的吸收边的红移，因此具有更强的可见光吸收和催化效率。结果发表在 *Appl. Surf. Sci.*, **255**(5), 2574-2580 (2008)。

掺杂氧化钛材料在使用时，催化效率会很快降低，这对实际应用带来很大的困难。因此催化效率的恢复对实际应用时的重复使用尤为重要。我们采用温和加热的方法对已经使用过的薄膜进行后处理，结果发现其光催化效率可以完全恢复，这对于材料的实际应用具有重要意义。这些结果已经发表于 *J. Photoch. Photobio. A*, **193** (2008) 222。

在制备掺氮氧化钛薄膜时我们发现使用氨做氮源往往会有很好的效果，究竟氢在氧化钛材料的能隙改变和催化的改善中有什么作是很值得研究的。我们基于第一性原理，计算了纯 TiO_2、填隙型和置换型的掺氮 TiO_2 和氮氢共掺杂 TiO_2 的能带结构和态密度，对可见光吸收机理进行了分析。发现在掺杂浓度为 2.1%时，置换型掺氮和氮氢共掺杂导致的带隙变窄是相同的，都是 0.12 eV；而填隙型只有氮氢共掺杂能引起带隙变窄 0.07 eV。这个计算结果，可以很好地解释我们以前实验中得到的结果，即氮氢共掺杂氧化钛比掺氮氧化钛有更强的可见光吸收和更高的可见光催化效率。上述结果已经发表在 *Chem. Phys. Lett.*, **458**, 341-345 (2008)。

TiO_2 in anatase phase has been widely applied in environmental protection and energy fields. However, TiO_2 has photoactivity only under ultraviolet (UV) light, which increases the cost seriously and obstructs the wide application of the material. Nitrogen doping into anatase can shift its absorption edge from UV to the visible light region, so that the sunlight can be effectively utilized for photocatalytic applications. So study on the synthesis of nitrogen doped TiO_2 will impose a profound positive effect on enhancing the photocatalytic efficiency, which is of importance for the wide application of TiO_2. We prepared N-doping and N:H co-doping TiO_2 nanoparticulate films and studied their photoactivities. The mechanism of visible-light photoactivity of N:H co-doped TiO_2 films was discussed on the basis of theoretical calculation.

Calcination of TiO_2 nanoparticulate films under flowing N_2 and NH_3 were applied to prepare N-doped and N:H co-doped TiO_2 films, respectively. The calcination were carried out under high

temperature for a short time and then under lower temperature for a long time to achieve high dopant concentrations and avoid the transformation of anatase phase. Characterizations of the produced films showed that the N-doping was more efficient when calcined in ammonia. With the same nitrogen dopant concentration, the films calcined in ammonia showed remarkable redshifts of the photoabsorption edges and higher visible-light photocatalysis efficiencies. This work was published on *Appl. Surf. Sci.*, **255**(5), 2574-2580 (2008).

The photocatalytic ability declined rapidly with the operating time. The deactivation of the material will result in a poor reusability, which is unfavorable to the practical applications. So the recovery of photocatalytic ability is crucial for TiO_2 to have higher commercial potentials. The method of mild-heating was applied for the regeneration of photocatalytic films. It was found that the photocatalytic ability of the used film was fully recovered by this treatment, which is of particular importance for the practical applications. This work was published on *J. Photoch. Photobio. A*, **193** (2008) 222.

A remarkable improvement of optical absorption in the visible light region was observed when using ammonia as the nitrogen source for the film preparation. It is worthy to study the effect of the hydrogen on the band gap narrowing and visible-light photoactivity of the material. We employed DFT (density-functional theory) calculations to study the geometric and electronic structures of N- and NH-doped anatase TiO_2 systems in both substitutional and interstitial doping configurations with a nitrogen doping concentration of 2.1%. For substitutional doping configurations, N- and NH-doping resulted in a similar bandgap narrowing of 0.12 eV. For interstitial doping configurations, only NH-doping resulted in a bandgap narrowing of 0.07 eV. This might be able to explain the remarkable redshifts of absorption, as well as the great improvement of the photocatalytic activities in our experimental results. This work was published on *Chem. Phys. Lett.*, **458**, 341-345 (2008).

2. CdTe 量子点在活体细胞中的发光行为研究和细胞环境对发光行为的影响。Environmental Influence on the Photoluminescence Behavior of Thiol-Capped CdTe Quantum Dots in Living Cells

水溶性半导体量子点作为一种新型的荧光探针，具有良好的光学特性，在生物领域的应用得到了广泛关注。由于量子点的表面积/体积比大，尤其是量子点表面由有机配体钝化，因此量子点的光致荧光对环境影响很敏感。总体而言，细胞内的环境比较复杂，因此细胞内的量子点的发光行为也比在溶液中复杂。我们分别研究了硫醇包覆的CdTe量子点在溶液中和活细胞中环境对其发光行为的影响，如溶液的pH值和不同的细胞器对荧光的影响。用共焦显微镜我们观察到CdTe量子点溶液随着pH值降低逐渐团聚的现象。pH值由12降至3，量子点的平均水相直径由28 nm增加到团聚后的1.4 μm。碱性环境能够促进量子点的分散，而酸性环境会造成量子点表面配体脱落，从而引起量子点的团聚。在pH值为12到7时，量子点的荧光寿命为80 ns，而pH值为5和3时，荧光寿命分别缩短到57和34 ns。细胞内的量子点荧光寿命也因细胞内微环境不同而不同。在酸性的溶酶体中，量子点的荧光寿命比在细胞其余区域中显著缩短。另外，在相同的pH值下，在活细胞中的量子点的荧光寿命要比在水溶液中的短。这是因为量子点与生物分子的相互作用也会造成荧光寿命缩短。酸性环境和生物分子与量子点的作用都是造成荧光寿命变短的两个可能因素。这些结果分别发表于*Small*, **4**(6), 770-780, (2008) 和*J. Lumin.*, **128**, 1948-1951 (2008)。

Water-soluble colloidal semiconductor quantum dots (QDs) as a new class of fluorescent

probes with excellent optical properties, have attracted considerable attention in bioapplications. Because of the large surface-to-volume ratio of QDs, especially in the case of QDs passivated with organic ligands, the photoluminescence (PL) of QDs is sensitive to the environmental conditions. Generally, the PL behavior of intracellular QDs is more complicated than that in solutions due to the complex cellular environment. We studied the environment influence on the PL behavior of thiol-capped CdTe QDs in solutions as well as in living cells, such as the pH dependence of the PL of QDs in solutions and the PL lifetimes of QDs in cell organelles. The pH-dependent aggregation of thiol-capped CdTe quantum dots (QDs) in solutions was observed with a confocal microscope. The average hydrodynamic diameter of the QD aggregates increased from 28 nm to 1.4 μm as the pH decreased from 12 to 3. The basic condition improved the dispersion of QDs while the acidic condition caused the detachment of surface ligands, leading to the aggregation of QDs. A PL lifetime of 80 ns was detected for QDs at pH from 12 to 7, while it was shortened to 57 and 34 ns at pH 5 and 3, respectively, due to the formation of surface defects caused by the detachment of surface ligands. The PL lifetime of the intracellular QDs also varied greatly depending on the intracellular environment. The PL lifetime of QDs in the acidic lysosomes was remarkably shorter than those in other parts of the cell. On the other hand, the PL lifetimes of QDs in living cells were generally shorter than that in aqueous solutions with similar pH. The interactions of QDs with biomolecules would also cause the shortening of the PL lifetime. The acidic environment and the interactions of QDs with biomolecules are two of the possible reasons for the shortening of PL lifetimes of intracellular QDs. These results were published on *Small*, **4**(6), 770-780, (2008) and *J. Lumin.*, **128**, 1948-1951 (2008), respectively.

等离子体特性和应用、功能材料的制备和性质研究 / Characteristics and applications of plasmas, preparation and properties of functional materials

成员：吴嘉达 许宁 应质峰 孙剑

Group members: Wu Jiada, Xu Ning, Ying Zhifeng,Sun Jian

采用直流等离子体反应沉积法在氮碳纳米锥的合成方面进行了一系列实验，得到了较好的结果：在硅衬底上合成出竖直生长、排列整齐的氮碳纳米锥阵列，成分分析表明其中的氮碳原子比可达到 4:3 左右，结构表征显示具有单晶形态单晶，主要由β-C_3N_4 相构成，观察到的锥尖曲率半径基本在 5 纳米以下，最大的 15 纳米左右，底部直径在几十至几百纳米，还探讨了相关的氮碳纳米锥生长机理。

A series experiments were performed on synthesis of CNx nanocones by DC-plasma reactive deposition. Vertically aligned CNx nanocone arrays with C:N atom ratio of 3:4 and single-crystalline β-C_3N_4 phase were grown on silicon substrates. The cone end has a radius of 5-15 nm, and bottom radius of tens of nanometers. The growth mechanisms were also discussed.

采用第一性原理计算比较了理想 ZnO 和 As 掺杂 ZnO 的电子结构，发现 As_{Zn}-$2V_{Zn}$ 缺陷体系中，禁带中不出现杂质能级。费米能级移入价带，体系表现为 p 型导电性质。费米能级处的 As 3d 态 PDOS 值很低，并且它在价带中是非定域的，显示了良好的电荷迁移性质，分析显示 As_{Zn}-$2V_{Zn}$ 是 As 掺杂 ZnO 中最有可能的受主缺陷。

The electronic structures of idea ZnO and As-doped ZnO were calculated by first-principle method. There's no dopant energy level within the forbidden energy gap of As_{Zn}-$2V_{Zn}$ defects system. The system presents p-type conductivity with the Fermi level in the valence band. The PDOS value of As 3d state on the Fermi level is very low and delocalized, with very good charge mobility. The As_{Zn}-$2V_{Zn}$ complex is the most possible accept defect in As-doped ZnO.

在 ZnO 材料方面，分别用脉冲激光沉积方法制备了性能优良的 ZnO 纳米棒薄膜和用等离子体辅助脉冲激光沉积方法制备了 ZnO 纳米晶薄膜，并进行了导电特性和退火行为的研究。对衬底的特定处理可以获得单晶形态 ZnO 纳米棒，室温下可以明显看到强烈的紫外光致发射峰，在低温 PL 谱中可以分辨出 ZnO 激子峰的精细结构。

ZnO nanorods films were synthesized by pulsed laser deposition and ZnO nanocrystal films were synthesized by plasma assisted pulsed laser deposition. The conductivity and annealing properties were studied. Single-crystalline ZnO nanorods were obtained after treatment of the substrates. A strong UV emission peak was observed in room-temperature PL spectrum, while the fine structure of exciton emission peaks was clarified in low-temperature PL spectrum.

开展了高 k 金属氧化物的合成制备和性质研究，用等离子体辅助脉冲激光沉积方法制备了常温条件下单斜结构的 HfO_2、ZrO_2 薄膜，在紫外至红外波段具有良好的透光特性，在硅衬底上制备的 HfO_2 和 ZrO_2 薄膜都不含 SiO_x 界面层，直至 900°C 都有良好的热稳定性，为下一步电学特别是介电特性的研究打下了一定的基础。

Synthesis and properties of the high–K metal-oxides were studied. Monoclinic HfO_2 and ZrO_2 films were synthesized by plasma assisted pulsed laser deposition under room temperature. The films are transparent at wavelength from UV to IR. No SiO_x boundary layer was observed for the films deposited on silicon substrates. The films present good thermal stability up to 900°C. Those results are fundamentals for the oncoming research work, especially on dielectrically

properties.

本年度获得国家自然科学基金面上项目 2 项，执行上海市科委国际合作基金项目 1 项，已获授权发明专利 1 项，发表学术论文 10 篇。

In this year, two NSFC projects were accomplished and one Shanghai International Cooperation (AM) project was approved. One patent was granted. Five papers were published and another one is in press and one was accepted for publication.

凝聚态光学性质与光谱学研究进展 / The Progresses on the Study of Optical Properties of Condensed Matters and Spectroscopy

成员：陈良尧 郑玉祥 王松有 李 晶 张荣君

Group Members: Chen Liangyao，Zheng Yuxiang, Wang Songyou, Li Jing, Zhang Rongjun

一、 主要研究进展 Progress on research

1．光在金属/空气界面传输的实验研究。Experimental measurement and study of the visible electromagnetic wave propagated at the metal/media interface

制备了一系列可精确控制入射角的楔形贵金属 Au 和 Ag 样品，采用光程放大的方法，对于光在最简单的天然贵金属／空气界面传播时发生由负到正的奇异折射现象进行了定量实验测量和分析。在研究中，围绕在不同波长下光在金属边界的折射角发生从负到正的变化规律，对于有可能导致奇异光折射现象的各种争议性机理进行了细致探索和讨论，包括表面和体等离子共振效应、负磁导率效应、Goos-Hänchen 效应、光在金属基界面的传播路径、由折射率色散特性所决定的快慢光子行为等效应。实验中获得了表观折射率值与入射和折射角的定量关系，并对实验结果进行了数值模拟，以及对其起源作了深入的讨论和分析。获得以下结论：（1）首次在实验上观察到可见光谱区光在穿过贵金属（Au）／空气界面时折射角发生从负到正的变化现象，这与 Drude 光谱区表征光子能量传播方向的群速度和群折射率的值随光子能量的增大而发生从负到正的变化规律一致；（2）对于 Ag 样品而言，在可见光区当探测光穿过 Ag／ 大气界面时，折射角均为负值，但负的程度随光子能量增加而减小，预期在更高光子能量的带间跃迁区将越过零点而转变为正值，这与相同光谱区群速度和群折射率随光子能量变化的规律一致；（3）按经典模型对光在大气/金属／大气界面的传输路径进行了数值模拟计算和分析，揭示了光从空气入射到金属和从金属入射进空气的传输路径具有不可逆的特性，这与实验观测的结果相违背；（4）无论对于 Au 和 Ag 样品，实验测量到光在金属/大气边界的表观折射率和折射角都随波长而改变，但与偏振无关；通过讨论和分析，对于贵金属 Au 和 Ag 样品来说，在可见光区光在金属／大气的负折射效应并不起源于表面和体等离子共振效应、负磁导率效应和 Goos-Hänchen 效应，而是与群速度的传播特征之间存在内在的联系。贵金属是自然界最基本的元素，发生在天然贵金属／大气界面的光折射现象将可增进人们对于光频电磁波在凝聚态吸收物质中的传播规律的认识和理解。在此基础上，我们将期待着进一步扩大实验金属样品的种类，开展对更多材料和结构的深入研究，发现新规律，从而为新型光电子功能材料和器件的研制建立基础。

In this work, we have fabricated a series of noble-metal-based samples (Au and Ag) with precisely controlled incident angles. We quantitatively measured the refraction of the light passing through the metal/air interface, and observed that the refraction can change from negative to positive in the visible range at the simplest interface of the natural noble metal. In terms of the refraction angle measured at the metal/air interface, we quantitatively obtained the relationship between the value of pseudo refractive index and incident angle. We studied and discussed those possible mechanisms used to explain the physical origin of the negative refraction effect, such as the surface and bulk plasmon resonance effect, negative permeability effect, Goos-Hänchen effect, slow and fast photon effect, predication of the light path at the metal-based interface, and so on. Through careful discussion and data analysis, the mechanism to result in the negative refraction has been studied and proposed. The results includes: (1) It is experimentally shown that light

refraction can go from negative to positive at pure air and Au interfaces in the visible region in this work. Results qualitatively agree with dispersion of the group refractive index n_g based on the refractive index and a Drude model, in which the dispersive properties of the phase refractive index n play the significant role to make n_g change its magnitude and sign in the energy region, due to the microinteractions between the photons and electrons with respect to the intraband and interband transitions in the material. (2) The light refraction has been measured for a series of prism-like Ag film samples in the visible Drude region and it was found that refraction is negative in the region. Light refraction has a spectral trend to be less negative with the increasing energy and is expected to be positive in the higher energy region, where the interband transitions will dominate the interaction between the electrons and photons in Ag. (3) According to classical model, the propagation path for light passing through air/metal/air structure has been numerically analyzed and the results show that the optical path from air to metal and from metal to air is irreversible, which conflicts with the experimental results. (4) For both Au and Ag samples, the experimentally observed refractive index for light from metal to air depends on the wavelength but is independent of polarization. Through careful discussion and data analysis, the physical origin of the negative refraction effect for noble metal Au and Ag is not attributed to the surface and bulk plasmon resonance effect, negative permeability effect, Goos-Hänchen effect, but related to the dispersion characteristics of group velocity. As all above, results shown in this work will help to understand the fundamental principle of optics both in theory and experiment based on Snell's law. More studies to explore the true physical origins regarding to those interesting phenomena happened at the metal-based interface will be expected to be followed in the future to help the design and fabrication of the new type of photonics materials and devices in wide applications.

2. 光子在薄膜材料中传播（反/透射）的空间干涉规律研究。Study of the spatial interference of light propagating in the film structure

对于等离子体辅助电子束蒸发方法制备SiO_2光子薄膜的最佳工艺参数进行研究，讨论了光子在薄膜材料中传播的空间干涉规律。对制备的样品进行多角度椭圆偏振光谱测量，波长范围为300 nm 到800 nm，并按新的模型对椭圆偏振光谱学的计算公式进行了修正。得到的主要结论如下：（1）采用等离子体辅助电子束蒸发薄膜生长方法制备SiO_2光子薄膜，获得最佳生长工艺条件和规律。采用扫描电子显微镜(SEM)观察样品的表面形貌，用X射线光电子能谱(XPS) 分析薄膜元素的化学态和化学配比，用椭圆偏振光谱（SE）方法测量SiO_2薄膜的折射率和厚度，研究了不同工艺条件（射频等离子辅助功率、生长速率和衬底温度等）对薄膜光学性质的影响。SEM测量结果表明薄膜表面较平整，薄膜厚度约为100nm，这与石英晶体测厚仪的结果基本一致。XPS结果表明薄膜样品为富氧的SiO_2薄膜。生长速率范围在0.4-1nm/sec，薄膜的折射率随生长速率的增大而减小。衬底温度在20℃－120℃，薄膜的折射率随着衬底温度的升高而增大。射频等离子体源功率范围在0-200W，薄膜的折射率随功率的增大而减小。由此，可以找到一个最佳制备SiO_2光子薄膜的工艺条件，薄膜生长速率为0.4nm/sec，衬底温度为120℃，射频等离子体辅助功率为200W。（2）研究了光子在薄膜材料中传播（反/透射）的空间干涉现象。在分析两束相邻光束干涉叠加过程中，考虑了光束在薄膜材料中传播时的空间分离。研究发现，对于以Si为衬底的SiO_2单层膜，当相邻反射光的光程差$\delta=\pi$，2π左右时，利用光波在薄膜材料中反射传播的经典干涉规律和经典椭偏测量模型拟合算出的理论计算值严重偏离实验测量值。只有在膜厚较小或远小于光的波长时，条件$\delta<\pi$得以满足，才可以不计干涉时相邻光束的空间分离效应的影响，否则,必需考虑。

The optimal deposition conditions for SiO_2 film deposited onto Si wafers by using the

e-beam evaporation method with the aid of plasma assisted deposition have been studied and the spatial interference characteristics of light propagating in the film structure was discussed. All samples were measured with spectroscopic ellipsometer at different incident angles and in the 300-800 nm wavelength range. The ellipsometric parameters were analyzed with a modified ellipsometric model. The conclusions are mainly as follows: (1) The optimal parameters and deposition rules for the deposition of SiO_2 onto Si substrate with e-beam evaporation method have been obtained and discovered. The morphology of surface for the samples was displayed with SEM. The chemical states and components were examined with XPS. The optical constants and thickness of the film samples were determined with SE. The effect of different technique conditions, including the power of RF plasma source, rate of deposition and substrate temperature, etc., on the optical properties have been studied. The results of SEM show that the film surface are smooth, and the thickness of the film is about 100 nm, which is coincident with the results from quartz oscillator monitor. The results of XPS show that the film is O-rich SiO_2. The deposition rate varies from 0.4 nm/s to 1 nm/s, and the refractive index of the film decreases with the increasing rate. The range of substrate temperature is 20℃ — 120℃, and the refractive index of the film increases with the increasing rate. The power of RF source ranges from 0 W to 200 W, and the refractive index of the film increases with the increasing power. The optimal deposition condition for preparing the SiO_2 film was found to be as follows, the deposition rate is 0.4 nm/s, the substrate temperature is 120℃，and the power of RF source is 200 W. （2）The phenomenon of spatial interference of the light propagating in the film structure has been studied. The light interference has been analyzed for the film structure by considering that the spatial separation exists for the two neighboring light beams which interfere with each other in the space. There is significant difference occurred between the situations of the interference with or without consideration of the spatial effect, especially around the region where the phase delay $\delta = \pi$ and 2π by taking example of the one-layered SiO_2/Si structure. It will be reasonable to extract the optical parameters by neglecting the spatial effect only for the thinner film with the thickness much smaller than the wavelength satisfying the condition of $\delta < \pi$, otherwise, the conventional formula used for film structures should be modified by considering the spatial deviation effect of two neighboring light beams.

3． $Zr_{73}Pt_{27}$玻璃中的短程和中程有序-----实验和理论研究。Short- and Medium-Range Order in a $Zr_{73}Pt_{27}$ Glass: Experimental and Simulation Studies

利用XRD方法结合第一性原理分子动力学以及逆蒙特卡罗(RMC)方法研究了$Zr_{73}Pt_{27}$金属玻璃的结构。在结晶过程中，形成了具有扭曲二十面体原子团簇的Zr_5Pt_3相(Mn_5Si_3型)。第一性原理分子动力学能够准确描述玻璃中的短程或中程有序结构。通过XRD得到的总的结构因子和第一性原理分子动力学得到的偏对关联函数作为RMC的约束条件，产生包含18000个原子的三维玻璃结构。在分子动力学和逆蒙特卡罗方法得到的原子模型基础上，通过Honeycutt and Andersen (HA)指数和Voronoi方法研究其短程和中程有序。第一性原理的结果表明二十面体型的短程有序结构在玻璃态中占支配地位。此外，通过分析约束条件限制的RMC模拟得到的原子结构可以发现，二十面体类团簇之间存在更高的相关性，因此该体系呈现出了高达两到三个团簇等级的中程有序结构。

The structure of a $Zr_{73}Pt_{27}$ metallic glass, which forms a Zr_5Pt_3 (Mn_5Si_3-type) phase having local atomic clusters with distorted icosahedral coordination during the primary crystallization, has been investigated by means of X-ray diffraction and combining *ab initio* molecular dynamics

(MD) and reverse Monte Carlo (RMC) simulations. The *ab initio* MD simulation provides an accurate description of short-range structural and chemical ordering in the glass. A three-dimensional atomistic model of 18000 atoms for the glass structure has been generated by the RMC method utilizing both the structure factor $S(k)$ from X-ray diffraction experiment and the partial pair-correlation functions from *ab initio* MD simulation. Honeycutt and Andersen (HA) index and Voronoi cell analyses, respectively, were used to characterize the short- and medium-range order in the atomistic structure models generated by *ab initio* MD and RMC simulations. The *ab initio* results show that an icosahedral type of short-range order is predominant in the glass state. Furthermore, analysis of the atomic model from the constrained RMC simulations reveals that the icosahedral-like clusters are packed in arrangements having higher-order correlations, thus establishing medium-range topological order up to two or three cluster shells.

4. 液态 $Al_{60}Cu_{40}$ 合金结构的实验和第一性原理分子动力学模拟研究。Experimental and ab initio molecular dynamics simulation studies of liquid $Al_{60}Cu_{40}$ alloy

利用 XRD 实验和第一性原理分子动力学计算研究了液态 $Al_{60}Cu_{40}$ 合金在 973 K 到 1323 K 温度下的微观结构。理论计算的对关联函数与实验结果相一致。通过利用 Honeycutt-Andersen 和 Voronoi 等方法分析体系的微观结构变化。可以看出，随着温度的降低，体系的结构更加有序化。在 $Al_{60}Cu_{40}$ 液态合金中，没有哪种团簇是占据绝对优势，但出现较多的团簇可以用扭曲的二十面体来描述。该系统中没有观察到团簇之间非常明显的关联或者已知的稳定晶体相。

X-ray diffraction and *ab initio* molecular dynamics simulation studies of molten $Al_{60}Cu_{40}$ have been carried out between 973 and 1323 K. The structures obtained from our simulated atomic models are fully consistent with the experimental results. The local structures of the models analyzed using Honeycutt-Andersen and Voronoi tessellation methods clearly demonstrate that as the temperatures of the liquid is lowered it becomes more ordered. While no one cluster-type dominates the local structure of this liquid, the most prevalent polyhedra in the liquid structure can be described as distorted icosahedra. No obvious correlations between the clusters observed in the liquid and known stable crystalline phases in this system were observed.

5. $Bi_{3.15}Nd_{0.85}Ti_3O_{12}$铁电薄膜的椭偏光谱研究。The ellipsometric study of $Bi_{3.15}Nd_{0.85}Ti_3O_{12}$ (BNdT) ferroelectric thin films

通过溶胶-凝胶法(sog-gel)在Pt/Ti/SiO_2/Si衬底上制备$Bi_{3.15}Nd_{0.85}Ti_3O_{12}$（BNdT）铁电薄膜，厚度约200nm。运用椭偏光谱分析的方法对BNdT铁电薄膜的光学性质进行了初步研究。在1.5~4.5eV光子能量范围测量了由溶胶-凝胶法制备的$Bi_{3.15}Nd_{0.85}Ti_3O_{12}$铁电薄膜的椭偏光谱。根据电介质色散关系及三相结构模型，拟合得到薄膜在可见光区的折射率和消光系数。并由Tauc’s法则计算得到所研究薄膜的直接禁带宽度为3.84eV。

The $Bi_{3.15}Nd_{0.85}Ti_3O_{12}$ (BNdT) ferroelectric thin films with thickness of 200 nm were deposited on Pt/Ti/SiO2/Si substrates by using a sol-gel technique. The ellipsometric spectra of the BNdt thin film were measured and investigated in the photon energy range of 1.5 - 4.5 eV. The ellipsometric spectral data were fitted by using the four-phase layer structure model and the Forouhi-Bloomer (FB) model, which was used to describe the optical dispersion relation of the sample. The optical constants of the sample were obtained by using a data analysis based on Tauc's principle and showed that the direct band gap of the BNdT sample existed at 3.84 eV.

6. 基于多微型检偏器、固定方位角、偏振态并行测量模式的新型椭圆偏振仪的研制。The study of a new type of ellipsometry by using a set of analyzers with fixed orientation

在研制的实验系统中，起偏器的方位角被固定在 45°，而通常采用的检偏器被一个由 12 个微型检偏器组成的组合检偏器取代，这 12 个微型偏振晶体的尺寸为 1.5mm×1.5mm×4mm，被置放于专门设计和加工好的金属工件中，各自方位角依次相隔约 15°，并大约覆盖 0-180° 的方位角范围，这个组合检偏器可同时探测 12 个不同的反射光偏振状态，并且无需任何光学部件的机械移动。该组合检偏器的通光孔径为 9.4mm。入射光被样品反射后，其偏振态发生了改变，再通过 12 个组合检偏器入射到二维 CCD 探测面上，可以在同一数据采集时间内获取由单一检偏器旋转一周才能获得的各偏振态的光强信号，经由计算机对信号进行光强权重的数值归一化以及数值拟合分析后，可快速获得椭偏参数。在实验中，选取波长 546.1nm 的探测光， 在 60° 入射角条件下对单晶硅片进行了测量，获得ψ=24.013° ，Δ= -177.600°；这与旋转偏振器的光度式椭偏仪的测量结果相符合。整个椭偏测量过程无任何机械位移部件，在满足测量精度的同时显著提高了测量速度，将可应用于薄膜生长过程的实时光学监控等方面。

In the system constructed in this work, one polarizer is used with fixed azimuth angle at 45°, and in stead of using one analyzer, 12 sub-analyzers with the size of about 1.5mm×1.5mm×4mm are used and almost uniformly distributed with different fixed azimuth angles in the 0-180° range to form an integrated analyzer which can detect 12 polarization states simultaneously without any mechanical movement of the optical elements. The integrated analyzer has the beam-through diameter of about 9.4mm. A CCD (Charge Coupled Device) camera is used to measure the intensity of the light emerging from the 12 sub-analyzers. By data analysis of the light intensity with respect to the 12 sub-analyzers, the set of ellipsometric parameters tanψ and cosΔ can be obtained quickly. In our experiment, a crystalline silicon wafer was measured to test the system at the wavelength of 546.1 nm of the mercury lamp at incident angle of 60°. The measured ellipsometric parameters ψ and Δ of the sample are 24.013° and 177.600°, respectively, those are in good agreement with the data (ψ=24.272° and Δ=177.298°) measured by using the conventional Rotating-Analyzer-Polarizer (RAP) type of ellipsometer in the lab. The new ellipsometer with fast data acquisition speed shows its advantage and potential to be applied in many fields in the future.

7. 微量掺杂对$Ge_2Sb_2Te_5$相变复合薄膜性能的改善研究。Phase change characteristics improvement of micro-elements doped $Ge_2Sb_2Te_5$ films

利用磁控溅射系统、采用共溅射方式制备微量掺杂的$Ge_2Sb_2Te_5$相变薄膜样品$M_x(Ge_2Sb_2Te_5)_{100-x}$，其中M为微量掺杂元素（如金属Al、Ti、或半导体Si、ZrO_2、TiO_2等）。利用在位温控椭偏光谱仪对掺杂样品进行变温椭偏光谱测量；还搭建Pump-probe时间分辨超快激光系统对样品的超快动力学过程进行实验研究；同时，运用第一性原理对此类样品微结构转变的分子动力学过程进行相应的理论研究。探索并阐明此类样品晶态-非晶态间的快速转变的分子动力学机制，为$Ge_2Sb_2Te_5$相变薄膜材料的性能改善及应用研究提供参考，为此类相变材料通过微量掺杂改善性能，并通过理论研究其分子动力学过程预测改性样品的微结构变化机制寻找新途径。

Micro-elements doped $Ge_2Sb_2Te_5$ Phase change films [$M_x(Ge_2Sb_2Te_5)_{100-x}$] were prepared by co-magnetron sputtering system. The “M” stands for different elements or molecules such as Al, Ti, Si, ZrO_2 or TiO_2, etc. The influence of M doping upon phase change characteristics of these $M_x(Ge_2Sb_2Te_5)_{100-x}$ films has been investigated by a temperature-regulable UVISEL™ typed

spectroscopic ellipsometry (TRSE). Experimental study on the ultrufast dynamic process of these phase change films has been made by a pump-probe time resolution response test system. In the meantime, the molecular dynamic processes of mirco-strucural transformation of these doped films have been simulated by ab initio calculation.

8. 可用于RRAM的Al/ZrO_2/Al结构薄膜的热稳定性研究。Thermal stability of resistive switching of stoichiometric zirconium oxide thin films for RRAM application

对纯化学配比ZrO2薄膜的电阻开关特性的热稳定性进行了实验研究，此薄膜的应用可提高非易失性存储器的产率。实验制备的Al/ZrO2/Al单元表现出极高的高低阻态转换特性。同时，对该存储单元在不同温度条件下（如：室温、100℃及150℃）的高低阻态的时间稳定性进行了测试，实验表明样品单元具有较高的稳定性。Al/ZrO2/Al单元的优异性能可以用在ZrO2界面处导电细丝的形成/断裂机制加以分析解释。

Thermal stability of resistive switching of stoichiometric zirconium oxide thin films is investigated for high yielding nonvolatile memory application. The Al/ZrO2/Al cell fabricated in the conventional device process shows highly reliable switching behaviour between two distinct stable resistance states. The retention capabilities are also tested under various conditions and temperatures. The excellent performance of Al/ZrO2/Al cell can be explained by assuming that anode/ZrO2 interface exists and by conducting filament forming/rupture mechanism. The device failure is illustrated in terms of permanent conducting filaments formation.

二、 研究项目与成果 Research Projects and Results

2008 年度，本组承担了国家自然科学基金项目 3 项、国家自然基金重大项目子课题 1 项、上海市科委重大项目子课题 1 项、教育部留学归国人员科研启动项目 1 项，以及教育部新世纪优秀人才计划 1 项。另外，本年度还获得一项上海市基础研究项目。完成国家自然基金 2 项。共发表 SCI 论文 10 篇及 EI 论文 2 篇，发表国际会议论文 2 篇以及国内会议论文 13 篇。授权国家发明专利 2 项。受理申请国家发明专利 5 项。

In 2008, our group has been carrying out 3 NSFC regular projects, 1 sub-project from a grand project of NSFC , 1 sub-project from a grand project of Shanghai committee of sciences and technology, 1 project for homecoming person after studying abroad from education ministry, and 1 new century excellent talent program of education ministry. In addition, a new regular project for the basic study has been approved by Shanghai committee of science and technology. Two NSFC projects have been accomplished. We have published 12 research papers in SCI or EI Journals, 2 papers in international conferences, and 13 papers in domestic conference. Two national invention patents have been authorized. Five national invention patents have been submitted for application.

纳米混合存储及其相关物理问题研究 / Nano hybrid magnetic recording and related physics

成员：金庆原 张宗芝 马斌 Group Members: Jin Qingyuan Zhang Zongzhi, Ma Bin

进入 21 世纪，信息产业已经成为支柱产业之一，信息量的爆炸式增长要求信息存储密度迅速提高。为了适应记录密度的不断提高，磁记录的方式也从过去的纵向磁记录转向垂直磁记录，垂直磁记录技术将并且正在成为新一代数据存储的方式。磁记录密度的进一步提高，导致每一个位的尺寸以及晶粒尺寸迅速收缩，在室温下出现超顺磁。为了克服超顺磁瓶颈，必须提高介质的垂直磁各向异性，这使得磁记录写入头遇到前所未有的困难，因为传统写入磁头不能提供足够大的磁场来克服介质非常高的矫顽力。为此，人们提出了激光辅助磁写入、磁读出型光-磁混合存储的技术。该技术是一种新型的存储方式，它集光存储和磁存储的诸多优点于一身，能大大提高写入密度和读出分辨率，从而使存储密度大大提高，理论上可实现 10 Tbit/in^2 的超高记录密度，这使得激光辅助混合磁存储将成为更新一代信息存储的手段之一。我们主要围绕激光辅助混合磁记录的材料制备、记录的动态过程和实现、读出头性能和物理机制等方面进行了研究。

Information industry is one of the most important pillar industries. With the explosive increase of the information, recording density is required to be increased rapidly. In order to increase the magnetic recording density, the traditional longitudinal recording has been replaced by perpendicular recording, and perpendicular recording will and is becoming a new method of data storage. However, both the recording bits and grains shrink greatly in size with further increasing recording density, resulting in the superparamagnetic effect. In order to overcome the superparamagnetic limit, high anisotropy media materials should be used. The problem of using highly anisotropy materials is that the strength of the field produced by the traditional write head is not high enough to overcome the very large coercivity. One possibility to overcome the writing problem is to employ heat assisted magnetic recording (HAMR) technique. This new kind of hybrid optical-magnetic storage technique, which combines the advantages of both optical storage and magnetic storage, can greatly enhance the recording density and is expected to reach the density up to 10 Tbit/in^2. Our work mainly focuses on the HAMR-related meida materials fabrication, dynamic recording process, read head materials performance and their physical mechanism.

1. 超高密度纳米混合磁存储材料与系统。ultrahigh density nano hybrid magnetic recording materials and systems

$L1_0$ 结构材料具有很大的磁晶各向异性，在超高密度磁记录介质和硬磁材料方面有很大的应用前景，在继续开展 FePt 有序合金薄膜的同时，我们开展了对低成本、高磁晶各向异性的 MnAl 薄膜的研究。通过对τ-MnAl 薄膜制备的研究，我们提出了采用多层膜和楔形膜结合的制备方法，获得了具有较好磁性能的薄膜。在此基础上，我们计划通过掺杂来进一步改善薄膜的磁晶各向异性，并研究反铁磁结构对薄膜磁性能的影响。

The $L1_0$ structural materials have great potential application in ultra-high magnetic recording media and hard magnetic films, because of their huge magneto-crystalline anisotropy. Besides the research on FePt ordered film, we have studied the preparation of τ-MnAl film. After studying the references, we put forward the method combining multilayer and wedge deposition. Good magnetic properties are obtained. Then, we are going to improve the magnetic properties by third element doping, and study the influence of anti-ferromagnetic structure on the its magnetic

properties.

利用传统的 Guzik Spinstand 磁盘测试仪（型号 1701A+），结合自行设计和搭建的精密光学系统，采用大光斑和异侧激光加热的方法，成功实现了激光辅助下的纵向磁头对垂直磁记录介质磁盘的动态写入与读出，为激光辅助磁记录的动态测试提供了一套经济和实用的测试平台。此系统可实现对 2.5 英寸记录盘片每分钟 5400 转高速转动情况下的动态性能实时分析，研究介质材料特性和热磁记录材料结构设计。激光波长 405 nm，聚焦光斑 2 μm 以内，功率超过 20 mW。在载噪比满足 40dB 前提下，对 CoCrPt 盘片获得了 64 Gb/in^2 的较高动态记录面密度。对不同矫顽力盘片的测试研究中发现，利用纵向磁头垂直磁场分量写入垂直记录介质时存在 echo field 的擦除效应，并且得到避免这样效应发生的有效办法。申请国家发明专利 2 项，国际会议大会邀请报告 1 次。

Using Guzik spinstand (type 1701A+) magnetic recording system and focused laser from another side, the laser (heat) assisted magnetic recording (HAMR) is demonstrated on the 2.5 inch CoCrPt one-side media. Considering the carrier noise ratio (CNR) beyond 40 dB, we achieved the recording areal density of 64 Gb/in^2. This demo system is useful for HAMR study, including calibration of media recording property, material and stucture design for HAMR media. Trailing field partial erasure is observed in lower coercivity media with ring head, which causes signal reduction with increasing write current or application of laser. Precautions should be taken against partial erasure in overall recording system optimization of HAMR in order to achieve ultra high recording density.

2． 纳米自旋体系超快动力学。ultrafast spin dynamics of nano systems

在激光辅助混合磁记录中，了解激光的热效应对垂直磁记录介质材料磁性能--磁化强度和矫顽力的影响及其动态变化特征，对于激光辅助下磁信息是否能够有效写入以及写入速度都起到关键的作用，有助于探获实现激光辅助混合磁记录的最佳激光功率和薄膜材料结构参数。

我们利用基于磁光克尔效应（MOKE）的时间分辨 Pump-Probe 测量技术，重点研究了激光功率和薄膜厚度对具有垂直各向异性的 FePt 薄膜的退磁程度、最大退磁时的剩余矫顽力及磁性恢复速度的影响。图 1 给出了不同延迟时间的瞬态 MOKE 回线。研究发现激光作用 FePt 后，磁化强度迅速降低，而矫顽力却变化很少。我们认为磁化强度的大幅度降低源于较高的电子温度导致的自旋翻转。晶格由于具有较大的热容其温度升高有限，垂直各向异性仍然很大，因此矫顽力比较大。同时晶粒间耦合的减弱也阻止了矫顽力的降低。在热辅助磁记录中，人们希望激光作用后矫顽力能大幅度减小以利于信息的写入，因此大的剩余矫顽力对于热辅助磁记录是不利的。进一步研究发现，通过提高激光功率和减小 FePt 薄膜厚度(如图 2 所示)，能够完全退磁，消除该剩余矫顽力，从而能够实现激光辅助写入信息的目的。实际应用中应该考虑高功率激光的热积累效应可能造成的局域薄膜性能损坏，以及高功率激光和薄膜厚度减小伴随的磁恢复速度变慢问题。得到的结果已经整理成文并投稿。

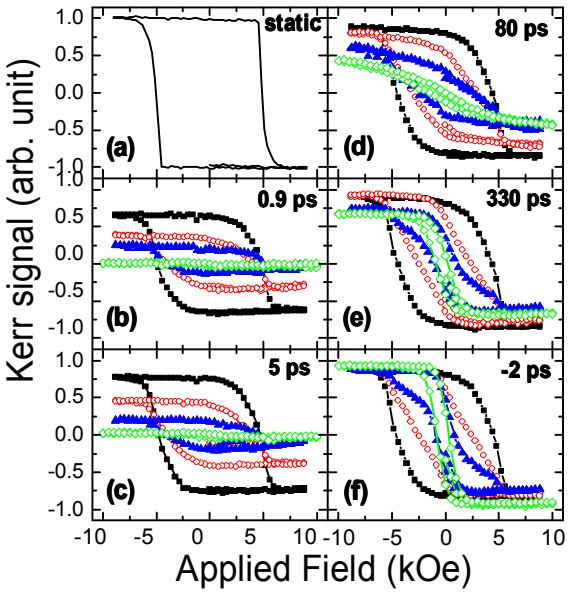


图 1 不同延迟时间的瞬态 MOKE 回线

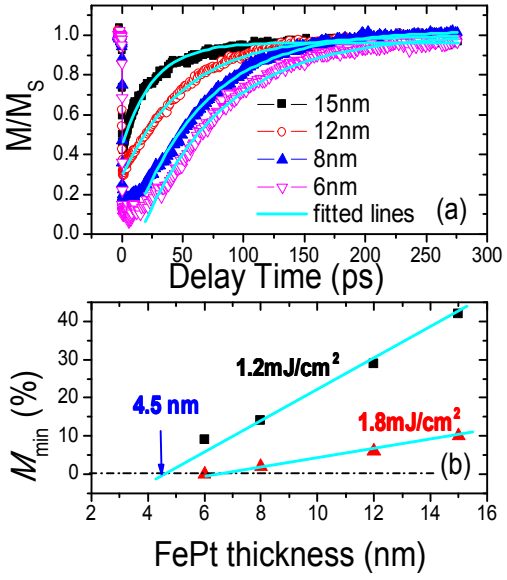


图 2 (a)不同膜厚的磁化强度动态变化，(b)0.9ps 时的磁化强度与厚度关系曲线

It is of cruicial importance to understand and detect the laser heating effect on the magnetic properties of magnetization and coercivity and their dynamic behaviors for the perpendicular media materials, which play a key role on the efficient and fast writing in heat-assisted magnetic recording (HAMR), and is helpful to acquire proper laser power and media structure parameters.

We have studied the spin dynamic demagnetization and relaxation process, particularly the effects of laser pump fluence and film thickness on the maximum demagnetization percentage, remaining coercivity, and magnetization recovery for perpendicular magnetic FePt films, by employing the time-resolved pump-probe technique. Fig. 1 shows the transient MOKE loops at various delay times. The magnetization after photoexcitation shows a dramatic reduction in picosecond time scale, in contrast, the coercivity drops only a little due to the combined effects of the limited reduction of magneto-crystalline anisotropy and the weakened exchange coupling between grains. The remaining coercivity vanishes when the film is fully demagnetized by increasing pump fluence and reducing film thickness. We claim that appropriate laser energy and film thickness are required to manipulate the remaining coercivity, as required for successful application of heat-assisted magnetic recording. Attention should be paid to the accumulated heating effect on the degradation of local film properties, and the slower recovery process observed in the thinner film or after high power laser pumping. The manuscript regarding these results has been submitted.

3． 自旋电子学材料和微磁学模拟。spintronics materials and micromagnetic simulation

在自旋电子学材料方面，研究了各层厚度（Co，Ni，Cu）和多层膜周期数对垂直各向异性和矫顽力的影响。通过优化结构，成功制备了垂直磁化的赝自旋阀和 MnIr 钉扎的自旋阀，并研究了其信号热稳定性。如图 1，2 所示，我们的研究结果表明赝自旋阀经过 200°C

热处理后，由于自由层和参考层的矫顽力差异降低，其 GMR 信号迅速从 7.7%降低到 1.0%。而与此对应的偏置自旋阀却拥有好的热稳定性，在热处理温度高达 300℃ 时，由于界面原子扩散混杂，才导致信号开始下降。相关结果已经整理成文并投稿。

The thermal stability and giant magnetoresistance (GMR) signal are assessed in pseudo and FeMn-biased spin valves with perpendicular magnetic $[Co/Ni]_N$ multilayer as free and reference layers. The observed GMR ratio for the pseudo sample is as high as 7.7%, whereas it rapidly decreases below 1.0% after perpendicular field anneal at 200°C. Such poor temperature stability is ascribed to simultaneous switching of the free and reference multilayers caused by loss of their coercivity difference. In contrast, FeMn-biased sample with similar structure although has slightly lower GMR signal of 6.5%, it exhibits much better thermal stability, showing the GMR reduction occurred at an elevated anneal temperature over 300 °C. This is due to the Mn diffusion and perpendicular anisotropy degradation at such high temperature. The manuscript regarding these results has been submitted.

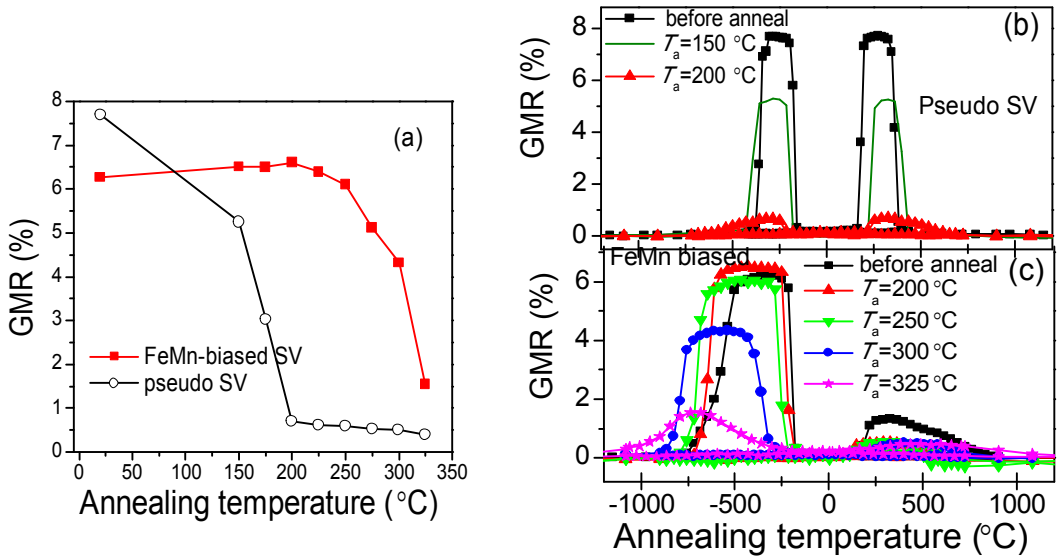


图 3 (a) 赝自旋阀和 FeMn 钉扎自旋阀的 GMR 信号与热处理温度关系，(b)和(c)分别是它们经过不同温度热处理后的 GMR 曲线

在自旋电子学的理论研究方面，我们首先用微磁模拟方法研究了垂直磁化自旋阀中的自旋转移矩效应，发现在垂直磁化的自由层中插入面内磁化软磁核能够大幅度的降低临界反转电流。在认为硬磁和软磁呈单畴结构的基础上，我们开发了一种解析模型来深入理解这种纳米软磁核的作用。结合解析和模拟计算结果，我们能够成功解释这种具有复合结构自由层的垂直磁化 GMR 器件中自旋力矩驱动磁化翻转的主要特征：垂直 GMR 结构中非对称的临界电流源于参考层的散磁场，以及与电流方向有关的自旋转移矩效率的本征差异。在自由层中加入软磁核后能够部分降低这种非对称性。这部分工作已发表于 Applied Physics Letters 和 New Journal of Physics。

A considerable reduction of switching current is observed by micromagnetic simulation in a perpendicularly magnetized GMR nanopillar with a soft nanocore inside the free layer. In this paper, an analytical model based on the single domain assumption both for the hard and soft regions is developed to deeply understand the nanocore effect. Combined the analytical solutions with the micromagnetic simulation results, we could well interpret the essential features of the

spin torque driven magnetization switching in such GMR pillars with perpendicular anisotropy. The asymmetric critical switching current is attributed to the stray field caused by the fixed layer together with the intrinsic difference of the spin torque efficiency associated with the current direction. However, such an asymmetric switching could be partially compensated by an asymmetric reduction in the critical current after a soft core inserted in the free layer. The work has been published in Appl. Phys. Lett and New Journal of Physics.

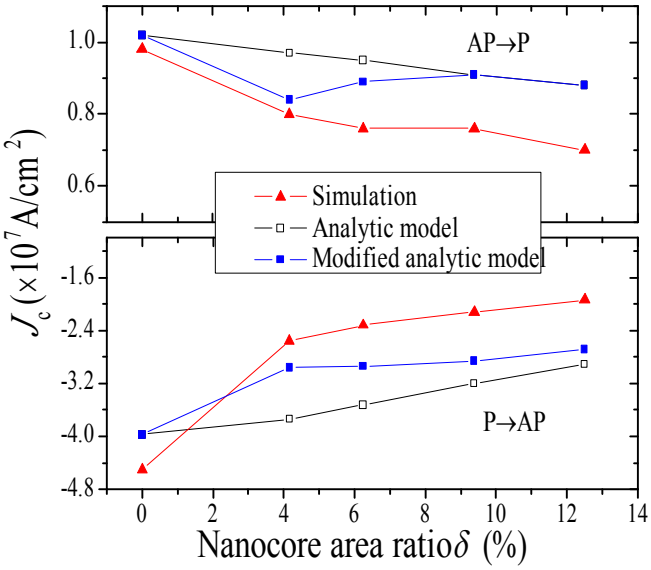


图 4. 采用模拟和分析获得的临界电流密度与自由层中软磁核尺寸的关系。

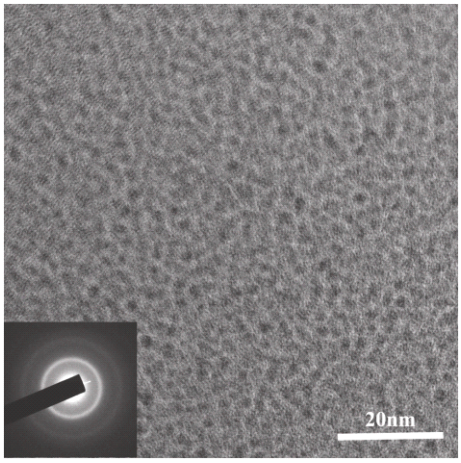
本年度共发表 SCI 论文 9 篇，申请中国发明专利 4 项，大会报告 1 次。

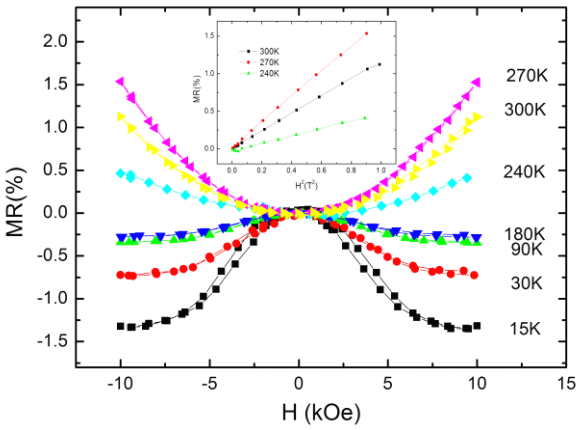
有机半导体的自旋电子学研究 / Spintronics in organic semiconductors

成员：倪刚 Group Member: Ni Gang

◆ 磁性有机半导体复合薄膜的输运性质/Transport properties of magnetic organic semiconductor hybrid films

我们采用真空共蒸镀膜的方法，制备了一系列 Co/Alq_3、Co/TPD 等磁性有机半导体颗粒膜，在其中观察到负的隧穿磁电阻效应，并研究了微结构、组分与输运性质的关系；我们还对自然氧化的 Si 衬底上的 Co/Alq_3 颗粒膜的输运性质进行了研究，在其中观察到正负磁电阻的转换和金属绝缘体转变，认为这和衬底与薄膜界面形成的 MOS 反型层相关；我们还在 Co/Alq_3 等颗粒膜中观察到较大的霍尔效应和磁光效应，并对机制进行了初步研究。





A series of Co-Alq_3, Co-TPD granular film samples were prepared using co-evaporating technique. The microstructures, magnetic and magneto-transport properties in these samples were investigated systemically. A crossover of magnetoresistance (MR) from positive to negative was observed in Co-Alq_3 granular film samples on silicon substrate with native oxide layer. The positive MR ratio reaches 17.5% at room temperature (H=50kOe, x=0.44), and the negative MR ratio reaches -1.35% at 15K (H=10kOe, x=0.44). Furthermore, a metal-insulator transition was also observed. The transition of resistance and MR results from the channel switching of electron transport between upper Co-Alq_3 granular film and inversion layer underneath. The possible mechanism of transport behavior was investigated. Hall effect and magneto-optical Kerr effect of magnetic metal-organic semiconductor granular films were also been investigated.

液晶光电子器件 / Liquid crystal electro-optical devices

成员：刘建华 戴海涛 徐克璹 Group Members: Liu Jianhua, Dai Haitao, Xu Keshu

1. 脉冲间歇式曝光及其对光致聚合的影响

对 TMPTA 体系, 研究了不同的间歇式曝光法对脉冲激光引起的光致聚合反应, 对比了两种曝光方法, 一是脉冲连续式曝光(CPC) 和 脉冲分组激发(GPI), 两种方法所用的激光脉冲总数保持相同. 与第一种聚合方法不同, 在后一种方法中, 观察到样品中聚合区域出现显著的光衍射现象. 通过 Fresnel 衍射的理论分析表明, 这一衍射是由于 GPI 聚合的样品中出现了一个聚合物的核, 其折射率变化相对于已聚合的区域增加了 90%. 实验结果与理论预期符合得很好.

Different intermittent curing methods were conducted for pulsed laser induced photopolymerization reactions in TMPTA acrylic system. Two methods of curing were compared, named grouped pulses impingement (GPI) and consecutively pulsed curing (CPC), respectively, in which the total number of the curing pulses were kept same. In GPI, a prominent light diffraction effect was observed in the post curing process, whereas absent in the CPC procedure. A condensed but limited sized core of polymeric structure was ascribed to the cause of the light diffraction. The amount of inhomogeneity in refractive index for the core was about 90% of the cured background. Simulations based on Fresnel diffraction theory were performed, and the result was in good agreement with the experimental observations.

2. 高质量宽频检测的实用改进型电化学衰减全反射表面增强红外光谱

衰减全反射表面增强红外光谱(ATR-SEIRAS)是研究电极界面结构和反应机理的重要方法。为确保工作电极的电化学稳定性和代表性，传统 SEIRAS 技术多使用硅柱作为红外窗口并在其反射面上沉积金属薄膜电极。不幸的是，由于硅柱在 1000 cm^{-1} 以下有较强的吸收，无法给出相应的红外信号，使该方法的应用能力受到制约。为克服此弱点，本文根据“衰势波穿透深度原理”和“平面波棱柱-膜耦合理论”，在硒化锌柱和硅片之间引入超薄水层，大大提高了多种入射角度下红外光在两不同折射率固相的穿透量，实现高质量宽频采谱目标。利用此实用新型 ATR-SEIRAS 系统，可同时获得电极表面吸附物种在 700-850 cm^{-1} 的面外振动和 1000-1700 cm^{-1} 面内振动模式谱峰，从而可靠地鉴定出甲醇在铂电极上的电氧化活性中间体甲酸根；同时也据此，详细解析了芳香分子 PNBA 在电极表面上的吸附构型。

A practically modified ATR configuration has been proposed for in situ electrochemical surface-enhanced IR absorption spectroscopy (SEIRAS) by sandwiching an ultrathin water interlayer between a hemicylindrical ZnSe prism and a Si wafer as an integrated window. This new ATR optics significantly enhances the throughput of an effective IR beam across the ZnSe/gap/Si/metal film, enabling high-quality spectral fingerprints down to 700 cm-1 to be readily detected at larger incidence angles without compromising the electrochemical feasibility and stability of metallic films deposited on Si. The advantages of this modified ATR-SEIRAS have been initially applied to explore two selected systems: wide-ranged in situ ATRSEIRA spectra provided strong evidence in support of the formate intermediate pathway for methanol electrooxidation at the Pt electrode in an acid solution; in addition, new spectral fingerprints revealed comprehensive orientational information about of the p-nitrobenzoate species at Pt

electrode as a result of the dissociative adsorption of p-nitrobenzoic acid molecules from an acid solution.

3. 焦距可精细调节的可编程分形波带片

分形波带片(FraZPs)是一种新型的聚焦器件,可以用于软 x 射线聚焦和成像等领域. 它基于分形和波带片的概念,能够在光轴上产生具有自相似特性的光强分布. 缺项概念的引入使得分形波带片的设计自由度大大的增加, 同时通过理论的计算还发现通过改变分形的缺项能够实现比常规波带片更为精细的焦距调节. 利用可编程的空间光调制器进行的实验则进一步验证了理论计算的结果. 实验证明在可控制的最小精度内, 通过调节分形波带片缺项的方法可以实现最小 1 cm 的焦距调节量, 相比常规的波带片最小 5.28 cm 的焦距调节量. 同时还在实验和理论上研究了焦距调节精度同分形标度因子γ的关系.

A novel device Fractal Zone Plates used in the field of soft x-ray focusing and imaging was introduced. It is based on the concept of the fractal and the zone plates, with the ability to generate a self-similar intensity distribution on axis. The freedom of designing FraZPs was improved largely by the concept of the lacunarity of the fractal, meanwhile the theoretic deducing also showed that the focal length of the FraZPs would experience a more finely shift by modifying the lacunarity than common Zone Plates. The experiment using programmable spatial light modulator (SLM) also verified this result furthermore. Comparing with minimum focal length displacement 5.28 cm of the common Zone Plates, it could be decreased to 1 cm by adjusting the lacunarity of the FraZPs. Both were in the condition of minimum precision on control. At the same time, the relation between the scale of the fractal and the precision of focal length was studied by theory and experiment.

4. 基于 LCoS 的高效率可调节的分形光锥

基于康托函数和相位调制的概念, 利用 LCoS 实现了改进的可调分形光锥. 高阶的光锥理论上可以实现 100%的衍射效率. 同时轴上光强分布保持了分形的结构. 理论和实验上对这种新型的分形原件进行了研究. 当分形阶次从 1 变到 3 的时候 光锥的焦距从 0.8m 增加到了 1m, 这表明了分形光锥具有很好可调节特性.

Based on the Cantor function and phase modulation, a tunable fractal axicon is formed on a liquid crystal on silicon (LCoS) with an improved generating method. It has higher focusing efficiency in higher fractal stage and approaches to 100% theoretically. The on-axis intensity keeps its fractal structure unchanged in operation of fractal stages. The tunability of the axicon is demonstrated by tune fractal stage from 1 to 3 and focal length from 0.8m to 1 m. We also provide details of theoretical analyses and experimental results.

专利/Patents

申请专利/Patents Applied

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[2] Lei Xu；Single-frequency laser from coupled asymmetric micricavities； The 6th Asia Pacific Laser Symposium (APLS 2008), Nagoya, Japan, Jan. 30-Feb. 1, 2008 (invited talk)

[3] QY Jin； Demonstration of laser-assisted hybrid magnetic recording on perpendicular media using a longitudinal magnetic head; 8th International Symposium on Optical Storage /2008 International Workshop on Information Data Storage (ISOS/IWIDS 2008) , Wuhan, China, November 24-27, 2008 (invited plenary talk)

[4] Pei Yang, Liying Liu, Lei Xu； Re-orientation of dye-doped liquid crystals by laser light: dynamic mechanism；IPS International Collaboration Symposium, Tokyo, Japan, Mar. 14-15, 2008 (oral)

[5] Lei Xu; Single frequency laser from coupled asymmetric micro-cavities; The 6th International Symposium on Advanced Photonic Science and Technology (6th ISAPST), Seoul and Kyeongnam, Korea, Aug. 26-29, 2008 (oral)

[6] Zian He, Yigang Li, Yingfeng Li, Yanwu Zhang, Liying Liu, Lei Xu; Low-loss channel waveguides and Y-splitter formed by ion-exchange in silica-on-silicon; The 6th International Symposium on Advanced Photonic Science and Technology (6th ISAPST), Seoul and Kyeongnam, Korea, Aug. 26-29, 2008 (oral)

[7] Wei Wei，Feng Liu，QingQuan Chen; Starburst Organic Semiconductors as Efficient Light Emitting Materials; The 6th International Symposium on Advanced Photonic Science and Technology (6th ISAPST), Seoul and Kyeongnam, Korea, Aug. 26-29, 2008 (oral)

[8] JB Chen, YR Chen, Y Shen, JC Ren LY Chen; Comparison study of the photonics crystal band structure by different numerical approaches; The 6th International Symposium on Advanced Photonic Science and Technology (6th ISAPST), Seoul and Kyeongnam, Korea, Aug. 26-29, 2008 (oral)

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[10] F Pei, S Wu, G Wang, M Xu, SY Wang, Y Jia, LY Chen; Electronic and optical properties of

Cu2O, Ag2O and Au2O from first-principles calculations; The 6nd International Symposium on Advanced Photonic Science and Technology, Seoul, Korea 2008 (poster)

[11] Wei Wei, Hongyu Wang; Photophysical Properties of a Donor-acceptor System Based on Perylene Bisimide and Oligo(p- phenylene ethynylene) Units; Sino-Singapore Symposium on Advanced Materials-2008 (S3AM 2008), September 24~27,2008, Nanjing, China (oral)

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学位论文/Dissertations

1. 博士学位论文

[1] 仇晓明，**新型稀土激光材料的研究**；导师：彭波

[2] 汤多峰，**基于芴基超支化聚合物的设计、制备与性能**；导师：韦玮

[3] 陈清泉，**基于核-臂结构的星状共轭大分子/超支化共轭聚合物的设计、 合成与性能研究**；导师：韦玮

[4] 谢逸群，**利用探针在金属表面进行单原子操纵的理论研究**；导师：干福熹，庄军

[5] 邬云骅，**可见电磁波在金属/空气界面传输特性实验研究**；导师：陈良尧

[6] 任　杨，**磁性薄膜的光诱导超快自旋动力学研究**；导师：金庆原

[7] 何子安，**玻璃基质光波导及其掺铒波导光放大器的离子交换法制备**；导师：刘丽英

[8] 张艳武，**有机/无机复合材料光子性质及其可调控光波导器件**；导师：徐雷

[9] 张　豫，**水相 CdTe 量子点在细胞中的光致发光行为研究**；导师：王培南

[10] 陈岳瑞，**二维多重折叠光谱的高分辨快速获取和高 K 材料缺陷能级的椭偏光谱研究**；导师：陈良尧

2. 硕士学位论文

[1] 覃春杨，**功能性超支化共轭聚合物的合成、表征及光物理性能研究**；导师：韦玮

[2] 刘　峰，**芘功能化光电材料的设计、合成与应用**；导师：韦玮

[3] 鲁家豹，**掺钕有机激光材料的制备与性能研究**；导师：韦玮

[4] 李政皓，**钛酸锶的光致发光和光催化研究及硅纳米柱制备探索**；导师：陆明

[5] 殷建芳，**磁性有机复合颗粒膜的霍尔效应的磁光效应的研究**；导师：倪刚

[6] 盛　鹏，**磁性复合有机纳米颗粒膜中的磁电阻效应**；导师：倪刚

[7] 杨雨婷，**KDP 晶体元件憎水减反化学薄膜的制备和研究**；导师：彭波

[8] 潘苏醒，**集成二维多光栅红外光谱成像系统的研制**；导师：陈良尧

[9] 卢意飞，**GaN 及 GaN 基薄膜的制备、表征和特性研究**；导师：吴嘉达

[10] 徐　明，**若干种新型材料的结构和性质的理论研究**；导师：王松有

[11] 陈　曦，**芴类共轭材料的设计、合成及其性能研究**；导师：韦玮

[12] 赵　慧，**磁性自旋阀和隧道结的制备及相关性能研究**；导师：张宗芝

[13] 孙学诚，**丙稀酸酯光致聚合特性实时测量研究**；导师：刘建华

[14] 邵　劼，**基于 ECR 等离子体辅助脉冲激光沉积的氧化锌薄膜制备与氮掺杂**；导师：吴嘉达

[15] 俞　丹，**Al_2O_3 薄膜的低温沉积和 Al_2O_3-Si 界面特性研究、硫系玻璃薄膜的制备和表征**；导师：吴嘉达

[16] 林建明，**新型含电子给-受体交叉共轭聚合物与铱配合物封端聚芴的研究**；导师：韦玮

[17] 何世海，**Fe(002)织构的形成肌理及其在磁记录中的应用**；导师：马斌

[18] 吴云飞，**宽光谱监控薄膜生长系统的研制**；导师：陈良尧

[19] 魏　崃，**细菌视紫红质蛋白聚合物复合膜的光学性质以及在光子学器件方面的应用研究**；导师：赵有源，陆明

主办国际会议/ Sponsored International Conferences

第六届中韩双边光子学科技研讨会；2008-8-26；Seoul and Kyeongnam, Korea

第六届国际先进光子科学与技术学术会议于2008年8月26日至29日在韩国首尔召开。来自韩国的20余位科学家和中国的11位教授学者进行了学术交流。中方的参加单位包括复旦大学、上海交通大学、中科院上海光机所和中科院技物所。本系是该会议的中方承担单位，共有5位教授与会报告了取得的科研成果。

学术组织与期刊任职/Academic Service

国际学术组织任职/Service to the International Professional Societies

干福熹　　国际光学工程学会资深会员 1998-
Gan Fuxi　　Fellow，International Society for Optical Engineering (SPIE)
美国光学学会资深会员 1990-
Fellow，Optical Society of America (OSA)

金庆原　　IEEE 国际磁学学会技术委员会委员；2005-2006
JinQingyuan　Member , IEEE Magnetics Society Technical Committee

国际期刊任职/Service to the International Journals

干福熹　　Gan Fuxi
国际《非晶态固体》杂志编辑委员会委员 1982-
Member of Editorial committee international journals USA《Noncrystalline Solids》

国际《光学材料》杂志编辑委员会委员 1992-
Member of Editorial committee international journals USA《Optical Materials》

国际《玻璃物理与化学》杂志编辑委员会委员 1996-
Member of Editorial committee international journals U.K《Glass physics and chemistry》

《马来西亚科学》杂志编辑委员会委员 1994-
Member of Editorial advisory committee international journals《Malaysia Science》

《马来西亚固体科学和技术》杂志编辑委员会委员 1994-
Member of Editorial committee international journals《Malaysia Solids Science and Technology》

国内学术组织任职/ Service to the Domestic Professional Societies

干福熹	中国硅酸盐学会名誉理事长	2004-
金庆原	中国光学学会基础光学专业委员会副主任	2005-
徐　雷	上海激光学会副理事长	2005-
钱列加	中国宇航学会光电专委会常务理事	2005-
王培南	上海激光学会理事	2005-
陈良尧	中国光学学会理事	2006-
	中国宇航学会光电专委会常务委员	2007-

国内期刊任职/Service to the Domestic Journals

干福熹	《辞海》编委会, 副主任	2004-
	《无机材料学报》顾问	1985-
	《自然科学进展》顾问	1992-
	《材料研究学报》顾问	1998-
	《光学学报》顾问	1998-
	《功能材料》杂志编辑顾问委员会委员	1990-
	《硅酸盐通报》杂志编辑顾问委员会委员	1995-
	《河南大学学报》杂志编辑顾问委员会委员	2000-
	《中国光电医学》杂志编辑顾问委员会委员	1992-
	《世界科技研究与发展》；杂志编辑顾问委员会委员	1995-

客座研究课题及来访人员/ Open Subjects & Guest scientists

重点实验室高访学者研究课题/Open Subjects

序号	课题名称	负责人	职称	工作单位	起止时间
1	主动光学用新型硫系玻璃及性能表征	陈国荣	教授	华东理工大学	2006.7 -2008.7
2	纳米材料激光处理和表征	陆永峰	教授	Univ. of Nebraska -Lincoln,USA	2006.7 -2008.7
3	磁记录介质研究的关键技术和实验方法	陆斌	技术主管经理	Seagate Technology，USA	2006.12 -2008.12
4	Ultrafast and nonlinear optics	许春晖（Chris Xu）	副教授	Cornell Univ.,USA	2006.12-2008.12
5	新型液晶显示模式设计研究	吴诗聪(Shin-Tson Wu)	教授	美国中佛罗里达大学（UCF）	2007.7 -2009.7
6	磁记录介质研究的关键技术和实验方法	刘小晰	副教授	日本国信州大学工学部信息工学科	2007.7 -2009.7
7	半导体量子点/嵌段聚合物复合膜的光谱性质	陈鑫	副研究员	中科院上海技术物理所	2007.7 -2009.7
8	电流诱导磁化翻转效应的物理原理及微纳米器件制备的关键技术	Paulo Freitas	教授	Physics Dept. of instituto superior tecnico and INESC MN, Lisboa, Portugal	2007.7 -2009.7
9	基于紧束缚近似的理论研究方法	王才壮	研究员	Ames Laboratory-USDOE	2007.7 -2009.7
10	超高密度光磁混合数字信息存储	王建平	副教授	Electrical and Computer Engineering Dept.Univ.of Minnesota, USA	2007.7 -2009.7
11	异型微腔传感及单频微腔激光	范旭东	副教授	University of Missouri - Colombia	2007.12 -2009.12

12	纳米液晶的非线性光学效应及光角动量和自旋交换	Lorenzo Marrucci	副教授	意大利那波里大学	2007.12 -2009.12
13	单分子技术在生物研究中的研究中的应用	杨炜东	副教授	Bowling Green State University，USA	2007.12 -2009.12
14	热辅助磁记录的动态测试	车晓东	实验室主任 Director	Hitachi Global Storage Technologies，USA	2008.5 -2010.5
15	新光学活性玻璃和透明玻璃-陶瓷材料的制备和性能研究	陈丹平	研究员	中国科学院上海光学精密机械研究所	2008.5 -2010.5

来室访问及作报告的学者/ Guest scientists & some visitors

序号	学者姓名及身份	国别	讲学（访问）内容	时 间
1	杨之中，刘致为，冯哲川等教授, 国立台湾大学光电所	台湾	来室参观和交流访问	2008.3.13
2	Prof. Shin-Tson Wu, 美国中佛罗里达大学	美国	Tunable liquid crystal photonic devices	2008.3.14
3	Prof. A. Douglas Stone， Yale University USA	USA	Ab initio theory of novel micro and nanolasers	2008.3.18
4	刘小晰，副教授,日本国信州大学	日本	1.磁性薄膜以及磁性纳米体中的磁畴及磁化分布的观测方法及应用。 2.振动样品磁强计的原理及测量。 3.Nd-Fe-B 及TbFeCo薄膜的制备及应用。 4. FeCo软磁薄膜的制备特性及应用。	2008.3.20 -4.1
5	H.Wang, Dept. of electrical engineering, Univ. Nebraska-Lincoln	USA	Fabrication characterization and simulation of large-scale 3-D photonic crystals using laser-assisted fabrication techniques	2008.4.22
6	杨炜东, 副教授, Bowling Green State Univ.	USA	1. Single molecule study of molecular mechanisms in cells. 2. Single molecule fluorescence approaches to biology.	2008.6.2-6.13

7	范旭东, 副教授,Univ. of Missouri-colombia	USA	1. Optical microring resonators: properties and applications. 2. An introduction of optical biosensors.	2008.6.11
8	Prof. Paulo Freitas , INESC-mn	葡萄牙	1. Spintronic biochips for biomolecular recognition. 2. Magnetoresistive sensors: aiming for fT sensitivity at low frequencies.	2008.6.24 -6.30
9	Prof.Yuen-Ron Shen, 加州大学伯克利分校	USA	来室指导	2008.9.12
10	Prof.Yuen-Ron Shen, 加州大学伯克利分校	USA	Optical characterization of carbon nanotubes	2008.9.16
11	Prof.岩崎俊一东北大学(日本瑞宝重光奖状获得者)	日本	Around the invention of perpendicular magnetic recording	2008.9.27
12	Prof.Hiroaki Muraoka, Tohoku Univ.	日本	perpendicular magnetic recording & high density data storage technology for next generation	2008.9.27
13	Bruce Terris, Hitachi Global Storage Techno，San Jose	美国	Patterned nanomagnetic bits and devices	2008.10.6
14	Zhan Chen, Univ. of Michigan, USA	USA	Molecular level understanding of polymer and biological molecules at interfaces using nonlinear optical spectroscopy	2008.11. 12
15	Prof.Yuen-Ron Shen, 加州大学伯克利分校	USA	Probing water interfaces with surface nonlinear optical spectroscopy	2008.12. 10
16	Dr. Fan, Assistant Prof., Biological Engineering Department at the U. of Missouri at Columbia	USA	Optofluidic ring resonator dye lasers	2008.12. 25