目录(Contents)

复旦大学光科学与工程系
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光科学与工程系简介/ Department of Optical Science and Engineering

复旦大学是我国最早开展光学与激光科学技术的高校之一。本学科点的前身是 1952 年由我国著名光学专家周同庆教授创办的固体发光与光谱实验室，在此基础上， 1953 年正式成立了光学教研组。1953 年成功研制了第一只国产 X 光管，1963 年研制成功国内高校第一台氦氖激光器。1970 年成立光学系和光学工厂，此后更名为激光物理研究室。1984 年设立“光学”博士点，1988 年起被列为国家重点学科。1990 年，国家教委和国家科委联合授予激光物理研究室“全国高校科技工作先进集体”称号。1992 年，光学博士点接受国家教委评估，位列全国高校第一名。所属一级学科“物理学”于 1998 年开始设置博士后流动站和长江特聘教授岗位， 是“211”工程重点建设学科。2000 年激光物理研究室并入信息科学与工程学院，成立光科学与工程系。2003 年设立光学工程硕士点，2010 年设立光学工程博士点。研究基地还有教育部“微纳光子学结构重点实验室”以及“上海先进光学超精密制造工程技术研究中心”。复旦大学光学与光学工程学科的发展紧跟国际科学前沿并积极面向国家产业和国防发展的需求。

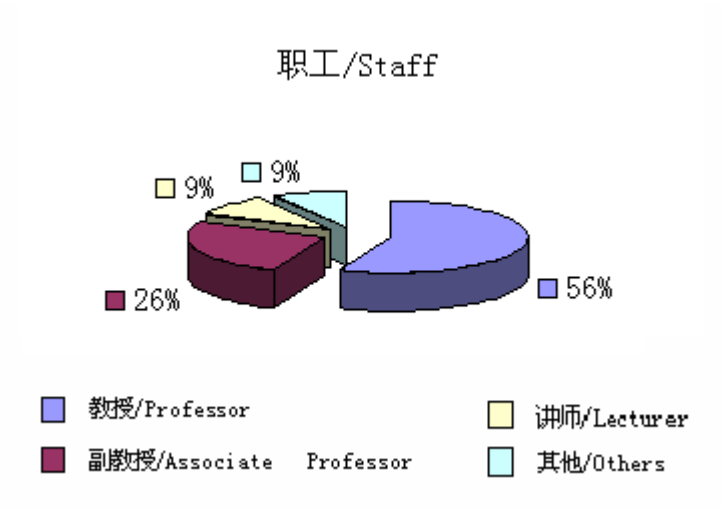
目前光学与光学工程学科的研究方向聚焦在四个方面，即超精密光学工程、光信息科学与技术、新型光能源材料与应用和光生物医学。承担了一大批国家和上海市的重大、重点以及面上项目，2010 年项目经费 550 万元。光科学与工程系现有教授 19 名，副教授 8 名。教授中包括 2 名院士、1 名长江特聘教授及国家杰出青年基金获得者、3 名国家杰出青年基金获得者、4 名跨世纪和新世纪人才基金获得者。光科学与工程系将继承老一辈的奋发图强精神，发扬光大复旦光学，建设国际一流学科。

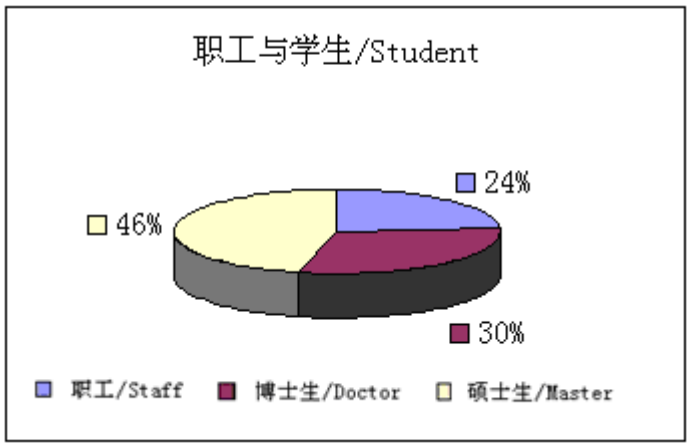
Fudan University was one of the pioneers in China to conduct research on optics and laser technologies. This discipline was founded in 1952 by Prof. Tong-Qing Zhou. In 1953, the first Chinese made X-ray tube was born here. Also the first He-Ne laser among universities of China was made in 1963. In 1970, Department of Optics and Optical Factory were established at Fudan. And in 1984 Optics Doctoral Program was started at Fudan, which was listed as the State Key Discipline in 1988 by MOE (Ministry of Education). In 1990, the team of the discipline was granted the honor of “Model Team of Science and Technology of National Universities” by MOE and Ministry of Science and Technology. In 1992, this discipline ranked the top one among the Optical disciplines in Chinese universities, as evaluated by MOE. In 2000, Department of Optical

Science and Engineering was founded and became a part of School of Information Science and Technology. The Optical engineering Master Program was started in 2003, and the doctoral one was issued in 2010. Affiliated to this discipline, there are Key Laboratory for Micro- and Nano-Photonic Structures (MOE) and Shanghai Advanced Research Center for Ultrafine Optical Processing and Fabrication. The development of this discipline has traced the international frontiers of science and aimed at the demand of industry and national defense of this country.

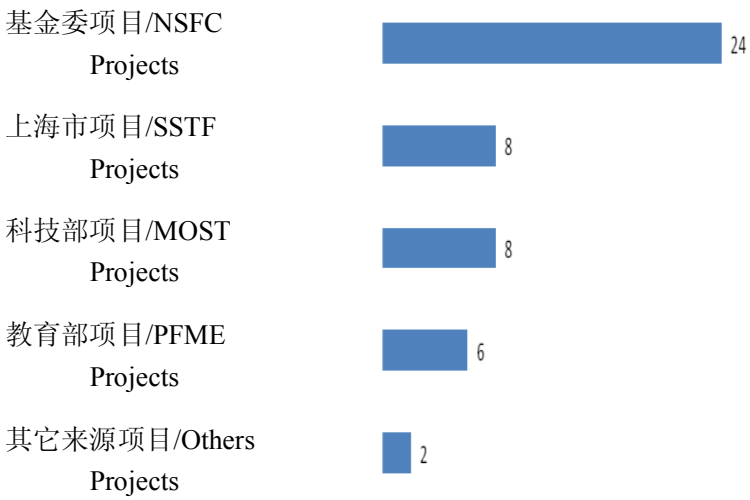
At present, the research of the discipline of Optics and Optical Engineering has been focused on four subjects, namely, Ultrafine Optical Engineering, Optical Information Science and Technology, New Optical Energy Materials and Optical Biology and Medicine, regarding which works supported by a vast number of programs both from the National and Shanghai Municipal Governments are underway. In 2010, the total budget received was 5.5 million RMB. There are 19 full professors, and 8 associate professors in this department, including 2 academicians, 1 Chang-Jiang distinguished professor, 3 Outstanding young professors, and 4 New Central distinguished professors. Inspired by the patriotic and hard-working spirits of the old generations, we will do our best to bring a more brilliant and fruitful future to the Optics and Optical Engineering at Fudan University.

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

陆　明　教　授　Lu Ming, Professor

光科系副主任/ Deputy Directors

赵海斌　教　授，Zhao Haibin, Professor

朱鹤元　教　授，Zhu Heyuan, 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

2009 张文献 Zhang Wenxian

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
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	张　浩	Zhang Hao
马　斌	Ma Bin	张荣君	Zhang Rongjun
糜　岚	Mi Lan	张文献	Zhang Wenxian
倪　刚	Ni Gang	张宗芝	Zhang Zongzhi
钱列加	Qian Liejia	赵海斌	Zhao Haibin
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
徐新民	Xu Xinmin	姚明远	Yao Mingyuan

博士生/ Ph.D Students

廖嘉霖	Liao Jialin	张启明	Zhang Qiming
张艳武	Zhang Yanwu	胡婧婷	Hu Jingting
周薇溪	Zhou Weixi	李　皓	Li Hao
周　靖	Zhou Jing	赵　源	Zhao Yuan
张　尉	Zhang Wei	李颖峰	Li Yingfeng
毛鹏辉	Mao Penghui	魏慎金	Wei Shenjin

邱静燕	Qiu Jingyan	涂　鑫	Tu Xin
张　弛	Zhang Chi	单　炯	Shan Jiong
刘明辉	Liu Minghui	蔡清元	Cai Qingyuan
钟亥哲	Zhong Haizhe	赵　坤	Zhao Kun
李　征	Li Zheng	周恩宇	Zhou Enyu
李　明	Li Ming	干　洁	Gan Jie
宁博元	Ning Boyuan	吴　松	Wu Song
张兴旺	Zhang Xingwang	马金贵	Ma Jingui
王永志	Wang Yongzhi	朱　江	Zhu Jiang
沈　彦	Shen Yan	朱焕锋	Zhu Huanfeng
李兴隆	Li Xinglong	陈　浩	Chen Hao
杨　琴	Yang Qin	岳国清	Yue Guoqing
邱　迎	Qiu Ying	董果凤	Dong Guofeng
刘　玄	Liu Xuan	李艳丽	Li Yanli
施　巍	Shi Wei	胡二涛	Hu Ertao

硕士生/ Master Students

张　淼	Zhang Miao	周信传	Zhou Xinchuan
马鎏学	Ma Liuxue	陈舒拉	Chen Shula
熊蓉玲	Xiong Rongling	陈永彬	Chen Yongbin
耿昭华	Geng Zhaohua	高　昆	Gao Kun
徐吉鹏	Xu Jipeng	贺　赫	He He
陆卫杰	Lu Weijie	任　勇	Ren Yong
徐　岫	Xu Xiu	陈珊珊	Chen Shanshan
陈剑波	Chen Jianbo	王绍军	Wang Shaojun
李　倩	Li Qian	曹兴鑫	Cao Xingxin
崔伯寅	Cui Boyin	陈　立	Chen Li
陈　坤	Chen Kun	付小牛	Fu Xiaoniu
崔　勇	Cui Yong	梁　旭	Liang Xu
李　丁	Li Ding	骆志远	Luo Zhiyuan

刘文明	Liu Wenming	许宏淮	Xu Honghuai
徐　达	Xu Da	朱艳燕	Zhu Yanyan
张冬旭	Zhang Dongxu	曲韶华	Qu Shaohua
丁大宇	Ding Dayu	许　妮	Xu Ni
沙剑剑	Sha Jianjian	徐子杰	Xu Zijie
陈文婷	Chen Wenting	程丹辰	Cheng Danchen
冀　巍	Ji Wei	林　崴	Lin Wei
袁昊辰	Yuan Haochen	任力强	Ren Liqiang
张金虎	Zhang Jinhu	王光中	Wang Guanzhong
张　颖	Zhang Ying	武　娜	Wu Na
朱炜炜	Zhu Weiwei	杨　苏	Yang Su
程文凯	Cheng Wenkai	俞　翔	Yu Xiang
郭红华	Guo Honghua	俞振涛	Yu Zhentao
吴康宁	Wu Kangning	周小勇	Zhou Xiaoyong

光学工程/Optical Engineering

王治国	Wang Zhiguo	赖菊水	Lai Jushui
高　斌	Gao Bin	伍经纬	Wu Jingwei
孙　涛	Sun Tao	龙　虎	Long Hu
顾劭忆	Gu Shaoyi	吴　佳	Wu Jia
刘　珏	Liu Jue	仇荣生	Qiu Rongsheng

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	磁性多层结构中磁各向异性的量子调控方法和机理-3 2009CB929201-3	金庆原	2009.7-2012.12
2	973子项目	磁性多层结构中磁各向异性的量子调控方法和机理-2 2009CB929201-2	李 晶	2009.7-2012.12
3	973课题	多带隙和纳米结构材料在太阳光全光谱光电转换中的应用 2010CB933703	陆 明	2010.1-2011.12
4	973课题	新型微纳结构硅材料及其广谱高效太阳能电池研究 2010CB933801	庄 军 赵 利	2010.3-2012.3
5	863项目	高增益低噪声放大技术研究 2007AAXXX507	钱列加	2007.1-2010.12
6	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
7	国家自然科学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
8	国家自然科学基金重点项目	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
9	国家自然科学基金面上项目	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
10	国家自然科学基金面上项目	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
11	国家自然科学基金面上项目	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
12	国家自然科学基金面上项目	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
13	国家自然科学基金面上项目	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
14	国家自然科学基金面上项目	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
15	国家自然科学基金面上项目	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

16	国家自然科学基金面上项目	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
17	国家自然科学基金面上项目	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
18	上海市优秀学科带头人	微控光子学材料与器件（A类） 08XD14006	徐　雷	2008.7-2010.7
19	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 2008CG03	糜　岚	2008.11-2010.12
20	上海市科委浦江计划	眼安全波长高功率光纤激光器及相关技术的研究 09PJ1402200	沈德元	2009.7-2011.7
21	上海市科委基金	回音壁模式耦合微腔激光器的光学性能及其在生物传感上应用研究09ZR1402800	吴　翔	2009.7-2012.7
22	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	2009.1-2010.12
23	国家自然科学基金重点项目	光在金属介质界面传播特性及其在信息和能源器件领域的应用研究 60938004	陈良尧	2010.1-2013.12
24	国家自然科学基金青年项目	铁磁性薄膜的超快自旋磁矩进动研究 60908005	赵海斌	2010.1-2012.12
25	国家自然科学基金青年项目	回音壁模式耦合微腔激光器光学性能及其用于生物传感的基础研究 60907011	吴　翔	2010.1-2012.12
26	国家自然科学基金青年项目	量子调控旋量波色超冷原子气体中的自旋交换和偶极相互作用 10904017	张文献	2010.1-2012.12
27	国家自然科学基金面上项目	高功率铒、镱共掺光纤激光器中寄生振荡产生机理及抑制方法的研究60978033	沈德元	2010.1-2012.12
28	国家自然科学基金面上项目	新型亚微米高度大纵横比玻璃光波导的光传输特性与制备技术研究 60977047	刘丽英	2010.1-2012.12
29	国家自然科学基金面上项目	金属氧化物的新型带隙调制及广谱光分解效应研究 10974034	陆　明	2010.1-2012.12
30	国家自然科学基金面上项目	液态和非晶态铝-半导体合金微观结构的多层次、多尺度分子动力学研究 10974029	王松有	2010.1-2012.12
31	上海市教委创新项目	原子纵向操纵的新方法及其在纳米结构修饰构造中的应用10ZZ02	庄　军	2010.1-2012.12

32	博士点基金	半导体量子点中电子自旋的退相干过程及相干时间的延长 20090071120013	张文献	2010.1-2012.12
33	教育部留学回国人员基金	旋量波色-爱因斯坦凝聚中的多体量子自旋动力学研究	张文献	2009.1-2011.12
34	教育部新世纪优秀人才计划	半导体量子点中自旋体系的退相干过程及相干时间的延长	张文献	2010.1-2012.12
35	浦江人才计划	量子调控微纳结构自旋体系的相干时间 10PJ1401300	张文献 庄 军	2010.7-2012.6
36	浦江人才计划	自旋注入异质结界面磁性及自旋输运研究	赵海斌	2010.9-2012.8
37	上海人才发展资金	硅基半导体自旋电子器件的界面性质研究 2009010	赵海斌	2010.1-2011.12
38	国家自然科学基金	可逆原子纵向操纵的新方法及其在纳米结构修饰构造中的应用 11074042	庄 军	2011.1-2013.12
39	国家自然科学基金	铁磁邻近极化效应下的GaAs电子自旋相干运动研究 11074044	赵海斌	2011.1-2013.12
40	国家自然科学基金	磁性隧道结中垂直自旋转矩效应的微磁研究 11074046	张宗芝	2011.1-2013.12
41	国家自然科学基金	复合结构高Q光学微谐振腔的构建与光学特性研究 11074051	刘丽英	2011.1-2013.12
42	国家自然科学基金	掺杂氧化钛在可见光诱导下对癌细胞的光动力杀伤效应与机理的研究61008055	糜 岚	2011.1-2013.12
43	国家自然科学基金	有机自旋阀的制备、界面调控与输运性质 61076093	倪 刚	2011.1-2013.12
44	国家自然科学基金	FePt基磁耦合结构的超快自旋动力学 61078030	金庆原	2011.1-2013.12
45	国家自然科学基金	共振泵浦光纤-体块混合激光器及激光晶体中反斯托克斯荧光冷却效应的研究 61078035	沈德元	2011.1-2013.12
46	国家自然科学基金	金纳米结构对偶氮苯分子光致异构量子效率的调控 61078052	徐 雷	2011.1-2013.12
47	国家自然科学基金	交换耦合复合结构薄膜的热稳定性机理研究 51071046	马 斌	2011.1-2013.12
48	博士点基金(新教师)	掺锰硒化锌半导体量子点在细胞中的输运与荧光特性研究 20100071120029	糜 岚	2011.1-2013.12

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

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研究工作报告/Scientific Report

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

本年度在凝聚态光谱学和材料性质方面的研究进展包括：The research progress on spectroscopy of condensed matter and properties of solid state materials includes:

1．横向位移空间干涉效应对光波在单层介质薄膜中的传播特性研究。Lateral Shift Effect on the Spatial Interference of Light Wave Propagating in the Single-Layered Dielectric Film

采用连续变入射角的椭圆偏振光谱分析方法，对考虑空间干涉效应后的 s 和 p 分量光波在薄膜中的传播特性进行了研究，由新给出的解析公式和计算方法得到的结果与椭偏实验结果有很好的吻合。研究结果表明，考虑空间干涉效应后的光学薄膜器件模型有其合理性和更宽的适用范围，这对于具有复杂结构的高性能分光谱滤波片等光学薄膜器件的设计制备和应用具有积极的意义。

Under the oblique incidence condition, the multiple reflection wave packets in the layered film structure will have a lateral shift increasing with the film thickness. In the analysis of the spatial interference with consideration of the lateral shift effect, a set of new analytic formulas to normalize the intensity of the s- and p-polarized wave packet was obtained to reduce the error of ellipsometry parameters significantly as the optical path difference δ is close to $m\pi$. The principle and method developed in this work also can be applied to other film structures in more general applications.

2．多光谱分区的高效率太阳光电转换器件研究。Study of spectrum-splitting solar photovoltaic device with high efficiency

单种类光电子器件的光电响应特性难以获得与太阳能全光谱匹配的高效率光电转换，突破其物理限制的努力方向是研制高转换效率的“第三代”分光谱多结电池。在本工作中，采用分光谱技术，将太阳光谱分成 4 个子光谱区，分别为 400－630 nm；630－800 nm；800-900 nm；900-1800 nm；与这些子光谱区的范围相对应，采用能隙值与子光谱区相匹配的 4 个不同种类的具有较高光电转换效率的高性能光电器件，实现将太阳光高效率转换成电能。在太阳能电池辐照测试的 0.5－6.0 个 SUN(AM1.5G)变化条件下，对多光谱组合的太阳电池的光电转换效率进行了测试，获得了在 2.8 个 SUN(AM1.5G)辐照条件下 35％的峰值光电转换效率。在此基础上，给出了制备高效率（>40%）组合型分光谱太阳能光电转换系统的途径，该技术具有较低成本和实际推广应用价值。

It is difficult to achieve high efficiency of photoelectric conversion by using single junction solar devices in the full solar spectrum range. The key to overcome the physical limits is to develop the system consisting of a set of solar cells in which the photo-electronic conversion of each cell will match to the sub-spectrum of the solar radiation with high conversion efficiency. In

the study, the spectrum splitting method is used to divide the solar spectrum into four sub-ranges of 400-630nm, 630-800nm, 800-900nm and 900-1800nm, respectively. Four high performance single-junction photo diodes are used, and each of them has high quantum-efficiency of photo-electronic conversion matching to the sub-ranges of solar spectrum. Under the 0.5-6.0 SUN radiation condition, the photo-electrical conversion efficiency of the system with four solar cells has been measured with the result to show that the photo-electric conversion efficiency of 35% is achieved under the typical 2.8 SUN radiation condition. The results given in this work show the potencial to realize a high photo-electric conversion efficiency (>40%) of the solar system in application.

3. 可见光波在贵金属铜界面从负到正折射研究。Study of positive and negative refraction of visible light at the Cu/air interface

在研究中制备了一系列入射角精确可控的贵金属 Cu 样品，采用不同波长的激光，对于光波在铜界面的传播特性进行了定量实验测量，获得表观光折射随入射角和波长从负到正变化的定量关系，对导致奇异光传播现象的机理进行了细致分析和讨论，研究结果将有助于人们理解光波在金属基界面传播的物理机理，从而为新型微纳光电子材料和器件的研制和应用建立基础。

Light transmission at the Cu/air interface was measured in the visible region for a series of wedge-shaped Cu film samples. It is found that light refraction at the Cu/air interface changes from negative in the Drude region, passing through zero at about E_g, to positive in the interband-transition region. Detailed discussion is given to understand better light refraction phenomena in metal-based materials in broad frequency region.

4. 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 meatime, the molecular dynamic processes of mirco-strucural transformation of these doped films have been simulated by *ab initio*.

5. 尺寸可控的硅纳米晶的非线性光学性质研究。Study of the nonlinear optical properties of

size controlled silicon nanocrystals

使用 Z 扫描测量技术测量了用 SiO_x/SiO_2 超晶格制备方法制备的尺寸可控的硅纳米晶的非线性光学性质。得到样品的非线性折射率和吸收系数分别为 1.2×10^{-13} cm^2/W 和 1.5×10^{-9} cm/W，硅纳米晶的非线性效应比体硅强。硅纳米晶的尺寸较小（实验中为 2 nm 直径的晶粒），由于量子限制效应它的能带发生分裂，导致带内跃迁的发生，这会增强它的非线性光学效应。因此实验中测得的硅纳米晶非线性折射率和吸收系数相对于体硅的增强与量子限制效应有关。

The nonlinear optical properties have been studied using the Z-scan technique for silicon nanocrystals embedded in SiO_2 matrix, formed by high temperature annealing of SiO_x/SiO_2 superlattices grown by thermal evaporation. A mode-locked Ti:sapphire laser system producing 140 fs long pulses at 800 nm was used as the optical source for the Z-scan measurement. The nonlinear refractive index and the nonlinear absorption coefficient of silicon nanocrystals are found to be 1.2×10^{-13} cm^2/W and 1.5×10^{-9} cm/W, respectively, and to be strongly enhanced compared to those of bulk silicon. Such enhancement of nonlinear optical properties is considered due to the quantum confinement effect of silicon nanocrystals.

6. 薄膜生长的宽光谱监控技术及其应用研究。Development and application of a broadband monitoring technique for a film deposition system.

本部分研究工作主要包括：（1）研制了用于电子束蒸发薄膜生长设备的一套宽光谱监控系统，解决了系统研制过程中的各种软硬件问题。对传统的宽光谱监控数据处理方法进行了改进，大大减少了计算量。提出软硬件两种处理方法去除衬底干涉噪声，并分别采用 K9 玻璃衬底和双面抛光硅片衬底制备的窄带滤波片，均实现了良好的带通特性。利用宽光谱监控系统的在位误差补偿功能，所制备薄膜的最终光谱与理论模拟光谱符合得很好，验证了所研发的红外宽光谱监控系统具有满意的监控效果。（2）研究了 SiO_2 薄膜光学常数随厚度变化的趋势，及这种趋势与生长速率的关系。利用电子束蒸发方法在硅片衬底上制备系列 SiO_2 薄膜样品，厚度范围为~1nm 到 600nm。采用变角度椭圆偏振光谱仪对薄膜样品进行测量，每个样品获得 200 多组椭偏参数。选用适当的模型进行拟合得到了 SiO_2 薄膜的折射率色散关系及厚度值。实验结果表明快速和慢速生长的 SiO_2 超薄膜的折射率随厚度变化趋势不同，慢速生长的薄膜更容易形成致密膜层。

This work mainly includes the following two parts: (1) A broadband monitoring system was set up with solving encountered software and hardware problems and applied to an electron beam evaporation system for film deposition. The conventional data processing was improved and the computational amount was obviously reduced. Both hardware-based and software-based methods were proposed to filter the interferential effect caused by the substrate. The noise-filtering methods were applied to the real deposition of narrow band filters using both K9 glass and silicon as substrates, and with in-situ error compensation process based on BOM technique, several narrow band filters with good performance, which is in accordance with the theoretical design, were finally obtained. The results demonstrated the validity of this broad band monitoring method on film deposition. (2) The thickness dependence of the optical constants of SiO_2 films at different deposition rates was studied. All samples of SiO_2 films with thickness ranging from ~1 nm to 600 nm were deposited on Si substrates by EBE method, and then measured with variable-angle

spectroscopic ellipsometry (VASE). More than 200 sets of ellipsometric parameters were obtained for each sample. The optical constants and thicknesses of SiO_2 films have been obtained with fitting the measured data using appropriate model. The results showed that the evolution of optical constants of SiO_2 films with thickness differs for the samples deposited at higher rates and the samples at lower rates, and it is favorable to deposit films at low rate for getting denser film.

7. V 掺杂 $SiGe_2N_4$ 和 $GeSi_2N_4$ 电子结构和光学性质第一性原理研究。First-principles study on the structural, electronic and optical properties of V-doped $SiGe_2N_4$ and $GeSi_2N_4$

利用第一性原理方法研究了不同V剂量掺杂条件下$SiGe_2N_4$ 和$GeSi_2N_4$电子结构和光学性质结果表明：掺杂后化合物的晶格常数相对于母体而言有稍微增加，对于八面体位替代掺杂，晶体结构发生明显的形变。在费米能级附近出现了由V的3d轨道的杂化的3重简并态。$Ge_2Si_3VN_4$ 的禁带中出现了部分占据的中间能带，该中间能带的出现显著增强了材料对可见光和红外光的吸收。

The electronic structure and optical properties of $SiGe_2N_4$, $SiVGe_4N_8$, $Si_2Ge_3VN_8$, $GeSi_2N_4$, $GeVSi_4N_8$, $Ge_2Si_3VN_8$ are studied in the frame work of the first principles calculations based on the density functional theory. The lattice parameters of V-doped semiconductors increase slightly compared to the hosts. Especially the crystal deformation is more obvious when the octahedrally coordinated atoms is substituted by V. The band near the Fermi level is mainly come from the triply degenerated t_{2g} mainfold of 3d orbital of V atom. And $Ge_2Si_3VN_4$ presents a isolated, partially filled intermediate band(IB). The computed optical absorption of those compounds compared to the corresponding undoped semiconductors predicts an enhancement of the absorption in the visible and nearly infrared region.

8. Cr-O 共掺杂对 GaN 电子结构和光学性质的影响。Effect on electronic and optical properties of CrO codoped GaN

利用第一性原理方法研究了 O、Cr 和 CrO 共掺杂对宽禁带半导体材料 GaN 的结构、能带和光学性质的影响。结果表明 Cr-O 共掺的方法可以在原 GaN 晶体中产生中间能带，Cr-O 共掺的方法较单个氧原子掺杂可以降低材料的形成能。中间能带的出现实现了材料对低能光子的吸收，增强了其对太阳光谱中红外波段的能量利用，从理论上预言 Cr-O 共掺 GaN 作为第三代太阳能电池的半导体材料的可行性。

The effect on crystal structure, electronic and optical properties of Cr, O and CrO codoped GaN were calculated by first-principles calculation. The results show that codoping method brings in new intermediate band as well as lowering the formation energy in comparison with single oxygen atom doping. The formation of intermediate band enhances absorption of low energy photons, especially in infrared range of the sun spectrum. Our calculation predicts the feasibility of CrO codoped GaN used as a third-generation solar cell semiconductor material.

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

2010 年度，本组承担了 9 项科研项目，包括国家自然科学基金重点项目 1 项，国家自然科学基金面上项目 2 项，教育部博士点基金 1 项，上海市科技项目 2 项，参与 973 项目 2

项, 国家重大专项“02”项目 1 项。

发表期刊论文 17 篇， 其中 SCI 论文 14 篇，EI 论文 1 篇。发表会议论文 25 篇，其中国际会议论文 5 篇，国内会议论文 20 篇。授权国家发明专利 1 项。受理申请国家发明专利 2 项。

In 2010, our group has been carrying out 9 research projects, including 1 NSFC key project, 2 NSFC regular projects, 1 project for doctor station from the Ministry of Education of China, 2 projects from Shanghai committee of science and technology, 2 sub-projects from national 973 program, 1 sub-project from major national science and technology project. We have published 17 research papers, including 13 SCI papers, 1 EI paper, and presented 25 papers in academic conferences, including 5 papers in international conferences and 20 papers in domestic conferences. 1 national invention patent has been licensed, and 2 national invention patents have been accepted 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

1. 超高密度纳米混合磁存储材料(ultrahigh density nano hybrid magnetic recording materials)：

在 L10-FePt/Fe 交换耦合介质中，Fe 的磁化易轴倾向于沿着面内，因此会降低耦合薄膜的热稳定性；并且，随着 Fe 层的厚度增加，磁滞回线的矩形比也会大幅降低。因此，我们制备了垂直型 L10 FePt/[Co/Ni]N 交换耦合介质。即在 FePt 薄膜的表面沉积具有垂直磁各向异性的 Co/Ni 多层膜（磁各向异性常数约 2~3×106 erg/cc，饱和磁化强度约 800 emu/cc），得到垂直取向的交换耦合结构。实验结果显示 Co/Ni 多层膜能有效地降低耦合介质的矫顽力，在 Co/Ni 多层膜厚度为 8 nm 时，FePt/[Co/Ni]N 交换耦合介质的矫顽力为 4.4 kOe，磁滞回线的矩形度大于 0.8。

实验发现，交换耦合介质的磁化翻转可以分为两个过程：在软磁层内的成核过程，以及在软、硬界面的不可逆磁化翻转过程。当成核过程顺利完成时，软、硬层间强的交换耦合作用有利于硬磁层的翻转；而当软磁层太薄而难以成核时，较弱的交换耦合作用更有利于降低矫顽力。

In a L10-FePt/Fe ECC composite, the magnetic easy axis of Fe layer tends to along the film plane, leading to low thermal stability. Moreover, the square ratio of the hysteresis loop decreases greatly with the increase of the Fe layer's thickness. Then, we have prepared a perpendicular L10 FePt/[Co/Ni]N ECC composite, where a perpendicular Co/Ni multilayers are deposited on a (001) textured L10 FePt layer. The experimental results show that the coercivity of FePt/[Co/Ni]N greatly decreases with the thickness increase of Co/Ni multilayers. For FePt/[Co/Ni]10 with 8-nm-thick soft layer, its coercivity is 4.4 kOe, the square ratio of the hysteresis loop is beyond 0.8.

The magnetization reversal of L10-/FePt/[Co/Ni]N comprises nucleation in the soft layer and incoherent reversal in the hard layer. When nucleation is completed, strong exchange coupling between the soft and the hard regions is favorable for coercivity reduction, while the composite is too thin to form nuclei, weak exchange coupling due to an inserted Pt layer is favorable.

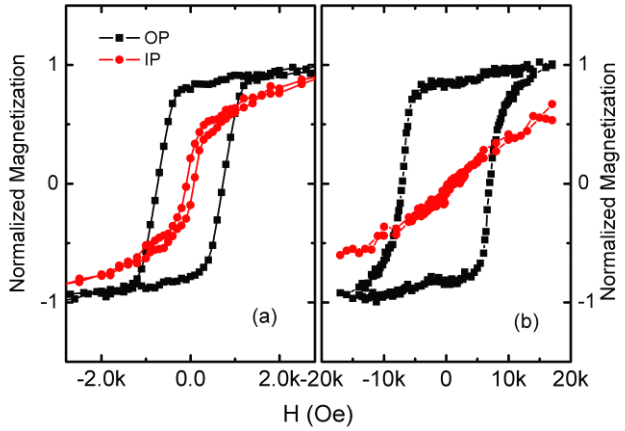

图 1： [Co/Ni]$_5$ (a)多层膜和 $L1_0$-FePt/[Co/Ni]$_5$ (b)交换耦合薄膜的水平和垂直方向的磁滞回线。.

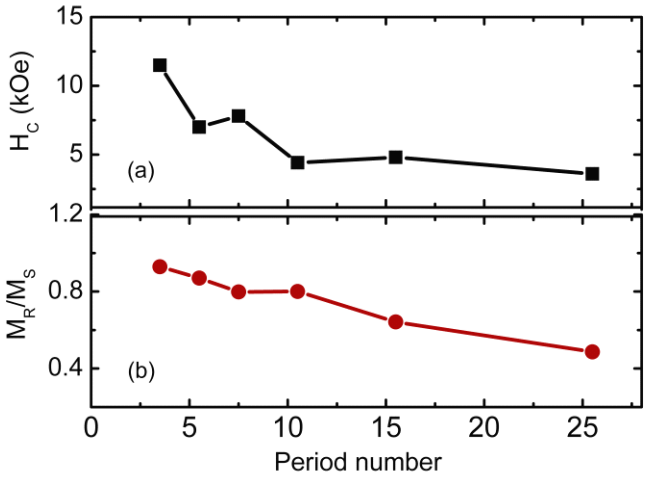

图 2：$L1_0$-FePt/[Co/Ni]$_N$ 耦合薄膜的矫顽力和回线矩形比随 Co/Ni 多层膜的周期数的变化。

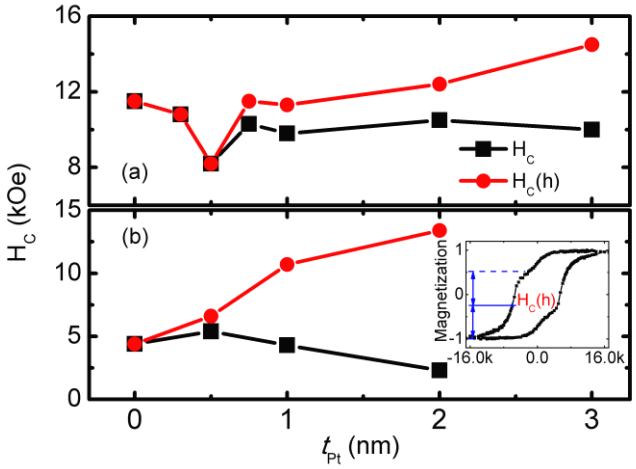

图 3：$L1_0$-FePt/Pt(t nm)/[Co/Ni]$_3$ (a)和 $L1_0$-FePt/Pt(t nm)/[Co/Ni]$_{10}$ (b)的矫顽力随非磁性 Pt 插

入层的厚度的变化。其中，H_C 是耦合薄膜的矫顽力，$H_C(h)$是硬磁层的矫顽力。图 3(b)中的小图是 FePt/Pt(0.5 nm)/$[Co/Ni]_{10}$ 的磁滞回线。

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

激光的热效应不仅能够激发磁性材料的超快退磁和解耦合现象，合适条件下还能够诱导磁矩的一致进动过程。利用基于磁光克尔效应（MOKE）的时间分辨 Pump-Probe 测量技术，我们研究了 FePt/CoFe 耦合膜的进动规律和机制。图 4(a)示意了不同 CoFe 厚度的 FePt/CoFe 膜的磁化动力学行为：可以看出，1ps 附近出现激光诱导的最大退磁，随后对 CoFe 厚度大于 2nm 的样品表现出磁化强度的进动和衰减行为。CoFe 层太薄的样品由于自旋和电子温度太高而使其自旋混乱，因而不可能观察到自旋的一致进动。CoFe 太厚的样品，由于磁化强度倾向于膜面内，因而也不能观察到由于磁化矢量偏离易轴而出现的进动现象。进动幅度随着延迟时间的增加快速衰减，到 100 ps 时进动信号已经不可分辨。从图 4(b)可以看出，磁化进动频率与 CoFe 的厚度无关。图 5 给出了进动频率与外磁场的依赖关系，可以看出随外磁场的增大进动频率线性增加，说明激光诱发的进动过程是由 Kittel 的一致进动模式主导（K=0 模式）。这些结果与 LLG 方程预测的结果一致，通过理论分析和拟合，我们得到 FePt/CoFe 耦合体系的进动衰减因子α~0.13，这个值远远大于 CoFe 的衰减因子。我们认为如此高的α值主要来源于 FePt 层中具有强自旋轨道相互作用的贵金属 Pt 的贡献。对磁化矢量进动和衰减过程的研究有利于探讨磁存储的极限写入速度，掌握材料的一些本征动力学参数如进动阻尼系数等。

It is known that the absorption of the intensive laser pulse not only can trigger ultrafast demagnetization and exchange-decoupling, but also can cause magnetization precession behaviors. Femto-second laser-triggered magnetization precession dynamics in exchange-coupled hard FePt/soft CoFe films has been studied by the time-resolved magneto-optical Kerr effect. Note that maximum demagnetization takes place at a delay time of about 1 ps, after that we observe a damped magnetization precession behavior for the bilayers with CoFe thickness over 2 nm. The amplitude reaches its maximum at 7nm CoFe. This varying bahavior can be explained as follows: the uniform magnetization precession would not be able to occur in the bilayer with very thin CoFe layer because of the high electron and spin temperature, resulting in inhomogeneous spin rotation by laser heating. In contrast, for the sample with thick CoFe, the effective magnetization is inclined to the film plane, which is parallel to the effective field direction. Correspondingly, the precession is suppressed, too (see Fig. 4). With increasing the delay time, the precession amplitude decays rapidly and then becomes unresolved at a delay time of ~100 ps. Fig. 5 shows the dynamic curves of Kerr signal for the sample with t_{CoFe}=7 nm. The precession frequency is shown to be independent of the CoFe thickness t_{CoFe}, while linearly proportional to the external field. implying that the magnetization relaxation is governed by a uniform Kittel precession mode. The result agrees well with the theoretical prediction based on the Landau-Lifshitz-Gilbert equation. The

obtained damping factor α~0.13 is quite large and is thought to be dominated by the FePt layer.

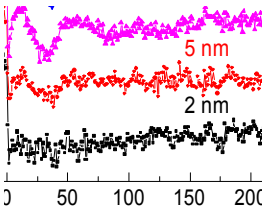

图 4 (a) 时间分辨的 MOKE 信号；(b) 频率和振幅对 CoFe 厚度的依赖性。

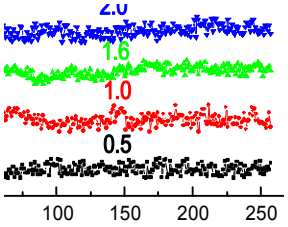

图 5 (a) 时间分辨的 MOKE 信号；(b) 频率和衰减因子对外场的依赖关系。

3． 自旋电子学材料(spintronic materials)

我们研究了具有垂直各向异性的 TbCo 合金膜与$[Co/Ni]_N$多层膜的耦合作用。通过选择富 Tb 的 TbCo 与$[Co/Ni]_N$多层膜组成垂直交换耦合结构，以该结构作为参考层的自旋阀表现出了优异的性能。图 6 表明具有强垂直各向异性的 TbCo 能够克服 Co/Ni 的退磁能，使其倾斜的易轴垂直于膜面方向。稍微增加 TbCo 的厚度，耦合结构的垂直矫顽力会明显增大，从而增加了自由层与参考层的翻转场差，实现在较大的外场范围内磁化方向的平行与反平行，如图 7 所示。由于参考层的磁矩反平行排列，产生的散磁场很小，因而 TbCo 耦合自旋阀不仅能保持高的 GMR 信号，自由层翻转场没有受到散磁场的影响，GMR 回线关于原点对称，如图 8 所示，这些性能对实际应用非常重要。

We have investigated the exchange interaction between the perpendicularly magnetized ferrimagnetic TbCo layer and the Co/Ni multilayers. The spin valves, which use the perpendicularly exchange-coupled composite structure as the reference layer, display specific features. Fig. 6 indicates that the TbCo layer has strong perpendicular magnetic anisotropy which can overcome the demagnetization energy of the Co/Ni, resulting in the tilted magnetization orientation perpendicular to the film plane. By slightly increasing the TbCo thickness, the coercivity of the coupled structure greatly increases, thereby giving an effective way to widen the difference in switching fields for the free and reference layers, and making it possible to manipulate magnetizations parallel or antiparallel for a wide range of fields, as shown in Fig. 7.

Such composite reference layer can not only maintain a high perpendicular GMR ratio, but it also minimizes the field offset in the minor GMR curves due to the negligible stray field generated by the antiferromagnetically aligned moments in the reference layer, see Fig. 8.

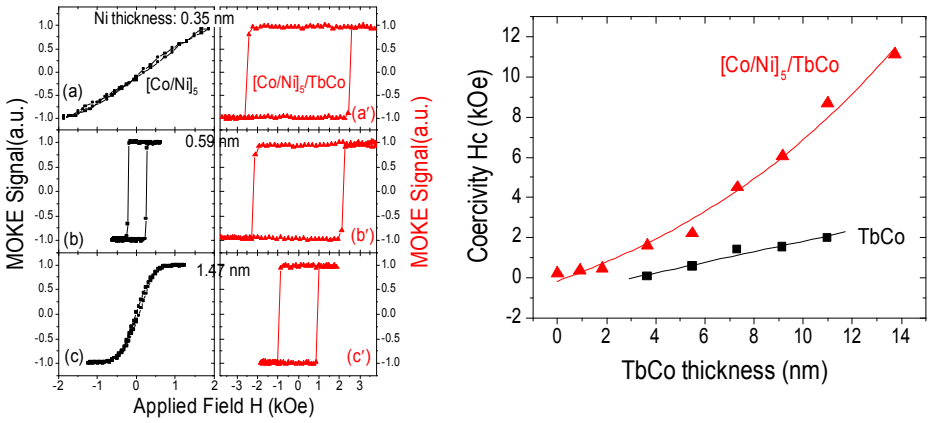

图 6 (a) Co/Ni 和[Co/Ni]/TbCo 的极向 MOKE 回线；(b) 不同 TbCo 厚度下 Co/Ni 多层膜和[Co/Ni]/TbCo 复合膜的矫顽力。

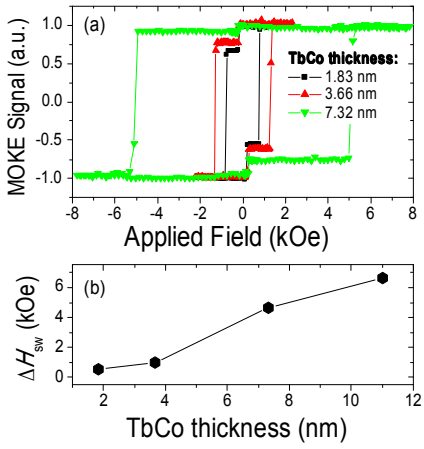

图 7 (a) TbCo/[Co/Ni]自旋阀的 Kerr 回线; (b)自由层和参考层的磁化强度翻转场差。

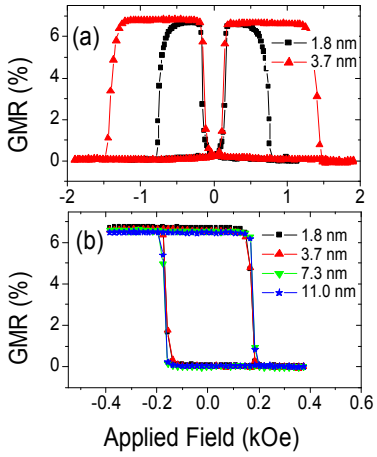

图 8 高场(a)和小场(b)下 TbCo/[Co/Ni]自旋阀的 GMR 曲线;

4. 自旋转矩效应的微磁学模拟 (micromagnetic study of spin transfer torque effect)

近来的研究表明，自旋转移矩效应包含两项，一项平行于自由层和参考层磁化矢量决定的平面，另一项则垂直于该平面。不同于自旋阀，在磁性隧道结中自旋转移矩效应的垂直项在磁化翻转中也起着很重要的作用。我们微磁模拟了自旋转移矩在有或无垂直项两种情况下的磁矩翻转，发现相同电流密度下，垂直自旋转移矩项的存在能够加速磁化强度的翻转，而且负电流时垂直转矩项的作用明显大于正电流情况。这种非对称行为与理论关于偏压依赖性的预测一致。随着电压的增大，垂直项作用增强，如图 9 所示。这些微磁模拟结果能够为自旋转矩型高密度 MRAM 的研发提供一定的理论支持。

Recent study indicates that the spin-transfer torque (STT) includes two terms: one is the

well-known in-plane component, and the other field like torque term is oriented perpendicular to the plane defined by the magnetization vectors of the free layer and pinned layer. Unlike the spin valves in which the perpendicular spin torque is very small, it can reach 10-30 % of the in-plane spin-torque in nano-scaled MTJs, suggesting that the perpendicular STT should play an important role in the magnetization switching of tunnel junctions. Micromagnetic simulation is employed to study the effect of field-like spin torque in a perpendicularly magnetized tunnel junction. We find that the field-like torque significantly reduces the switching time for the electrons flowing from free layer to pinned layer while has less effect for the opposite current. This asymmetric behavior is consistent with the theoretical prediction on the bias dependence of the field-like spin torque. The effect of perpendicular torque increases with the increase of bias voltage, as shown in Fig. 9.

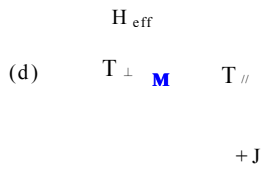

图 9　(a) (b) 翻转时间对正负电流的依赖性；(c) 垂直转矩项对偏压的依赖性；（d）垂直磁化隧道结结构、电流流向和自旋转矩方向示意图

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 focuses 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. 硫系玻璃微/纳光子学器件的制备和研究 Fabrication and characterization of chalcogenide micro/nanophotonics devices

制作出的基板上的掩埋型硫系玻璃微纳光子学器件。通过熔融拉锥方法制作出直径最小为 200 nm 的 As_2S_3 玻璃光纤，并成功地将微纳光纤掩埋于聚合物 SU8 胶中并固定并保护在硅基板上。制作出低传输损耗的波导与高 Q 值的结形微腔。利用 532 nm 连续激光的照射，实现了结形微腔共振波长的调节，调节范围约 1.5 nm。通过中心波长在 1560 nm 的飞秒激光泵浦直径为 1 μm 长度为 7 cm 的直波导，在脉冲能量为 2 nJ 的情况下，实现了光谱宽度为 500 nm 的激光超连续展宽。该项工作发表于 Opt. Lett. 35(22), 3829-3831 (2010)。

利用飞秒激光对硫系玻璃的作用在As_2S_3体材料玻璃制作了各种微纳光子学结构。利用飞秒激光对材料的表面烧蚀，在多脉冲照射情况下产生周期为180 nm的纳米光栅，在单脉冲照射下产生直径为200 nm的纳米洞结构。并通过系列的实验验证了产生纳米光栅的理论。指出在硫系玻璃内，激光诱导等离子体的非均匀生长可能是产生纳米光栅的主要原因。研究了飞秒激光暗化后材料在有机胺类溶液的选择性腐蚀效应，制作出宽为2.5 μm的微管。该项工作发表于Opt. Express, 18 (7), 6885-6890 (2010)。

Chalcogenide (As_2S_3) nanofibers as narrow as 200 nm in diameter are drawn by the fiber pulling method. The nanofibers are successfully embedded in SU8 polymer, thus form on-chip waveguides and high-Q microknot resonators ($Q=3.9 \times 10^4$) with smooth cleaved end faces. Resonance tuning of resonators is realized by localized laser irradiation. Strong supercontinuum generation with a bandwidth of 500 nm is achieved in a 7-cm-long on-chip chalcogenide waveguide. Our result provides a method for the development of compact, high-optical-quality, and robust photonic devices.

Sub-wavelength nanostructures on the surface of As_2S_3 chalcogenide glasses are fabricated by appropriately controlling the irradiation condition of single-beam direct femtosecond laser writing. Nanogratings with a period of 180 nm were realized by multi-pulse irradiation. More importantly, controllable nanoholes as small as 200 nm in diameter (one quarter of the illumination wavelength) were, for the first time, achieved in As_2S_3 using direct laser writing by single-pulse irradiation.

2. 高 Q 值半螺旋型对称微腔的单方向光发射性质。High-Q unidirectional emission properties of the symmetric half-spiral microcavities

利用二维时域有限差分方法研究了一种新型半螺旋型对称微腔的模场和光发射特性。计算结果表明该微腔可支持高 Q 值($Q>10^4$)方向性出射的回音壁模式。而且，通过两个不同尺寸半螺旋型对称微腔之间的耦合，可以控制微腔 Q 值和出射方向性，最终获得发散角为 19^o 的单方向出射的光发射。论文发表于 J. Opt. Soc. Am. B., 27(2), 300-304 (2010) 。

Mode field patterns and light emissions of novel symmetric half-spiral microcavities (SHSMs) are investigated by the two-dimensional (2-D) finite-difference time domain (FDTD) method. The calculation results show that an SHSM can support high-quality (Q) ($Q>10^4$) distorted whispering-gallery modes with directional emissions. Moreover, artificial controls on the Q factor and emission directionality are realized in the coupled size mismatched SHSMs, and unidirectional emission from the coupled cavity structure with a divergence of 19° is achieved.

2010 年度本课题组完成国家自然科学基金重点项目 1 项和上海市优秀学科带头人计划 1 项。2010 年申请到国家自然科学基金面上项目 2 项。2010 年度课题组发表文章 3 篇，其中 SCI 文章 2 篇，与其他课题组合作发表 SCI 文章 3 篇；在国际会议上报告 10 次，其中 2 次为会议邀请报告；在国内会议上报告 3 次；授权国家发明专利 2 项。

硅纳米结构的制备、发光及其在太阳电池中的应用 / Si nanostructure: preparation, light emission and application in solar cell

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

本年度在 4 个方向上开展工作，分别是：1）利用室温法和高温相分离法制备硅纳米晶并基于 PL 转换原理，将其应用于晶体硅太阳电池效率的提高。研究发现室温法（溶胶凝胶法）制备的硅纳米晶可相对提高硅太阳电池效率 2.2%；高温相分离法制备的硅纳米晶可相对提高电池效率 9.1%。2）基于高温相分离法，发展了一种新的增强硅纳米晶光致发光和电致发光的方法，即通过在起始一氧化硅薄膜中引入额外的成核点，来提高硅纳米晶的密度。利用 CO_2 激光预退火后，发现光致发光和电致发光强度均增加了一倍以上。部分结果发表在 Appl. Sur. Sci.。另外研究了光激发的受激辐射现象，发现了较强的光增益现象。 3）利用离子束轰击结合重金属掺杂，获得了大高宽比的硅纳米锥阵列。还研究了硅纳米点阵的形成机理，论文发表在 Phys. Rev. B. 目前将其应用于一种新型陷光型光伏结构。4）另外，我们还研究了 SrTiO3 表面处理后的紫外和可见光光催化增强，以及 BR 薄膜的光学非线性效应。部分结果发表在 Appl. Phys. Lett.

Research of the year of 2010 covers 4 aspects. 1) Preparation of Si nanocrystals by means of sol-gel and phase separation, and application of the Si nanocrystals to improve the performance of Si solar cell based on the principle of PL conversion. The efficiency of solar cell has been increased by 2.2% with the help of sol-gel prepared Si nanocrystals, and it has been increased by 9.1% by using Si nanocrystals made by phase separation. Parts of the results have been submitted to Nanotechnology. 2) To develop a new method of increasing the PL and EL intensity of Si nanocrystals by means of CO_2 laser preannealing. The preannealing induced defects act as additional nucleation sites that enhance the formation of Si nanocrystals. Also, lasing phenomenon regarding Si nanocrystals has been studied, and high optical gain was found. 3) By using ion beam bombardment combined with heavy metal ion in corporation, high aspect ratio nanostructure of Si cone arrays were prepared. Also the mechanism of the impurity effect during the formation of Si nanostructures was investigated. Application of this kind of “black Si” has been conducted to develop a noval photovoltaic structure. 4) Enhancement of UV and visible photocatalysis in $SrTiO_3$ after hydrogenation and/or ammoniation was studied. Meanwhile, nonlinear effect of BR thin film was investigated.

本年度执行国家自然科学基金面上项目 2 项，973 项目子课题 1 项。发表 SCI 论文 3 篇。国际会议大会报告 1 次（国内组织）。投稿 7 篇。申请国家发明专利 2 项目。

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　　Group members: Qian Liejia, Zhu Heyuan, Fan Dianyuan

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：

窄带脉冲增强的啁啾化宽带脉冲频率上转换;Narrowband pulse-enhanced upconversion of chirped broadband pulses

我们提出并实验验证了一种基于窄带脉冲与啁啾化宽带脉冲的和频方案，它结合了较大光谱接受带宽与减缓时间走离效应的优点，有利于获得更高的转换效率。验证实验获得了啁啾化和频脉冲的能量高达 360 μJ（波长为 455nm），对应的转换效率达 40%，且脉冲可被压缩至 110fs。该和频方案为深紫外飞秒激光脉冲的高效产生提供了一种有前景的途径。

We propose and demonstrate an efficient sum-frequency mixing scheme based on narrowband and chirped broadband pulses. It cimbines the advantaged of wider spectral acceptance bandwidth and of alleviating the temporal walk-off, which are both beneficial to higher conversion efficiency. Chirped sum-frequency pulses at 455 nm with energy up to 360 μJ, corresponding to a conversion efficiency of ~ 40%, are obtained and the pulses can be compressed to ~ 110 fs. The sum-frequency mixing scheme may provide a promising route to the efficient generation of deep-ultraviolet femtosecond pulses.

啁啾脉冲光学参量放大系统中抽运光位相调制导致的脉冲信噪比恶化研究; Pulse-contrast degradation due to pump phase-modulation in optical parametric chorped-pulse amplification system

我们在理论上研究了啁啾脉冲光学参量放大（OPCPA）系统中，由于抽运光时间域位相调制导致的脉冲信噪比恶化效应，揭示了使脉冲信噪比降低的两种物理机制：由群速失配引起的位相转移效应和由群速色散引起的从频率调制向振幅调制的转换效应。为了削弱位相转移效应，我们提出了一种分别由信号光和闲频光注入的两级 OPCPA 方式，分析表明它可以有效地改善输出脉冲的信噪比。

We theoretically study the pulse-contrast degradation of optical parametric chirped-pulse amplification (OPCPA) system pumped by a temporally phase-modulated laser. We reveal two physical mechanisms that reduce the contrast in such a parametric process: the effect of phase transfer caused by group-velocity mismatch (GVM) and the effect of FM-to-AM conversion caused by group-velocity dispersion (GVD). To reduce the effect of phase transfer, a pair of OPCPAs seeded by the signal and idler respectively, is studied for effectively improving the contrast in such a case with pump phase modulation.

飞秒激光参量下转换中的光谱相移研究; Spectral phase shifts in femtosecond parametric

down-conversion

理论上研究了色散介质中由参量频率下转换产生的中红外飞秒激光脉冲的光谱相移问题，侧重于群速色散（GVD）效应，旨在获得对该类体系色散补偿与脉冲压缩的准则。我们考虑了两种产生中红外飞秒激光脉冲的方式：差频（DFG）和光学参量放大（OPA）。中红外飞秒激光脉冲的位相由初始注入条件及高频场累积光谱位相的转移所决定。在 DFG 中，抽运光耗损对光谱位相影响很小；在 OPA 中，GVD 和高参量增益的综合效应使光谱位相明显地依赖于增益：增益越高，光谱位相越小。

We theoretically study the spectral phase shift of mid-infrared (MIR) femtosecond pulse generated through parametric frequency down-conversion in dispersive media, with an emphasis on the effect of group-velocity dispersion (GVD), with the aim of obtaining guidelines for dispersion compensation and pulse compression in such systems. We consider two common ways of MIR femtosecond pulse generation: difference frequency generation (DFG) and optical parametric amplification (OPA). The resultant spectral phase is determined by the initial injection condition, and the transfer of the spectral phase accumulated by the higher-frequency fields. Our results show that in DFG, pump depletion has little effect on the spectral phase, while in OPA, the combined effect of linear GVD and high parametric gain lead to a notable dependence of spectral phase on gain—the higher the gain, the less the spectral phase.

本年度共发表 SCIE 文章 8 篇，被授权发明专利 2 项。

8 papers were published in SCIE journals and two patents were approved in 2010.

高功率掺 Tm 光纤激光器及共振泵浦光纤-体块混合激光技术 / High power Tm fiber lasers and in-band pumped fiber-bulk hybrid 2 um laser sources

成员：沈德元 Group members: Shen Deyuan

研究了体布格拉格光栅(VBG)在高功率掺铥光纤激光中波长选择及线宽窄化等方面的应用，通过不同 VBG 的并联及串联实现了超过 100W 输出的多波长及窄线宽掺 Tm 2 微米光纤激光输出。其中多波长输出激光的波长间隔任意可调，在 THz 产生及激光雷达等领域有重要应用。用 VBG 对实现了掺 Tm 光纤激光线宽 2pm、功率超过百瓦及波长连续可调输出。并用所建立的高功率掺 Tm 光纤激光共振泵浦 Ho:YAG 激光陶瓷，实现了 21 瓦连续激光输出。

Volume Bragg gratings (VBGs) recorded in photo-thermal refractive glass combines the advantages of high diffraction efficiency, narrow spectral linewidth, low insertion loss, high damage threshold and good thermal stability. Simultaneous dual-wavelength operation has been demonstrated via combining VBGs of different specifications and using a simple resonator configuration for wavelength selection. The wavelength splitting range is continuously tunable from 1 nm to 50 nm (0.1-3.8 THz), with >115W of diffraction limited total output power. The laser demonstrated should be readily extended to multi-wavelength operation by simply adding more VBGs in the external cavity. A novel technique for further spectral narrowing of high power fiber lasers via pairing of different gratings has been demonstrated. Over 113 W of diffraction limited output at 1990 nm has been generated with a relatively narrow linewidth of ~ 2.2 pm (FWHM).

High power and high efficient operation of a polycrystalline Ho:YAG ceramic laser in-band pumped by a Tm fiber laser at ~ 1907 nm has been achieved. Over 21.4 W of continuous-wave output power at 2097 nm has been generated with the 1.5 at.% doped Ho:YAG ceramic under 35 W of incident pump power, corresponding to an average slope efficiency with respect to the incident pump power of 63.6%.

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

继续对氮碳纳米锥的生长和性质进行了一系列实验研究，研究了不同放电等离子体条件对氮碳纳米锥的成份、晶态结构、化学键态、长度、直径、分布密度和均匀度的影响，并研究了氮碳纳米锥的导电特性，结果表明氮碳纳米锥的生长位置是个很重要的因素，只有在衬底与等离子体接触时可以合成出具有高氮含量、形态完好的晶态氮碳纳米锥阵列。

Further experimental work is gong on the growth and properties of CN_x nanocones, including the dependence of the composition, crystal structure, bonding configuration, length, diameter, size and spatial distribution, and homogeneousness of the synthesized CN_x nanocones on the plasma conditions. The conducting properties are also studied for the synthesized CN_x nanocones. Our results show that the position where the CN_x nanocones grow is one of the key factors, and CN_x nanocones with high nitrogen content, well-shaped crystalline CN_x nanocone arrays can be fabricated on the substrate being in contact with the plasma.

高 k 金属氧化物的合成制备和性质研究表明，用等离子体辅助脉冲激光沉积方法制备在 Si 衬底上的单斜结构的 HfO2 和 ZrO2 薄膜，具有很好的热稳定性和与 Si 衬底良好界面特性，还具有良好的介电特性。以常温制备的 HfO_2 和 ZrO_2 为介电层制作的 MIS 电容显示良好的电容-电压和漏电流-电压特性，对介电层的预退火处理还可以明显改善电容-电压特性、提高介电常数。

On the synthesis and properties of the high–K metal-oxides, monoclinic HfO_2 and ZrO_2 films synthesized on Si substrates by plasma assisted pulsed laser deposition show excellent dielectric properties in addition to their good thermal stability and interfacial properties between the oxides and the Si substrates. The MIS capacitors incorporating HfO_2 and ZrO_2 dielectrics exhibit excellent C-V and J-V characteristics. Our results also show than pre-annealing of the dielectrics can further improve the C-V characteristics and increase the dielectric constants.

继续开展多种纳米结构材料的制备，包括 CdS 纳米线、ZnSe 纳米线、TiO_2 纳米孔、ZnO 纳米棒等。其中，我们用脉冲激光沉积方法制备的 ZnO 纳米棒具有良好的 c 轴取向晶态结构，在很强的低温光致发光谱中识别出包括自由激子、束缚激子等精细结构，还获得了类似于随机激光的光发射。我们还在上述纳米材料制备和性质研究的基础上尝试制作了以纳米结构材料作为电子传输层的聚合物/无机复合薄膜太阳能电池。

Various nanostructured materials are prepared including CdS nanowires, ZnSe nanowires, TiO_2 nanoholes, and ZnO nanorods. Of them, ZnO nanorods synthesized by pulsed laser deposition show good c-axis orientation and crystallinity. Detailed emission structures including those associated with free- and bound excitons are identified in the strong low temperature photoluminescence from the ZnO nanorods. Optical emissions resembling random lasing are observed from the synthesized ZnO nanorods. Based on the synthesis of the above nanostructed materials and the study of their properties, hybrid polymer/inorganic thin film solar cells using nanostructured materials as the electron transport layers are fabricated.

本年度执行国家自然科学基金面上项目 2 项，参加 973 项目 1 项，发表学术论文 6 篇。

In this year, two NSFC projects are carrying out. Six papers were published.

半导体量子点在活细胞中和细胞间的输运研究 / Intracellular and Intercellular Transport of Semiconductor Quantum Dots

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

1. Tat 多肽耦合 CdTe 量子点在活细胞内的光谱特性。 The characteristics of Tat peptide conjugated CdTe quantum dots in living cells

Tat 多肽作为最常用的穿膜蛋白之一，能帮助细胞吞噬 CdTe 量子点（QD）。通过 Tat 多肽和量子点的耦合，为设计“药物-Tat-QD”耦合方式提供了可能性。这种耦合物，不仅仅可以通过表面修饰靶向运载药物，而且可以通过检测量子点的荧光而跟踪药物。

基于这样的构想，我们进行了 Tat 多肽与 CdTe 量子点的耦合，并且研究了它进入细胞后的光谱变化。我们发现 Tat 与量子点耦合，能够引起量子点光谱的红移。当 Tat-QDs 进入细胞之后，会集中分布在溶酶体中。在溶酶体内的水解酶的作用下，Tat 多肽被水解为游离的氨基酸，从量子点表面脱落，从而使得量子点的光谱蓝移。这也就意味着，当药物到达目的地之后，可以通过水解 Tat 多肽，将药物释放，与此同时，我们可以借助量子点的微区荧光光谱的变化来分析药物的释放情况。这一部分工作发表在 *J. Fluoresc.*, **20**, 551-556 (2010) 。

As one of the most popular cell-penetrating peptide (CPP), Tat peptide can facilitate the cellular uptake of CdTe quantum dots. The conjugation of Tat peptide and quantum dots provides the possibility of designing “cargo-Tat-QD” conjugates. This conjugation has the benefit for both cargo delivery and tracking, which may have a bright future in drug delivery.

Based on the blueprint, we conjugated Tat peptide with CdTe quantum dots. The conjugation of Tat peptide with QDs (Tat-QDs) leads to a remarkable redshift of the photoluminescence (PL) spectrum of quantum dots (QDs). After cellular uptake of the Tat-QDs conjugates, Tat-QDs would mainly distribute in the lysosomes. The micro-PL spectrum of Tat-QDs in lysosomes showed a spectral blueshift, which was most probably due to the fact that Tat peptide was digested by the enzymes, leaving the Tat-detached QDs in lysosomes. Therefore, after the conjugates reach their destination, the cargo may be easily released from the QDs through the digestion of Tat peptide, which could be traced and verified by the changes of the micro-PL of QDs. This work was published on *J. Fluoresc.*, **20**, 551-556 (2010).

2. 掺氮氧化钛在可见光诱导下对癌细胞的杀伤效应。Study on the Visible-light-induced Photokilling Effect of Nitrogen-doped TiO_2 Nanoparticles on Cancer Cells

近年来，由于氧化钛的低毒性和光稳定性，其作为光敏剂在光动力治疗领域吸引了人们的注意力。但氧化钛只能被紫外光激发，阻碍了其应用。用染料修饰或掺杂的方法可以促进氧化钛对可见光的吸收，从而促进其作为光敏剂在光动力治疗中的应用。

在我们的实验中，通过在氨气气氛下煅烧锐态矿相氧化钛制得了掺氮氧化钛纳米颗粒。掺氮氧化钛在可见光区比纯氧化钛表现出更高的吸收作用。我们研究了它们对三种癌细胞的细胞毒性与光毒性，结果表明氧化钛材料没有明显的细胞毒性。同时我们观察到了可见光诱导下氧化钛杀伤癌细胞的作用，细胞存活率随着氧化钛浓度的增加而降低，掺氮氧化钛比纯氧化钛对癌细胞具有更大的杀伤作用。我们发现在光杀伤作用的过程中，活性氧基团 ROS

起到重要的作用。另外，我们用激光扫描共聚焦显微镜研究了氧化钛在细胞中的分布，观察到了氧化钛可以存在于细胞核与高尔基体中。用可见光照射用掺氮氧化钛处理过的细胞后，观察到了微核，这也进一步表明进入细胞核的氧化钛可以直接对细胞的遗传物质造成损害，从而实现杀伤癌细胞的目的。这一部分工作刚刚被 Nanoscale Research Letters 期刊接收。

In recent years, TiO_2 attracted much attention as a photosensitizer in the field of photodynamic therapy (PDT) due to its low toxicity and high photostability. However, TiO_2 can be activated by UV light only, which hinders its applications. Improvement of the optical absorption of TiO_2 in the visible region by dye-adsorbed or doping methods will facilitate the practical application of TiO_2 as a photosensitizer for PDT.

In our experiments, Nitrogen-doped TiO_2 (N-TiO_2) nanoparticles were prepared by calcining the anatase TiO_2 nanoparticles under ammonia atmosphere. The N-TiO_2 showed higher absorbance in the visible region than the pure TiO_2. The cytotoxicity and visible-light-induced phototoxicity of the pure- and N-TiO_2 were examined for three types of cancer cell lines. No significant cytotoxicity was detected. However, the visible-light-induced photokilling effects on cells were observed. The survival fraction of the cells decreased with the increased incubation concentration of the nanoparticles. The cancer cells incubated with N-TiO_2 were killed more effectively than that with the pure TiO_2. The reactive oxygen species was found to play an important role on the photokilling effect for cells. Further more, the intracellular distributions of N-TiO_2 nanoparticles were examined by laser scanning confocal microscopy. The co-localization of N-TiO_2 nanoparticles with nuclei or Golgi complexes was observed. The aberrant nuclear morphologies such as micronuclei were detected after the N-TiO_2-treated cells were irradiated by the visible light. This is an evidence of the direct damage to the nucleus resulted from the photoexcited N-TiO_2 nanoparticles. This work was accepted by *Nanoscale Research Letters* recently.

自旋电子材料及器件及非线性光谱 / Nonlinear Optical Studies of Spintronic materials and devices

成员：赵海斌 Group members: Zhao Haibin

新型的自旋电子器件由于其功耗低、速度快、多功能集成等特点可能在未来的高密度随机存储、逻辑运算等领域带来革命性的变革。本课题小组主要利用时间分辨非线性磁光光谱开展自旋电子材料与器件的超快自旋动力学、自旋调控、界面磁性性质与自旋输运等的研究。

The novel spintronic devices may revolutionize the areas of high density random access memory and logic operations with lower power consumption, fast speed, high integration, and multifunction properties. Our group focuses on study of the ultrafast spin dynamics, manipulation, interface magnetism and spin transport by time-resolved nonlinear magneto-optical spectroscopy.

目前实验室已经利用钛宝石飞秒激光建立了时间分辨磁光克尔效应以及磁性二次谐波等测量系统，目前动态克尔角测量精度可以达到 1μrad。

We have built up a time-resolved magneto optical Kerr system, with dynamic Kerr angle measurement precision of 1μrad, and a magnetic second harmonic generation measurement system using femtosecond Ti:Sapphire lasers.

本课题组目前正在开展的项目和方向包括：1) 铁磁半导体异质结的界面磁性及其铁磁自旋动力学研究，2) 铁磁邻近效应下的半导体自旋输运与动力学过程，3) 声子的激发及其对自旋的调控。纳米磁性薄膜界面存在很多与薄膜内部迥异的自旋特性，比如我们发现的交换偏置场，非平行自旋排列等，这些性质深刻影响到自旋通过界面的输运。在开展对界面自旋性质表征与形成机制研究的同时，我们利用超快激光产生的声子等来调节磁各向异性以及自旋角动量，探索一种新型的自旋超快调控的手段。

The ongoing projects and research directions include: 1) Interface magnetism and spin dynamics in ferromagnetic semiconductor heterostructures. 2) Spin transport and dynamics in semiconductors under ferromagnetic proximity effect. 3) Phonon generation and its spin manipulation. The interface magnetic properties may be distinctively different from the bulk spins of the film, for example the exchange biasing and noncollinear spin alignment as we have discovered at the ferromagnetic semiconductor interface. These properties may profoundly affect the spin transport across the interface. We are exploring a novel approach of fast spin manipulation by phonon modulation of magnetic anisotropy and spin angular momentum at the interface as well as characterization of interface spin structures and understanding of the underneath mechanism.

量子信息与量子调控 / Quantum Information and Quantum Control
团簇光物理 / Photophysics of Nanoclusters

成员：庄军 张文献 Group member：Zhuang Jun, Zhang Wenxian

1. 电子和原子核自旋的耦合系统对于发展基于固态体系的、长寿命的量子比特具有非常重要的意义，但是全面理解它们的动力学过程仍然是一个挑战。我们发现，在电子和原子核耦合强度空间分布不均匀的单电子量子点中，耦合强度较强的原子核自旋在动态原子核极化（DNP）的过程中形成一个极化核心。在总的核自旋极化率较小的情况下，被极化的自旋核心（共有 N1 个原子核）保护电子自旋，延缓其弛豫过程，使电子的弛豫速率减小 N1 倍。这种保护效应在量子点以及固体中的缺陷中心（比如金刚石氮空位中心）中都可能实现，利用这种效应可以制作长寿命的量子比特和量子存储器。

Understanding fully the dynamics of coupled electron-nuclear spin systems, which are important for the development of long-lived qubits based on solid-state systems, remains a challenge. We show that in a singly charged semiconductor quantum dot with inhomogeneous hyperfine coupling, the nuclear spins relatively strongly coupled to the electron spin form a polarized core during the dynamical polarization process. The polarized core provides a protection effect against the electron-spin relaxation, reducing the decay rate by a factor of N_1, the number of the nuclear spins in the polarized core, at a relatively small total polarization. This protection effect may occur in quantum dots and defect centers in solids, such as nitrogen vacancy centers in diamond, and could be harnessed to implement in a relatively simple way long-lived qubits and quantum memories.

2. 我们提出，利用光学 Feshbach 共振的技术，通过周期性地改变旋量玻色－爱因斯坦凝聚的自旋交换相互作用，可以实现自旋混合动力学的局域化现象。借鉴相干调控的相关技术，我们在 ^{87}Rb 的旋量玻色－爱因斯坦凝聚中演示了自旋混合动力学的局域化效应、冻结效应、以及动力学不稳定性和自旋畴自发形成的抑制效应。通常旋量玻色－爱因斯坦凝聚中微弱的偶极相互作用会被自旋交换相互作用掩盖，而我们的研究成果指出一种非常有希望的研究偶极相互作用效应的方案。

We propose to localize spin mixing dynamics in a spin-1 Bose-Einstein condensate by a temporal modulation of spin exchange interaction, which is tunable with optical Feshbach resonance. Adopting techniques from coherent control, we demonstrate the localization and freezing of spin mixing dynamics, and the suppression of the intrinsic dynamic instability and spontaneous spin domain formation in a ferromagnetically interacting condensate of ^{87}Rb atoms. This work points to a promising scheme for investigating the weak magnetic spin dipole interaction, which is usually masked by the more dominant spin exchange interaction.

3. 在热力学中，人们通常假设正则系综和微正则系综等价的必要条件是体系和热库的耦合非常微弱，但是这个假设并没有人认真地验证过。一个例子就是正则系综中的温度在定义时假设体系同热库的耦合很弱或者没有耦合。通过研究耦合的复合自旋系统，我们研究了上述弱耦合近似成立的区间。我们的结果表明，体系和热库的耦合强度可以同体系自身的能级间距相当，显示弱耦合近似成立的条件比通常我们认为的条件宽泛得多。

It is typically assumed, without justification, that a weak coupling between a system and a bath is a necessary condition for the equivalence of a canonical ensemble and a microcanonical ensemble. For instance, in a canonical ensemble, temperature emerges if the system and the bath are uncoupled or weakly coupled. We investigate the validity region of this weak-coupling approximation, using a coupled composite-spin system. Our results show that the spin coupling strength can be as large as the level spacing of the system, indicating that the weak-coupling approximation has a much wider region of validity than usually expected.

4. 基于紧束缚势的理论计算,在一系列金属fcc(001)表面发现了吸附团簇的两种不同幻数行为， 这些吸附团簇包含了几百个原子。在一些表面,幻数系列随着团簇尺寸的增加能够一直保持下去，而在另外一些表面幻数系列则会逐步消失。为了解释这些不同的幻数行为，我们给出了基于原子-原子相互作用的理论模型。结果表明,虽然满壳层的幻数团簇决定于近邻（NN）原子-原子相互作用,但不同的幻数行为却是由于相对作用较弱的次近邻（NNN）原子-原子相互作用引起的。对于吸引的NNN原子-原子相互作用，满壳层的幻数团簇随着团簇尺寸的增加将变得不稳定，最后破裂，从而使得幻数系列消失。而对于排斥的NNN原子-原子相互作用，满壳层结构及幻数系列会一直保持。另外，我们的理论模型也有助于理解和解释平衡态下Cu(001)表面岛的形状特点.

Two different magic number behaviors in supported metal clusters, which contain several to hundreds of atoms, are revealed on a series of fcc(001) metal surfaces based on the calculations with the tight-binding potential. The magic number sequence persists on some surfaces while gradually disappears on the others with the increasing cluster size. A theory is proposed to explain these behaviors in terms of atomic interactions. We find in surprise that the different magic number behaviors are triggered by the relatively weak adatom–adatom interactions between next nearest-neighbor (NNN) atoms, although the closed shell of the magic cluster is enhanced by nearest-neighbor interactions. For an attractive NNN interaction, the closed shell of the magic cluster is gradually destabilized and eventually broken, leading to the disappearance of the magic number sequence with increasing cluster size. For a repulsive one, the closed shell and magic number sequence persists. Besides, our theory also allows a good understanding of the equilibrium shape of Cu islands on the Cu(001) surface.

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

继续开展已完成项目的后续研究"共振激励研究全息聚合物分散液晶的相分离"

1．全息光致聚合过程的活性自由基辅助的反应-扩散模型

提出了一个唯象的活性自由基浓度用以取代曝光光强，以此修改常规的反应-扩散理论中的反应常数与曝光光强成正比的理论模型，即反应常数是与活性自由基浓度成正比。 这一模型修正了光致聚合反应在曝光结束后反应常数即为零的理论缺陷，使得新的反应扩散理论可用于曝光及曝光后的整个聚合反应的全过程。 这一新理论在应用到聚合物-液晶复合光栅的形成过程的动态研究中取得了很好的结果，理论计算的和实验测量的一阶衍射效率获得了很好的一致性。

另外，实验结果表明聚合物单体的扩散系数在相差一个数量级的不同曝光强度下基本是一致的。 而光致聚合反应的衰减常数及扩散系数的衰减常数的变化与曝光强度的变化相对应。

A phenomenological concentration of reactive radical is proposed to take the role of curing light intensity in explicit proportion to the reaction rate for the conventional reaction-diffusion model. This revision rationally eliminates the theoretical defect of null reaction rate in modeling of the postcuring process, and facilitates the applicability of the model in the whole process of holographic photopolymerizations in photocurable monomer and nematic liquid crystal blend system. Excellent consistencies are obtained in both curing and postcuring processes between simulated and experimentally measured evolutions of the first order diffraction efficiency of the formed composite Bragg gratings.

An analytical method was applied for quantitative determinations of the initial rate coefficients of diffusion and reaction for a photo-curable recipe in holographic photo-polymerization. The results showed that the initial diffusion rate kept within small discrepancy despite an order of magnitude difference in the curing light power, while corresponding differences were found for the decay constants of diffusion and reaction in the curing process. Polymerization kinetics was analyzed for both curing and post curing processes.

2. 专利授权: 全息 Bragg 体光栅光谱仪

利用高效率全息 Bragg 体光栅，取代常规平面光栅构建光谱仪。 由于 Bragg 体光栅是密封在两层玻璃之间，表面不会受环境气份影响，并且可以擦拭，从而避免了平面(刻划)光栅表面受潮发霉或因表面不清洁而使其衍射效率严重下降的问题，从而延长系统使用寿命。

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[27] 刘明辉，蔡清元，毛鹏辉，郑玉祥，陈良尧；红外快速高分辨率的二维集成光栅光谱仪研究；第十五届全国凝聚态光学性质学术会议, 2010年8月，浙江，宁波

[28] 陈剑波，沈彦，周薇溪，赵海斌，郑玉祥，陈良尧；一维光子晶体能带结构的比较算法研究；第十五届全国凝聚态光学性质学术会议, 2010年8月，浙江，宁波

[29] 蔡清元，郑玉祥，毛鹏辉，张冬旭，张荣君，陈良尧；SiO_2超薄膜介电常数与厚度关系研究；第十五届全国凝聚态光学性质学术会议, 2010年8月，浙江，宁波

[30] 张冬旭 郑玉祥 蔡清元 毛鹏辉 陈良尧；Ta_2O_5纳米光学薄膜的椭圆偏振光谱研究；第十五届全国凝聚态光学性质学术会议,2010年8月，浙江，宁波

[31] 陈坤，徐达，朱焕锋，魏慎金，李晶；几种可用于太阳能电池的减反膜设计；第十五届全国凝聚态光学性质学术会议,2010年8月，浙江，宁波

[32] 陆卫杰，张荣君，蔡清元，郑玉祥，陈良尧；电子束蒸发薄膜制备系统宽光谱实时监控设计和实现；第十五届全国凝聚态光学性质学术会议, 2010年8月，浙江，宁波

[33] 俞翔，张荣君，陆卫杰，蔡清元，郑玉祥，陈良尧；电子束蒸发制备硅纳米晶体研究; 第十五届全国凝聚态光学性质学术会议, 2010年8月，浙江，宁波

[34] 盛明裕，赵源，郑玉祥，赵海滨，徐敏，陈良尧；光频电磁波在薄膜结构中传播的空间干涉现象研究；第十五届全国凝聚态光学性质学术会议, 2010年8月，浙江，宁波

[35] 盛明裕，赵源，郑玉祥，陈良尧；等离子体辅助电子束蒸发低温制备SiO_2纳光子薄膜; 第十五届全国凝聚态光学性质学术会议, 2010年8月，浙江，宁波

[36] 赵源，盛明裕，周薇溪，郑玉祥，陈良尧；分光谱太阳能光电转换系统研究；第十五届全国凝聚态光学性质学术会议,2010年8月，浙江，宁波

[37] 周薇溪，戴仲鸿，沈彦，陈剑波，李晶，郑玉祥，赵海滨，陈良尧；可见光在铜/空气界面的正负折射现象研究；第十五届全国凝聚态光学性质学术会议, 2010年8月，浙江，宁波

[38] 朱焕锋，魏慎金，陈坤，徐达，李晶，陈良尧；铁SiO2薄膜的制备及其磁光效应的增强; 第十五届全国凝聚态光学性质学术会议, 2010年8月，浙江，宁波

[39] 沈彦，周薇溪，陈剑波，李晶，郑玉祥，王松有，张荣君，陈良尧；金属的表面等离子体共振现象的机理研究；第十五届全国凝聚态光学性质学术会议, 2010年8月，浙江，宁波

[40] 耿昭华, 岳国清, 吴松, 王松有, 陈良尧，贾瑜；V掺杂SiGe2N4和GeSi2N4的电子结构和光学性质理论研究；第十五届全国凝聚态光学性质学术会议, 2010年8月，浙江，宁波

[41] 付相宇, 柯福顺, 吴松, 王松有, 陈良尧, 贾瑜； Cr、O共掺杂对GaN电子结构和光学性质影响的理论研究；第十五届全国凝聚态光学性质学术会议,2010年8月，浙江，宁波

[42] 岳国清, 王松有, 陈良尧, 贾瑜；$CuGa(S,Se,Te)_2$和$CuIn(S,Se,Te)_2$电子结构和光学性质第一性原理研究；第十五届全国凝聚态光学性质学术会议, 2010年8月，浙江，宁波

[43] 胡二涛, 王松有, 陈良尧, 贾瑜；I-VI族三元化合物$Zn_{1-x}Cd_xS$和$Zn_{1-x}Cd_xSe$的电子结构和光学性质第一性原理研究；第十五届全国凝聚态光学性质学术会议, 2010年8月，浙江，宁波

[44] 陈剑波，沈彦，周薇溪，赵海斌，郑玉祥，陈良尧；一维光子晶体能带结构的比较算法研究； 全国光学大学，2010年8月，天津

[45] 陈良尧；新一代高灵敏数码成像技术的研究和发展；(1).全国光学大会，2010年8月，天津。(2). 东方科技论坛，2010年9月，上海

[46] 赵源，盛明裕，周薇溪，郑玉祥，陈良尧；分光谱太阳能光电转换系统研究；全国光学大会，2010年8月，天津

[47] 第十五届全国凝聚态光学性质学术会议, 陈良尧教授担任会议组织委员会主席，2010年 8 月在浙江省宁波市召开。（举办的国内会议）

[48] 东方科技论坛，主题：三维数码信息获取和显示的研究与应用, 陈良尧教授担任会议共主席， 2010 年 9 月，在上海召开。（举办的国内会议）

学位论文/Dissertations

1. 博士学位论文

[1] 李晓凡，**太阳光谱选择性的微纳光子结构特性和制备研究**；导师：陈良尧

[2] 陈　英，**高功率钕玻璃激光系统的宽带三倍频技术方案研究**；导师：钱列加

[3] 邱　娉，**中红外飞秒光参量放大过程中闲频光相移研究**；导师：范滇元

[4] 任红艳，**光参量放大器件中泵浦激光位相研究**；导师：范滇元，　钱列加

[5] 赵　源，**分光谱太阳能光电转换系统研究**；导师：陈良尧

[6] 刘明辉，**红外快速高分辨率光谱分析和应用研究**；导师：陈良尧

[7] 毛鹏辉，**并行快速椭圆偏振分析方法研究**；导师：陈良尧

2. 硕士学位论文

[1] 张旭辉，**垂直磁记录介质材料的制备及翻转模式研究**；导师：马斌

[2] 唐　佳，**Fe/Ni 多层膜的结构与磁性研究**；导师：马斌

[3] 邱永成，**垂直磁各向异性器件中的自旋转移矩效应模拟研究**；导师：张宗芝

[4] 李振亚，**垂直磁化自旋阀的制备及其热稳定性研究**；导师：张宗芝

[5] 马鎏学，**探针作用下 Ag(001)表面吸附原子的扩散动力学及原子操纵**；导师：庄军

[6] 蒲海辉，**全息聚合物分散液晶 Bragg 光栅的机理研究与性能优化**；导师：刘建华

[7] 黄丽媛，**新型掺钕液体激光器液体介质的研究**；导师：彭波

[8] 李双柱，**新型超支化共轭聚合物三阶非线性光学性能研究**；导师：韦玮

[9] 腾雪雷，**基因突变的菌视紫红质聚合膜的光学非线性及在全息存储方面的应用研究**；
导师：赵有源　陆明

[10] 张　岩，**有机半导体复合薄膜的输运性质和横向光伏效应**；导师：倪刚

[11] 冯　慧，**ECR-PLA 的激发增强和 ECR-PLA 中的气相反应光学**；导师：吴嘉达

[12] 唐文涛，**ⅣB 族金属氧化物 HfO_2 和 ZrO_2 薄膜的制备、表征和性质研究**；导师：应质峰

[13] 王　刚，**两种红外探测材料和 Mg_2FeH_6 的电子结构和光学性质的理论研究**；
导师：王松有

[14] 冯　亮，**纳晶硅超晶格薄膜的椭偏光谱和发光性质研究**；导师：李晶

[15] 王骁栋，**掺杂对 ZrO_2 信息功能薄膜的影响及其性质研究**；导师：李晶

主办国际会议/ Sponsored International Conferences

第八届（2010）中韩双边光电子会议；2010-08-01, 首尔，韩国

2010 年 8 月 1- 4 日，第八届（2010）中韩双边光电子会议在韩国首尔召开。会议由韩国汉阳大学量子光科学研究中心、自旋动力学与自旋波器件研究中心和中国复旦大学信息科学与工程学院共同主办。大会主席由韩国物理学会会长、汉阳大学教授 Young-Pak Lee（李英白）和复旦大学信息学院陈良尧教授共同担任。来自中韩两国 40 余位代表参加了会议。与会代表提供了 21 篇口头报告和 16 篇张贴报告。其中复旦大学提供了 6 篇口头报告。本次会议内容覆盖纳米光子学、光子学器件、应用光学及材料光学性质、自旋电子学等研究领域的最新进展，为中韩两国在光电子学领域的同行提供了良好的交流平台。

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	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
2	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
3	红外Erbium(铒)系、Holmium(钬)系透明陶瓷材料的激光特性研究	唐定远	副教授	南洋理工大学 Nanyang Technological University	2010.10 -2012.10
4	聚合物-液晶复合光栅的光学层析显微研究	Zhongping Chen	教授	Beckman Laser Institute, Department of Biomedical Enginering, University of California, Irvine	2010.10 -2012.10
5	垂直磁化纳米巨磁电阻器件中的自旋超快动力学行为研究	Stephane Mangin	教授	Institut Jean Lamour,CNRS UMR 7198-Nancy-Université	2010.10 -2012.10
6	高Q微腔用于生物传感的探索性研究	范旭东	副教授	University of Michigan,USA	2010.10 -2012.10

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	Professor Yaron Silberberg, Physics of Complex Systems Weizmann Institute of Science, Israel	Israel	Tight-binding in a new light: Photons in periodic and disordered lattices	2010.1.11
2	Prof. Robert Chang, 美国材料科学与工程系教授，材料研究所所长，美国材料学会议员(councillor), J.Materials Research杂志主编。	USA	Dye Sensitized Solar Cell	2010.3.2

3	Viatcheslav V. Dobrovitski, Ames laboratory as DoE, and Iows state University	USA	Quanturn dynamics and control of spins in silicon and diamond	2010.3.31
4	肖力敏 博士, 2008年在英国巴斯大学物理系光子&光子材料中心从事博士后研究。	USA	Photonic Crystal Fiber and “Solid-air” Nanostructure Silica Material	2010.4.15
5	蔡司光学技术专家	德国	现代光学设计及先进制造技术	2010.5.10 -5.14
6	Dr. Haiqing Xianyu, College of optics and photonics, University of central florida	USA	Chiral liquid crytal in displays: Tunable color cholesteric liquid crystal display and polymer stabilized blue phase	2010.5.12
7	Prof. Weidong Yang, Bowling Green, University	USA	Single-molecule biophysics: Tjree-dimensional snapshots of nuclear transport in carcer cells	2010.6.2
8	唐定远 副教授，Nanyang Technological University	新加坡	Dark pulse emission lasers	2010.6.22
9	陈启婴教授, Memorial University of Newfoundland, Canada	加拿大	Ultrafast nano-photonics	2010.7.7
10	Prof.沈元壤, U. C. Berkeley	USA	Celebrating Fifty Years of Laser Science	2010.9.14
11	Wenhui Li，副教授，新加坡国立大学	新加坡	学术访问	2010.9.17 -9.25
12	Zhiqiang Xie Ph.D, Candidate Department of Electrical Engineering University of Nebraska-Lincoln Lincoln, Nebraska	USA	Laser vibrational excitation of chemical species in multi-energy processing for diamond deposition	2010.10. 18
13	王峰 Ph.D, Candidate at the liquid crystal institute of kent state university graduated from OSE	UK	Nano and liquid crystal research at liquid crystal institute of kent state university	2010.10. 18
14	Prof. Hailin Wang, University of Oregon and Oregon Center of Optics	USA	Optomechanics: controlling mec hanical motion with light.	2010.12. 15