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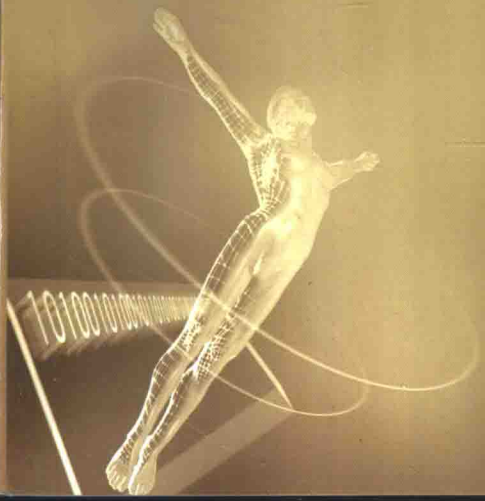
材料科学与化学工程

Materials and Chemical Engineering

魏巍　李伟　主编



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前　言

世界的发展需要中国，中国的富强也离不开世界。打开国门，与全世界交流，才是中国发展的正确道路。尤其是随着中国成功地加入 WTO，科技英语的地位显得更为重要，国际、国内的许多公司企业迫切需要掌握这项技能的人才。为了适应社会的发展和需要，同时为了配合目前高等学校纷纷设立的双语课程的教学，我们专门组织各高校工科专业的青年教师骨干和学术学科带头人编写了《21 世纪高新科技专业英语阅读系列》丛书。

本丛书共分 8 册，包括：《材料科学与化学工程》、《计算机与信息技术》、《光电世界》、《电子世界》、《现代通信技术》、《航空航天技术》、《生物工程与医学》、《人工智能》。

每个分册都在精选富有时代感和代表性文章的基础上，精心设计了技术背景、词语注释、句子注释三个方面的内容。技术背景能帮助读者进一步了解各项科学技术在全世界的发展、现状以及未来；词语注释、句子注释能使读者更好地理解文章内容，并进一步掌握专业词汇和语句。其中：

《材料科学与化学工程》用通俗易懂的语言讲述了材料科学和化学工程的各个研究方向，使读者对这两个学科有较全面的了解。本书在选材方面注意了材料科学和化学工程领域内的最新科技进展，使读者能够追踪到两个学科的研究发展前沿。

《计算机与信息技术》是一系列当今热点技术的汇总，覆盖了几乎整个计算机与信息技术领域内的相关内容。无论是早期的电

话网、大型计算机和半导体技术，或是新兴的 Internet、局域网、个人计算机及重要软件；无论是最新的理论研究，或是实践中的重大成果，都有相关的英语文章与之相对应。

《光电世界》主要讲述了光电技术的应用，包括电力市场、太阳能发电、电子碰撞电离现象、电荷耦合器件、全光逻辑器件以及光子学的研究等知识。

《电子世界》收集了可编程逻辑电路、转换脉冲、数字信号处理、动态随机存储器、混合信号设计及有关电子工程技术各个方面的知识。

《现代通信技术》讲述了现代通信技术的各种方式以及各种通信系统，并对下一代通信方式进行了预测：随着社会经济的发展，电话业务的适度发展和数据业务的超常发展将是未来我国电信业务市场的主要特征，电话业务由主变辅，以互联网技术为核心的数据网络将最终成为网络的主体。

《航空航天技术》基于“航天航空技术的发展显示了中国综合国力的增强”这一认识，对航空航天技术中相关领域分别进行了阐述，不仅介绍了太阳系的成员，探索了外层空间，阐述了飞机的制造，更展望了航空航天技术的发展。

《生物工程与医学》涵盖了人类基因工程、人类基因组数据、人工制造血管、超级人造细胞、干细胞、人类寿命、遗传、克隆等生物技术知识，并分析了进餐时间与人体生物钟的关系，人寿保险与社会的关系，癌症药物的新来源以及过敏、精神分析、肥胖症和糖尿病等社会医学问题，全面概述了生物与医学等方面的知识。

《人工智能》讲述了人工智能理论的原理，人类智能与机器之间的关系，人工智能、逻辑推理计算机、模糊计算机和神经网络计算机之间的关系以及人工智能技术开发、人工生命研究、机器人等

知识，能够帮助读者获得有关人工智能各个方面的最新技术发展情况。

通过对丛书的阅读，我们不仅希望能使读者对相关领域内的常用科技英语词汇、术语有一个全面的初步印象，还想借此机会能够让大家进一步了解到科技的发展现状与趋势，从而为大家在具体研究中起到一定的帮助作用。

如果您看完本书后觉得物有所值，能使您的知识有所增长，那就是我们最大的欣慰了。由于时间仓促，作者水平有限，书中难免存在疏漏与不足之处，还望各位专家读者不吝赐教，以便我们修订再版时予以订正。

编　者

2003.05

内容简介

材料是所有工业的基础，材料工业是我国国民经济建设中的重要工业。材料科学包括超导材料，复合材料，磁性材料等；化学工程包括反应动力学，化工原理，化学工艺等。本书着重讲述了这两个方面的最新研究方向。以期使读者了解这两个学科的发展前沿。本书在选材方面注意了材料科学和化学工程领域内的最新科技进展，使读者能够追踪到两个学科的研究前沿发展。

本书可作为高等院校材料工程与化学工程专业师生的科技英语学习指导书，也可作为科研人员和专业人士进行科技英语学习的参考书。

Content

目　录

Chapter 1 Superconducting Materials
超导材料

【原文】

1

We examine the effects of random magnetic field errors on the performance of a free electron laser(1). We report a modification of the straightest wiggler orbit operating point【1】(SWOOP) theory for two very high efficiency systems. The first system utilizes a gapless pulsed cryogenic wiggler【2】and the second a continuous wave gapless superconduction wiggler【3】. We further show a method to improve the choice of separation of correctors. To establish this method we show that corrected steering errors【4】, BPM errors and gap maladjustments are errors similarly construed as phase errors(ESCAPE). The corrected steering errors also have a component that requires retuning of the wiggler and this task is relegated to unoptimized SWOOP. Without this retuning, these errors are similar to an effective emittance, but because the steering errors are homogeneous and the emittance is inhomogeneous, the emittance cannot be removed by retuning except for the resonant particle. The remaining part of the field errors are similar to phase errors and behave like a random force in the KMR potential (2). In a retuned wiggler, the effective energy broadening fromemittance is responsible for the initial trapping and the field errors are responsible for the detrapping. This work constitutes a complete high-efficiency model of phase, gap and corrected steering errors for an ensemble of free

electron lasers. The classical bound-free transition, the detrapping phenomenon, is treated as the Kramers problem.

2

The transport properties in two-phase (Ac, M)granular composites generally depend on several parameters: the interfaces(Ac/Ac, M/M, Ac/M), the grain sizes and morphologies, the percolation threshold(3). Generally in such(Ac, M)composites, one of the component(M)plays a mechanical role, and an other(Ac)presents a transport property as electron conduction, superconduction, or ionic conduction. We present here the various simulation approaches which can be used to better understand the final properties of such composites. Two types of composites can be considered: sintered two-phase composites in which chemical diffusions and interphase formation occur at the interfaces, polymer/ceramics composites in which weak links are involved between grains(4). To better understand the transport properties in two-phase composites three types of approaches are presented:

(1) a microstructural approach[5];

(2) the effective medium approximation[6];

(3) the percolation theory[7]. Several examples are selected to illustrate and discuss these various approaches.

3

The outer-most electrons of metal atoms and the remaining valence electrons of any molecular atoms form three-dimensional crystallizing π-bondings(5). These π-bondings are quantum-mechanically [8]modeled by a cyclic Kronig-Penny modeland energy band structures are analyzed with their potential barrier thickness[9]. The waves generated between plus charged ions are the particular π-far

infrared rays, which have dual properties between material and electro-magnetic waves[10]and can be measured not by a modern electro-magnetic tester but by a biosensor[11], such as the finger's force tester on the quantum resonance spectrometer. Circulating electrons on the crystallizing orbitals are thrown out into space at the deficient atom sites in the case of copper oxide and organic superconductors(6). In the case of metallic compounds and pure metals, because the outer-most electrons of the same sites have very low kinetic energy[12]at very low temperatures, they also seem to have deficient atom sites of the π-bonding orbitals such as do high temperature superconductors[13]. The electrons thrown out into space circulate around the π-bonding orbitals near to the deficient atom sites, which is the vortex. If a moving electron is at any end side of the superconductors, the electron can move without any resistivity[14] in any direction.

4

Experimental and calculated dependences of granular superconductor magnetic susceptibility on the superconduction volume fraction in regimes of shielding(ZFC), Meissner effect(FC)and remanence(REM)were determined(7). Fractional dependences were calculated with Braggeman's asymmetric theory[15]and allowing for the shape of superconducting grains and the sample and the influence of grain sizes upon their polarizability[16]under different magnetization conditions[17]. A granular superconductor with intergranular links is calculated as a three-component system where closed clusters are regarded as superconducting particles and the function of distribution of these particles, depending on the superconducting volume fraction[18], is introduced. The results of calculation agree well with the experimental data in the ZFC regime for all fraction

$f = 0 \sim 1$ but in the FC and REM regimes for $f \leqslant 0.6$. The calculation for the links region gives a qualitative description of singularities in the experimental dependences. Nomograms for determining the superconducting volume fraction in high-Tc superconductors were constructed(8).

5

Numerical and analytical calculations of the current charging process into a round superconducting composite with properties homogenized over its cross-section are presented(9). A solution was sought which accounted for simultaneous thermal and electromagnetic processes[19]taking place. A wire was considered with a current-voltage characteristic[20] approximated by an exponential curve with the current density and temperature taken as parameters. The results obtained are compared with the pulsed thermal disturbances stability theory[21]. It is shown that calculations of the superconducting state stability of the wire made at various rates of current charging, the I-V characteristics, the matrix materials, the heat transfer coefficients and other parameters agree qualitatively with the basic principles of the thermal stability theory. Accordingly, a limiting current exists below which the wire remains in the superconducting state and above which the wire is quenched when current charging is stopped(10); this current is somewhat less than the take-off current. The approximate analytical solution of the problem is defined. The non-isothermality[22]of the wire, its heat capacity, and its thermal and electric conductivities are taken into account in the derived stability criterion.

6

High-Tc ceramic(YBCO)superconduction microstrip transmis-

sion lines have been fabricated on MgO and $SrTiO_3$ substrates by a sputtering technique and a screen printing method(11). Sputtering conditions for preparation of microstrip lines are described, and properties of the sputter-deposited films【23】are discussed. The characteristic impedance of the microstrip line was measured by a digitizing oscilloscope【24】to compare it with the specifications. A satisfactory agreement was obtained with theoretical results at both room and low temperatures. In order to investigate the properties of the fabricated microstrip transmission line, the propagation constants【25】, mainly the attenuation and the phase constant, were measured for a sinusoidal wave with the frequencies from 10 MHz to 26.5 GHz, in comparison with those of Al microstrip line fabricated on the MgO substrate. The results show that the attenuation of YBCO transmission line at 4.2 K was about the order of 10^{-2} dB/cm, a limit of the experimental equipment, for the frequency up to 10 GHz (12).

7

Superconducting $Ba_2YCu_3O_{7-\delta}$ (BYCO) film were prepared on yttria-stabilized zirconia substrates by the dipping-pyrolysis process using metal laurates as starting materials(13). Propionic acid【26】and pyridine【27】were selected as solvents based on a screening test on solubility of Ba^+, Y^+ and Cu^+ laurates in 26 organic liquids with various functional groups. An homogeneous solution of mixed laureates(Ba: Y: Cu=2: 1: 3) was prepared using a mixture of propionic acid pyridine. This solution was spin-coated【28】on the YSZ substrates and preheated at 500°C in air to make ($BaCO_3$-Y_2O_3-CuO) precursor films. After this procedure was repeated 15 times, the precursor films were heat treated at 925℃～970℃ in O_2 to give 2 μm thick films which showed superconduction at $T_{c,zero}$ of 69K～

84 K. Observation with a scanning electron microscope and X-ray diffraction analysis showed dense textures of orthorhombic grains [29].

8

A study was made of the effects of Ag doping on the superconductivity of $YBa_2Cu_3O_y$ ceramics (14). Three type of systems of nominal composition $YBa_{2-x}Ag_xCu_3O_y$, $YBa_2Cu_{3-x}Ag_xO_y$, and $YBa_2Cu_3O_y$. Ag_x ($x=0.1$, 0.3, 0.7), were used as the Ag substituted and doped samples and were compared with each other with respect to their structural, morphological, and superconducting properties. Ag is substituted for Cu in preference to Ba, although Ag is not completely substituted for these cations [30] in the range xgt; 0.1. Ag promotes crystallization and c-axis orientation in Y-Ba-Cu systems, especially in the case of the presence of Ba vacancies. Ag catalyzes the intergranular coupling [31] of the superconductor grains in the ceramics, even if relatively large amounts of impurity phases are present. The Tc slightly shifts to higher temperature and the Jc increases upon nominal Ag substitution for Cu. This result suggests that the Ag substituted superconductor phase for Cu has a higher Tc and a larger Jc than the nondoped phase(15).

9

Usually, introduction of holes into La_2CuO_4 is made by the replacement of part of La with M (Ba, Sr, or Ca), while most of studies on $(La_{1-x}M_x)_2CuO_y$ superconductors have been conducted by changing the content of M(16). Enhancing the content of excess oxygen is another method of controlling the hole concentration. The typical example of this method is $YBa_2Cu_3O_y$. The different methods of doping affect the superconductor in different ways and would

be useful in bringing about high Tc superconduction and in improving the properties of superconductors. The purpose of this study is to determine Tc as a function of x and y[32] for$(La_{1-x}M_x)_2CuO_y$.

Most researchers have calculated the composition of samples not on the basis ofchemical analysis but on the weights of the raw materials used for the preparation(17). However, the raw materials often contain water and other impurities[33]and in some cases lose weight by evaporation[34]during heating at high temperatures. As a result, the actual composition deviates from that calculated. A process whereby the sample of desired composition can be obtained without deviation must be employed. It has widely been recognized that oxygen content is crucial [35]to the high Tc superconduction. The anneal condition[36]and the chemical analysis of the oxygen content [37]must be established. However, to date studies carried out using qualified samples seem to be quite few.

The thermodynamic studies on the superconducting oxides have revealed that these oxides are thermodynamically[38]not very stable in low temperature(18). An example is $(La_{1-x}M_x)_2CuO_y$, which shows a remarkable decrease in Tc near $x\frac{1}{4}0.0625$. We have determined the enthalpy change[39]of formation reaction of LBCO from the constituent simple oxides by solution calorimetry[40]and have found that LBCO with x in the vicinity of 0.0625 [41]is thermodynamically unstable. It was concluded that the energy at this instability level would partially be released by the successive THT—OLT—TLT transition and results in a remarkable decrease in T_c. This fact means that care must be taken in the preparation of the superconductors so that the segregation does not occur(19). [42] Inthis study, samples were prepared with care with excellent reproducibility [43]of data.

10

Following a lengthy period of development, Stirring refrigerators have emerged as the preferred system for the miniature cryocoolers used in infrared night-vision, missile guidance systems, and other low-capacity cryogenic sensors(20). Single-stage expansion integral and split-Stirling refrigerators having capacities of 1/4 to 1 W at 80 K are in series volume production. They are characterized by increasing reliability. Present difficulties with the cooler/sensor interface and of fluid leakage will be overcome by manufacture of integrated cooler/sensor units welded leakproof【44】and having no provision for field servicing. Eventual production is anticipated of throwaway, radio-tube-like, cryocooler/sensor units capable of plugging in to ambient temperature circuits. The use of multistage expansion Stirling cryocooler【45】for superconduction electronics is anticipated with the development of the high-temperature superconducting materials having critical temperatures near 20 K and operating temperatures near 10 K. The availability of a reliable, compact, relatively low-cost, 10 K refrigerator would eliminate the need for liquid helium cooling【46】.

【技术背景】

自 1986 年发现氧化物高温超导体后不久,“超导热”不仅吸引了世界上许多科学家,而且就连普通人也家喻户晓。临界温度 T_c 从发现时 La 系中的 30K,像腾空之龙一样急剧上升,Y 系(90K)、Bi 系(85K,110K)、T1 系 130K,已经非常简单地超越了属于高温超导体实用一大目标的液氮温度(77K),正可谓是一场“革命”。与此同时,高温超导体以实用化为目标的开发研究工作随之稳步开展。

我们知道,BCS 理论对高温超导体已不适用,虽然目前氧化物高温超导的物性正逐渐得以搞清,但是,要想简洁明快地说明这些内容还是很难的,至今还没有成功的实例。现在也仅能将已发现