



真空与表面工程

——第十届国际真空冶金与表面工程学术会议、
2011年真空工程学术会议、
2011年真空咨询工作会议学术论文集

Vacuum and Surface Engineering

——Proceedings of the 10th International Conference on Vacuum Metallurgy
and Surface Engineering, Vacuum Engineering Conference 2011
and Vacuum Consultancy Workshop 2011

主 编：巴德纯

Editor in Chief: Ba Dechun

副主编：雷震霖 张振厚 张世伟 刘 坤

Subeditor: Lei Zhenlin Zhang Zhenhou Zhang Shiwei Liu Kun



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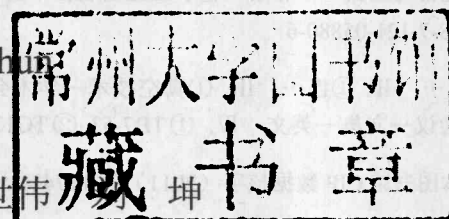
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内 容 简 介

本书是 2011 年在中国沈阳举办的第十届国际真空冶金与表面工程学术会议、2011 年真空工程学术会议、2011 年真空咨询工作会议的学术论文集,收录了来自国内外的 82 篇投稿论文,反映了近年来在真空冶金与表面工程、真空科学与技术、真空工程等领域的许多最新科研成果,内容主要包括炉外精炼技术;真空冶炼;真空热处理;真空冶金涂层;表面改性技术;生物材料表面工程;纳米表面工程和纳米摩擦学;超硬薄膜与功能薄膜;气相沉积技术;摩擦学;腐蚀与防护;纳米新材料的真空制备技术;表面工程基本问题;真空技术及应用;真空设备故障诊断;真空冶金设备的自动化;真空工程技术的展望;真空工程技术的最新理论探讨;真空技术的新发展;真空工程技术的新工艺;大型成套真空设备的研究开发及应用;引进国外真空技术消化吸收和国产化;真空测量技术的发展和运用;真空检漏;真空技术其他领域等,可供从事真空工程、真空冶金、表面工程、真空应用等研究和应用领域的学者、技术人员和研究生参考。

This book gathers 82 pieces of papers from the the 10th International Conference on Vacuum Metallurgy and Surface Engineering, Vacuum Engineering Conference 2011 and Vacuum Consultancy Workshop 2011 held in Shenyang, China in 2011, which reflects many latest research achievements in such areas as vacuum metallurgy and surface engineering, vacuum science and technology, vacuum engineering in recent years. The papers mainly cover many subjects like refinement technique outside furnace, vapor deposition technology, vacuum melting technology, tribology, vacuum heat treatment, corrosion prevention, vacuum metallurgy coating, the vacuum fabrication technology of new nanometer material, surface modification technology, the basic problem of the surface engineering, the surface engineering of biological materials, vacuum science and technology, the nanometer surface engineering and nanometer tribology, fault diagnose to the vacuum equipments, superhard film and functional film, the automatization of large vacuum metallurgy equipments, new process of vacuum engineering, research and development of large scale vacuum equipments, vacuum leak detect, and others in vacuum technology, etc. As a good reference book, it is fir for scholars, technical personals and graduate students engaged in vacuum metallurgy, vacuum engineering, surface engineering, and vacuum applications.

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Preface

The international conferences on Vacuum Metallurgy and Surface Engineering are sponsored by the Vacuum Metallurgy Committee of Chinese Vacuum Society (CVS-VMC), which has been already held eight times since 1978. Moreover, the next conference was held every two years since 2003, which is to provide a chance for experts, scholars, technical engineers in these areas to communicate with each other. As a result, science and technology in these areas can be rapidly developed.

Vacuum Engineering Conference 2011 is sponsored by the Vacuum Engineering Committee of Chinese Vacuum Society (CVS-VEC), which is one of the most important conferences in vacuum science and technology. Vacuum Engineering Conference was held every two years since 2005.

Vacuum Consultancy Workshop 2011 is sponsored by the Vacuum Consultancy Committee of Chinese Vacuum Society (CVS-VCC), which provides policy consultancy and survey report for vacuum industry held every year.

The 10th Vacuum Metallurgy and Surface Engineering Conference, joined with VEC2011 and VCW2011, will be held in May 22nd to 26th of 2011 in Shenyang, Liaoning Province of China. This conference is sponsored by Northeastern University and SKY Technology Development Company Ltd. of CAS. About 10 well-known scholars or professors will give wonderful invited speeches at the conference.

Close till April 30, 2011, we totally received over 120 articles. This book gathered 82 pieces of papers selected by the Academia Committee. There are three grouped conference include Vacuum Metallurgy, Vacuum Engineering, Vacuum Science and Technology. We also organized visits to some related factories. We hope that the meeting could become the bridge of universities, research departments, factories and enterprises. We should appreciate the financial support of several enterprises.

Thanks for the hard work of Electronics Industrial Publication House and the outstanding work of each author, which helps the proceedings able to be printed. We also hope that our work will be meaningful for the academic and technical development of vacuum metallurgy and surface engineering.

VMC/VEC/VCC of CVS

May 26, 2011

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Part 1 Vacuum Metallurgy

A Study of Sintered Nd-Fe-B magnet coated by DyAl layer

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Abstract: A DyAl layer has been deposited on sintered Nd-Fe-B magnet surface by DC sputtering method. The magnets coated by DyAl layer were processed heating treatment. Magnetic properties, resistance of corrosion and microstructures of the annealed samples have been investigated. The results show that the magnetic properties of the samples can be improved because the Dy and Al elements are diffused into the magnet. The press cooker test (PCT) and spray salt test (SST) shows that the corrosion resistance and magnetic loss resistance have been obviously improved. The microstructure observation reveals that the Dy and Al element diffusion optimizes distribution of Dy and Al in the sample, and is responsibility for the improvements of magnetic properties and protecting corrosion.

Keywords: Sputtering, DyAl layer, sintered Nd-Fe-B, thermal diffusion.

1 Introduction

Recently, NdFeB permanent magnetic materials are a more and more important role because it's excellent energy product and high intrinsic coercivity. Sintered NdFeB magnet is widely used in electronic information, automotive industry, medical facilities, energy and transportation, industrial energy-saving motor, energy-saving household electrical appliances, wind power generation. However, the sintered NdFeB magnet has some problems, such as poor heat loss resistance and corrosion resistance, which limited its more application. How to improve heat-resistance and corrosion resistance of the sintered NdFeB magnet has become an urgent subject.

In this work, the DyAl alloy layer was deposited on the sintered NdFeB magnets surface by magnetron sputtering. And then a heating treatment was processed to diffuse Dy and Al elements into magnet. The diffused Dy and Al elements mostly locate on the grain boundary, which can optimize microstructures. It's expected to improve heat-resistance and corrosion resistance by using this method.

2 Experimental

The sintered 45M magnets were sampled into a few of cylinders ($\Phi 10 \times 5$ mm). The DyAl layer was deposited by FJL560CI1 sputtering system under following parameters, target with $\text{Dy}_{35}\text{Al}_{65}$ composition, background vacuum of 8×10^{-4} Pa, and DC power of 300W. The samples were sputtered for different time (0.5 h, 1 h and 1.5 h), and the fabricated samples for different time were named 1[#], 2[#], and 3[#] (3[#]-1、3[#]-2), respectively. The samples 1[#], 2[#], and 3[#]-1 were thermally diffused at 800°C for 6h, and then the samples were processed a heating treatment (900°C×2.5h+490°C×5h). The sample 3[#]-2 was sealed into quarter tube, and then was processed heating treatment