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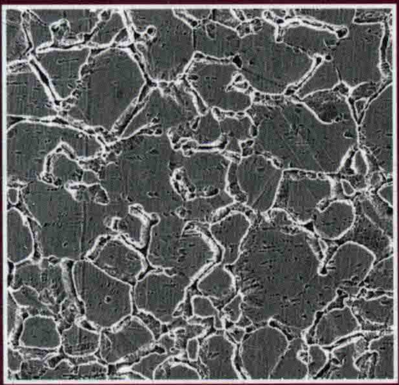

激光表面改性处理合金的耐蚀性能

Laser surface modification of alloys for corrosion and erosion resistance

Edited by Chi Tat Kwok

哈爾濱工業大學出版社
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Chi Tat Kwok
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影印版说明

本书介绍了近年来激光表面改性技术在腐蚀防护、腐蚀损伤零部件修复等方面的应用成果，讨论了钢、镍合金、钛合金等合金提高耐蚀性能的多种技术方法，分析了应用激光表面改性技术防止金属遭受液体冲蚀等不同腐蚀机制的腐蚀以及激光再制造损伤零件等的研究成果。

本书共分两部分内容，第一部分为提高耐腐蚀抗开裂性能，第二部分为改善耐磨和耐蚀性能。

本书主要适合从事表面改性处理的科研人员、技术人员使用，也可供高等院校相关专业的师生参考。

Chi Tat Kwok　中国澳门大学机电工程系副教授，在腐蚀和表面工程研究领域成果突出。

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联系电话 0451-86412421

　　　　 0451-86414559

邮　　箱 yh_bj@aliyun.com

　　　　 xuyaying81823@gmail.com

　　　　 zhxh6414559@aliyun.com

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Edited by

Chi Tat Kwok

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Contributor contact details

(* = main contact)

Editor

C. T. Kwok
Department of Electromechanical Engineering
University of Macau
Macau
China

E-mail: fstctk@umac.mo

Chapter 1

R. Vilar
Department of Chemical Engineering
Instituto Superior Técnico
Technical University of Lisbon
Av. RoviscoPais
1049-001 Lisbon
Portugal

E-mail: rui.vilar@ist.utl.pt

Chapter 2

K. Shinozaki*
Department of Mechanical Science and Engineering
Hiroshima University
1-4-1 Kagamiyama
Higashi-Hiroshima
Hiroshima
Japan

E-mail: kshino@hiroshima-u.ac.jp

T. Tokairin
Babcock-Hitachi K.K.
5-3 Takaramachi
Kure
Hiroshima
Japan

E-mail: tsuyoshi.tokairin.bu@hitachi.com

Chapter 3

W. K. Chan, C. T. Kwok* and K. H. Lo
Department of Electromechanical Engineering
University of Macau
Macau
China

E-mail: fstctk@umac.mo

Chapter 4

N. Semmar* and C. Boulmer-Leborgne
GREMI-UMR 6606 CNRS
University of Orléans
14 rue d'Issoudun
BP 6744
45067 Orléans cedex 2
France

E-mail: nadjib.semmar@univ-orleans.fr

Chapter 5

K. W. Ng and H. C. Man*
Department of Industrial and Systems Engineering
Hong Kong Polytechnic University
Hong Kong
China

E-mail: mfhcman@inet.polyu.edu.hk

Chapter 6

M. Duraiselvam
Department of Production Engineering
National Institute of Technology
Tiruchirappalli – 620 015
India

E-mail: durai@nitt.edu

Chapter 7

R. C. Shivamurthy and M. Kamaraj*
Department of Metallurgical and Materials Engineering
Indian Institute of Technology Madras
Chennai-36
India

E-mail: kamaraj@iitm.ac.in; rcshy123@yahoo.co.in

R. Nagarajan
Department of Chemical Engineering
Indian Institute of Technology Madras
Chennai-36
India

E-mail: nag@iitm.ac.in

S. M. Shariff and G. Padmanabham
Centre for Laser Processing of Materials
International Advanced Research Centre for Powder Metallurgy and Newer Materials (ARCI)
Hyderabad-05
India

E-mail: saabi@rediffmail.com; gpb@arci.ernet.in

Chapter 8

P. K. Wong and C. T. Kwok*
Department of Electromechanical Engineering
University of Macau
Macau
China

E-mail: fstctk@umac.mo

H. C. Man and F. T. Cheng
Department of Industrial and Systems Engineering
The Hong Kong Polytechnic University
Hong Kong
China

Chapter 9

J. H. Yao, Q. L. Zhang and F. Z. Kong
Zhejiang University of Technology
No.6 Chaohui District
Hangzhou
310014
China

E-mail: laser@zjut.edu.cn

Chapter 10

Buta Singh Sidhu
Punjab Technical University
Jalandhar-Kapurthala Highway
Jalandhar (Punjab)
India-144601

E-mail: butasidhu@yahoo.com

Introduction

C. T. KWOK, Department of Electromechanical Engineering,
University of Macau, Macau, China

Corrosion and erosion are material degradation processes which cause considerable environmental nuisance because they lead to valuable materials deteriorating, and becoming damaged and wasted. They can lead to failures in tools, machines, vehicles and infrastructure which are usually costly in terms of maintenance, environmental damage and human safety. Corrosion and erosion occur due to certain external actions on the surface of a material. According to the definitions, corrosion means the deterioration of a material because of chemical or electrochemical reaction with its environment [1] whereas erosion means the progressive loss of original material from a solid surface due to mechanical interaction between that surface and a fluid, a multi-component fluid, or impinging liquid or solid particles [2]. Corrosion and erosion often occur synergistically and material loss can be notably higher than the sum of the effects of the processes acting separately [3]. There are various types of corrosion including uniform corrosion, galvanic corrosion, pitting corrosion, crevice corrosion, intergranular corrosion, stress corrosion cracking, hydrogen embrittlement and selective leaching. Erosion involves several different processes such as liquid impingement erosion, slurry erosion (solid particle erosion), erosion-corrosion and cavitation erosion. The problems caused by corrosion and erosion can be avoided by various methods. Conventionally, numerous surface engineering techniques, such as electroplating, galvanizing, anodizing, diffusion coating, carburizing, nitriding and flame, induction hardening and thermal spraying possess several limitations such as high consumption of time, energy and materials, environmental-unfriendliness, poor-precision and flexibility, lack in scope of automation and complicated heat-treating procedures for fabricating protective coatings on the relative weak substrate alloys.

A laser is a clean heat source that exhibits a unique set of properties, namely high monochromaticity, coherence and directionality. It allows a wide range of surface treatments from mere heating to melting of coating materials on the substrate surface through the absorption of the laser energy. One of the limitations of laser surfacing is small laser beam size. Nevertheless, it is highly suitable for surface treating localized regions and remanufacturing undersized, corroded, worn or cracked engineering components. The generic term 'laser surface modification' includes laser transformation hardening

(LTH), laser surface melting/remelting (LSM), laser surface alloying (LSA), laser cladding (LC) and laser shock peening (LSP). When no additional materials are added to a substrate material, the laser energy can be used to heat the substrate surface to transformation temperature (for carbon steels) and even melting temperature for achieving LTH and LSM respectively. Owing to rapid quenching, the steels can be transformed into hard martensite by LTH while the structure and grain size of some alloys can be changed to the refined grain and homogeneous structure leading to enhanced corrosion or erosion resistance. When the additional alloying materials are alloyed or clad on the substrate, the tailor-made coatings can be fabricated for specific properties such as hardness, electrical and thermal conductivities, and corrosion and erosion resistance, to name a few. The service life of the laser-modified surface or laser-fabricated coatings for engineering components working in corrosive and/or erosive environments can be considerably extended. The laser-modified surface or laser-fabricated coatings on the substrate alloys can be effectively protected against the corrosive environments through the formation of protective passive layers or against the erosive environments by hard and energy-absorption coatings. The avoidance of corrosive or erosive damage on engineering alloys plays a crucial role in maintaining their quality, reliability, safety and profitability.

In the past three decades, a number of publications on laser surface modification of metallic materials for corrosion and erosion resistance have been reported. During 1970 to 2011, a quick survey with SCOPUS using the keywords 'laser AND corrosion OR erosion' gave about 3180 published papers. This indicates that laser surface modification for corrosion and erosion resistance is still an emerging topic deserving further investigation. Numerous studies were performed regarding a diversity of laser surface modification for fixing the corrosion and erosion problems in automobile, aerospace, nuclear plants, naval, defense, marine, electronic and biomedical applications. *Laser surface modification of alloys for corrosion and erosion resistance* intends to address the lack of a comprehensive book dealing with this topic and provide an impetus to the research on laser surface modification of various engineering alloys for enhancing their corrosion and erosion resistance. Scholars and experts of laser surface engineering from different countries/cities including China, France, Hong Kong, India, Japan, Macau and Portugal have generously contributed to this book.

The book is divided into two parts: Part I is about improving corrosion and cracking resistance and Part II is about improving erosion resistance for the laser-surface modified engineering alloys. In Chapter 1, Professor Vilar begins with theoretical approach on discussing phase transformation of steels and cast irons and then provides an extensive review on corrosion issues of the laser-surface modified steels and cast irons and their applications. In Chapter 2, Professor Shinozaki and his coworker study LSM of the weldments of

Ni-based alloys for improving the resistance against intergranular corrosion and cracking and propose a model describing the Cr depletion profiles near the grain boundary during heat treatment and LSM treatment. In Chapter 3, the published work related to the intergranular corrosion behavior of the laser-surface melted austenitic and duplex stainless steels are reviewed by the Editor and his coworkers. In addition, studies on intergranular corrosion of aged stainless steels including nickel-free austenitic stainless steel, Nb-stabilised austenitic stainless steel, and super duplex stainless steel after LSM are reported. In Chapter 4, pulsed excimer laser surface treatment of multilayer Au/Ni/Cu coatings for electronic components for corrosion resistance is reported by Professor Semmar and his coworker. Moreover, a model has been developed for simulating the thermal behavior of thin films obtained by the pulsed excimer laser. In Chapter 5, Dr Ng and Professor Man report laser surface alloying of NiTi alloy with molybdenum for improving its biocompatibility and corrosion resistance. The corrosion resistance of the laser-surface alloyed layer is found to be improved and it is intended to be used in biomedical implants. In Chapters 6, 7 and 10, Professor Duraiselvam, Professor Shivamurthy and his coworkers, and Professor Sidhu report that the laser-fabricated metallic and composite coatings have been applied to various substrates for resisting liquid impingement erosion, slurry erosion and erosion-corrosion respectively. In Chapter 8, the Editor and his coworkers describe LSA of copper with various metals for electrical erosion and corrosion resistance. In Chapter 9, field testing and applications of laser remanufacturing were investigated by Professor Yao and coworkers who indicate that laser remanufacturing is an effective and useful way to enhance the corrosion and erosion resistance of the engineering components.

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Contents

Part I

Improving corrosion and cracking resistance