Laser Cladding

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Dedications

Ehsan Toyserkani

To my father and mother, who taught me to learn. To my beloved wife and son, Homeyra and Ali, who have truly brought joy in my life.

Amir Khajepour

To my son and wife for the joy and comfort you have given to my life, and my family for your support.

Stephen Corbin

To the memory of my sister, Pamela Corbin, who was an enthusiastic and passionate teacher for over 20 years. Pamela inspired my own interest in the field of education which ultimately led to my academic career.

Preface

Laser cladding by powder injection has received significant attention in recent years due to its unique features and capabilities in various industries involved in metallic coating, high-value components repair, prototyping, and low-volume manufacturing. This emerging laser material processing technique is an interdisciplinary technology utilizing laser technology, computer-aided design and manufacturing (CAD/CAM), robotics, sensors and control, and powder metallurgy and rapid solidification. Further development of this technique depends on enhancement of the technologies involved and understanding the interconnections among these technologies and the process quality.

A good comprehension of the underlying physics of the laser cladding process is key in the development of the process as a reliable coating and manufacturing technology. In addition to a good grasp of feedback control and automation, a strong knowledge of material science, heat transfer, and fluid dynamics is essential to a successful development of an automated laser cladding system.

The intent of this book is to address the lack of a comprehensive book dealing with the different aspects of laser cladding. The authors have used the results of their own research and experience in the past few years along with the findings of many other researchers in the preparation of this book. The book provides a solid and detailed description of laser cladding in modeling, materials, and control and can be used in both academia and industry.

The book begins with a review of the applications of laser cladding, and continues with physical descriptions of the process and the parameters involved, process modeling and control, process applications, and the physical metallurgy of alloying and solidification during laser cladding. We illustrate the general principles of the technique with several case studies based on a number of important common laser cladding applications. Extensive references to the current literature have also been provided to guide the reader to further information on desired topics.

We are very much indebted to many colleagues and students for their help in the preparation of this book. Special thanks go to Professors David Weckman, Walter Duley and Jan Huissoon of the University of Waterloo for their valuable comments. We are grateful to Dr. Steffen Nowotny of the Fraunhofer Institute for Material and Beam Technology, Dr. Lijue Xue of the Integrated Manufacturing Technologies Institute (IMTI) of National Research Council of Canada (NRC), Dr. Frank Arcella of AeroMet Cooperation, Dr. Joohyun Choi of University of Missouri at Rolla, Mr. David Gill of Sandia National Laboratories, and Mr. Michael Kardos of Optomec Inc. for providing us

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Waterloo, Ont., Canada, 2004

About the Authors

Dr. Ehsan Toyserkani received his Ph.D in mechanical engineering from the University of Waterloo, Ontario, Canada, in 2003. His early research and industrial interests were on design of mechatronics systems. This interest was expanded to include the development of intelligent controllers for laser cladding technology during his Ph.D program. He was awarded postdoctoral fellowships from the National Sciences and Engineering Research Council of Canada (NSERC) and the Canadian Space Agency (CSA) to conduct projects related to laser cladding technology. In 2004, he joined the Mechatronics Engineering Group of the Department of Mechanical Engineering at the University of Waterloo as an Assistant Professor.

Dr. Amir Khajepour received his Ph.D in mechanical engineering from the University of Waterloo in Ontario, Canada in 1996. In 1997, he joined the Department of Mechanical Engineering, University of Waterloo, where he is currently a Professor in Mechatronics Engineering. The thrust of Dr. Khajepour's research is in modeling and control of dynamic systems with focus on automated laser cladding, ultra high-speed robotics, and advanced vehicle systems. His extensive research collaboration with industry has resulted in many new technologies, patents, and journal publications.

Dr. Stephen Francis Corbin received his B.Eng and M.Sc. degrees in metallurgical engineering from Dalhousie University in 1986/87 and his Ph.D. in materials engineering from McMaster University in 1993. Following four years as a product and process development specialist with the Westaim Corporation in Fort Saskatchewan, Alberta, Dr. Corbin joined the University of Waterloo, Ontario, Canada in 1997 where he is currently an Associate Professor in the Materials Engineering and Processing Group within the Department of Mechanical Engineering. He has taught introductory materials engineering courses as well as senior and graduate courses in process and physical metallurgy and materials characterization. His areas of expertise include: powder metallurgy, laser processing, solders and brazes, porous materials and metal/ceramic composites.

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