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SMST-2004

Proceedings of the International Conference on

Shape Memory and Superelastic Technologies

October 3–7, 2004
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Baden-Baden, Germany

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TABLE OF CONTENTS

FATIGUE, FRACTURE, AND DEFORMATION

MODELLING AND DESIGN

MATERIAL DEVELOPMENT

CHARACTERIZATION AND TESTING

CORROSION AND BIOCOMPATIBILITY

THIN FILMS

POWDER METALLURGY AND POROUS MATERIALS

NONMEDICAL APPLICATION AND ACTUATORS

MEDICAL APPLICATIONS AND TESTING

FOREWORD AND ACKNOWLEDGMENTS

The International Conference on Shape Memory and Superelastic Technology SMST-2004 was held October 3–7, 2004 in Baden-Baden, Germany. This was the second European event of the SMST conference series since Antwerp, Belgium in 1999. The beautiful city of Baden-Baden is located between the foothills of the Black Forest and the river Rhine. This location together with the Kurhaus has proven to be the ideal setting for hosting the SMST conference. Even though the casino in the basement of the Kurhaus was constantly tempting the participants with its wonderful historic setting and its luxuriant red carpets, the first floor of the Kurhaus was even more interesting due to the outstanding technical program of the conference. This environment gave rise to very interactive and vibrant sessions, which were attended by more than 300 participants. Attendance increased about one hundred percent compared to the attendance of the previous European SMST conference. Increased interest reflects the overall development of the shape memory technology and the related industry. The quality of the technical program is documented in these proceedings and it has once more been proven, that the SMST conference series mirror the state-of-the art of the field of Shape Memory and Superelastic Technology. Another indicator of the constantly growing industry is the fact that the Tuesday evening exhibition attracted about 22 exhibiting companies showing the latest in products and services from the shape memory industry. The gala banquet closed the Wednesday afternoon excursion to the Europapark, an amusement park in which the roller coaster challenged the physical condition of the conference registrants. The evening banquet culminated in a superb dinner livened up by a number of comedians and artists. What a wonderful evening and what a great company.

Our special thanks to Prof. Erhard Hornbogen, who gave the opening talk in the Monday morning session. This talk was very important for the entire conference for a couple of reasons, not just because it gave such a comprehensive and fundamental overview, but, also, because it was setting the level for the conference. Prof. Hornbogen's work in the field of martensitic transformations has such a long history that we couldn't find any better scientist to give this important opening talk.

Without the confidence and support from the SMST Society and without the outstanding cooperation and assistance of a number of persons and companies, the SMST-2004 conference would not have taken place. First, I would like to acknowledge the hard work and great cooperation of Harald Fischer as the co-chairman of the conference. Together with Jochen Ulmer and Rainer Steegmüller, who shared the work load as Conference Secretaries, we formed a very efficient and cooperative organization team. Even though being competitors in our daily work we became good friends during the hard work for the conference. Thank you very much, guys! Secondly, I would like to acknowledge the enthusiasm and hard work of Patricia Schmidt and Bettina Kopf who did a great job in organizing the location in Baden-Baden, the hotel room accommodations and many other very important things. Thanks, also, to Jim Proft who was very

helpful in contacting potential exhibitors and who solicited our generous sponsors, and to Valentina Imbeni who supported us enormously through the SMST Society. Gratefully acknowledged is, also, the prompt and competent work of Tom Duerig, Alan Pelton, and Jochen Ulmer, who helped us very much with reviewing of abstracts and papers. Finally, I would like to acknowledge the support and advice of the Organizing Committee and the International Advisory Board and of course I would like to thank all our international experts and colleagues who chaired sessions throughout the conference. The SMST-2004 Organizing Committee owes special thanks, also, to the SMIT Society, who has supported the conference by printing the abstracts in a special edition of the MITAT journal in a very valuable way.

After 2003, the SMST conference marked an important milestone in the history of the society when it became officially a nonprofit society with a membership. The SMST-2004 conference was the place for the announcement of another key milestone to the community as SMST became an affiliate society of ASM International, The Materials and Information Society with a worldwide membership of more than 30,000. The SMST membership was invited to join ASM and make profit from the enormous reservoir of information and contacts that ASM offers. Thanks to the very important support from the ASM Society, the SMST Society will continuously improve the effort to disseminate the technology of shape memory within all kinds of industries and research institutions. All of us are looking forward to this exciting new perspective for the future development of our society.

Finally, I would like to thank our sponsors whose generous contributions once more added a great value to the overall success of the conference. Sponsors for the SMST-2004 conference were:

- ASM International
- Boston Scientific
- Endosmart GmbH
- Euroflex GmbH
- Johnson-Matthey Corp.
- Memory-Metalle GmbH
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Their significant support for the SMST conference is reflected in their generosity and is gratefully acknowledged.

Dr. Matthias Mertmann
SMST-2004 Conference Chairman

SMST-2004 (#05181Z)

PREFACE

These proceedings are divided into eleven sections. The first section is entitled ***Basics about Shape Memory Alloys*** and summarizes all papers related to the fundamentals about the different alloys and the martensitic phase transformation. It starts with a paper comparing the martensitic phase transformation in shape memory alloys to the ferroelectricity found in other materials. Other interesting papers in this section deal with the phase transformation sequence and the relationship between microstructure and physical properties of shape memory alloys, where the research on the texture always plays an important role. Other papers in this section are covering special subjects or research areas related to the nature of the martensitic phase transformation or to other areas like friction and wear.

The second part of these proceedings with a total number of eight papers is dedicated to the increasingly important field of ***Fatigue, Fracture and Deformation***. It is the first time that this subject is addressed by an SMST proceedings with its own chapter that reflects the increasing interest into this matter. It's partly driven from the medical device industry that needs both understanding of the mechanisms as well as data for their designs.

Modelling and Design is the third section in this book with a total number of eight contributions. Shape memory alloys are known as nonlinear and nonconservative materials and are therefore a big challenge for the field of solid mechanics. When reviewing former proceedings it becomes obvious that this field has evolved significantly over the years. It can be noted that many papers are striving towards a microsizing of the models.

The fourth section is dedicated to ***Material Development.*** Besides the latest data from ferroelectric shape memory alloys, this section summarizes different approaches to produce both, Ni-free shape memory alloys as well as Nitinol semifinished shapes using unconventional production techniques. Furthermore, a new kind of a composite material using stainless steel and Nitinol is presented.

In the fifth section about ***Processing of Shape Memory Alloys*** we find a very interesting compilation of conventional and nonconventional processing techniques, starting from the melting processes over deep hole drilling towards modification of semifinished shapes properties by means of precipitation and ageing. The impact of the medical industry can be found in papers that discuss the state-of-the-art in laser cutting or laser welding and the papers that use medical products as examples for the presented processing methods.

Characterization and Testing in section six receives a great deal of interest as always in the field of shape memory alloys. These materials with their nonlinear and unconventional properties always need new methods for testing and characterizing. It is interesting to note the diversity of

the presented papers in this section, each of them covering a different aspect from transformation temperature measurement down to MRI visibility of Nitinol stents.

Due to the high nickel content of Nitinol, the ***Biocompatibility and Corrosion*** papers in section seven received significant interest during the conference. This chapter and the related research work are clearly driven by the medical device industry which needs to prove the biocompatibility towards authorities, doctors and patients. Even though the authors discuss the biocompatibility issues in an ambivalent, way the consensus about the undisputed biocompatibility of properly treated Nitinol surfaces in all different body fluids and environments is again confirmed. It becomes increasingly clear that processing errors and damages to the protective oxide layer of Nitinol may lead to significantly inferior performances.

The contributions in section number eight about ***Thin Films*** are receiving a constantly increasing amount of attention from science, industry and users. This section shows both, process as well as application related papers. It is surprising to see how this field has constantly evolved over the years and is nowadays also stimulated by the perspective of use of thin Nitinol films in biomedical applications.

It is also true for papers summarized in section nine about ***Powder Metallurgy and Porous Materials***. This field shows similar progress and is attracting a constantly increasing amount of interest. The presentation of first products manufactured from NiTi powder using processes like Hot Isostatic Pressing or Metal Injection Moulding seems only to be a question of time and triggers our interest towards following SMST conferences and proceedings.

The European SMST Conference is traditionally more focussed on nonmedical applications for good reasons. Hence, the tenth section about ***Nonmedical Applications*** is receiving a great deal of interest from the shape memory community. However, the groundbreaking innovation in actuator technology can not be found in these proceedings.

The ***Medical Applications*** of shape memory alloys have again attracted the biggest attention at SMST-2004. This is documented by the twelve papers summarized in this section. Some of which are showing new exciting applications of Nitinol in different products or concepts. The use of Nitinol has become a standard knowledge in the medical industry field and it is surprising to see how many experts and Nitinol-skilled engineers we meet in the different companies and institutes. The use of Nitinol in itself is no longer a novelty and knowing how to work with Nitinol has become a standard during the last years.

This book contains a total number of 93 papers. The papers have been carefully reviewed and edited for reasons of content and format either by the editor, by an independent expert and in some cases finally by the authors themselves. This time consuming process made it possible that only a total number of 4 papers had to be rejected for different content related reasons. The editor gratefully acknowledges the excellent and competent work of the reviewers and experts (Harald Fischer, Alan Pelton, Jochen Ulmer), who were very responsive and helpful. Readers may note that the applied review process was different compared to the last set of proceedings published in 2004. For this reason, the editor would like to make the reader aware of the fact that not all published opinion or data in this book can be considered being proven. In fact, it might be in the hypothesis stage or reflect new concepts or ideas.

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