Preface

Thank you for taking the time to read this book on Additive Manufacturing (AM). We hope you benefit from the time and effort it has taken putting it together and that you think it was a worthwhile undertaking. It all started as a discussion at a conference in Portugal when we realized that we were putting together books with similar aims and objectives. Since we are friends as well as colleagues, it seemed sensible that we join forces rather than compete; sharing the load and playing to each other's strengths undoubtedly means a better all-round effort and result.

We wrote this book because we have all been working in the field of AM for many years. Although none of us like to be called "old," we do seem to have 60 years of experience, collectively, and have each established reputations as educators and researchers in this field. We have each seen the technologies described in this book take shape and develop into serious commercial tools, with tens of thousands of users and many millions of parts being made by AM machines each year. AM is now being incorporated into curricula in many schools, polytechnics, and universities around the world. More and more students are becoming aware of these technologies and yet, as we saw it, there was no single text adequate for such curricula. We believe that the first edition of this book provided such a text, and based upon the updated information in this 2nd edition, we hope we've improved upon that start.

Additive Manufacturing is defined by a range of technologies that are capable of translating virtual solid model data into physical models in a quick and easy process. The data are broken down into a series of 2D cross-sections of a finite thickness. These cross-sections are fed into AM machines so that they can be combined, adding them together in a layer-by-layer sequence to form the physical part. The geometry of the part is therefore clearly reproduced in the AM machine without having to adjust for manufacturing processes, like attention to tooling, undercuts, draft angles, or other features. We can say therefore that the AM machine is a What You See Is What You Build (WYSIWYB) process that is particularly valuable the more complex the geometry is. This basic principle drives nearly all AM machines, with variations in each technology in terms of the techniques used for creating layers and in bonding them together. Further variations

include speed, layer thickness, range of materials, accuracy, and of course cost. With so many variables, it is clear to see why this book must be so long and detailed. Having said that, we still feel there is much more we could have written about.

The first three chapters of this book provide a basic overview of AM processes. Without fully describing each technology, we provide an appreciation for why AM is so important to many branches of industry. We outline the rapid development of this technology from humble beginnings that showed promise but still requiring much development, to one that is now maturing and showing real benefit to product development organizations. In reading these chapters, we hope you can learn the basics of how AM works.

The next nine chapters (Chaps. 4–12) take each group of technologies in turn and describe them in detail. The fundamentals of each technology are dealt with in terms of the basic process, whether it involves photopolymer curing, sintering, melting, etc., so that the reader can appreciate what is needed in order to understand, develop, and optimize each technology. Most technologies discussed in this book have been commercialized by at least one company; and these machines are described along with discussion on how to get the best out of them. The last chapter in this group focused on inexpensive processes and machines, which overlaps some of the material in earlier chapters, but we felt that the exponentially increasing interest in these low-cost machines justified the special treatment.

The final chapters deal with how to apply AM technology in different settings. Firstly, we look at selection methods for sorting through the many options concerning the type of machine you should buy in relation to your application and provide guidelines on how to select the right technology for your purpose. Since all AM machines depend on input from 3D CAD software, we go on to discuss how this process takes place. We follow this with a discussion of post-processing methods and technologies so that if your selected machine and material cannot produce exactly what you want, you have the means for improving the part's properties and appearance. A chapter on software issues in AM completes this group of chapters.

AM technologies have improved to the extent that many manufacturers are using AM machine output for end-product use. Called Direct Digital Manufacturing, this opens the door to many exciting and novel applications considered impossible, infeasible, or uneconomic in the past. We can now consider the possibility of mass customization, where a product can be produced according to the tastes of an individual consumer but at a cost-effective price. Then, we look at how the use of this technology has affected the design process considering how we might improve our designs because of the WYSIWYB approach. This moves us on nicely to the subjects of applications of AM, including tooling and products in the medical, aerospace, and automotive industries. We complete the book with a chapter on the business, or enterprise-level, aspects of AM, investigating how these systems

enable creative businesses and entrepreneurs to invent new products, and where AM will likely develop in the future.

This book is primarily aimed at students and educators studying Additive Manufacturing, either as a self-contained course or as a module within a larger course on manufacturing technology. There is sufficient depth for an undergraduate or graduate-level course, with many references to point the student further along the path. Each chapter also has a number of exercise questions designed to test the reader's knowledge and to expand their thinking. A companion instructor's guide is being developed as part of the 2nd edition to include additional exercises and their solutions, to aid educators. Researchers into AM may also find this text useful in helping them understand the state of the art and the opportunities for further research.

We have made a wide range of changes in moving from the first edition, completed in 2009, to this new edition. As well as bringing everything as up to date as is possible in this rapidly changing field, we have added in a number of new sections and chapters. The chapter on medical applications has been extended to include discussion on automotive and aerospace. There is a new chapter on rapid tooling as well as one that discusses the recent movements in the low-cost AM sector. We have inserted a range of recent technological innovations, including discussion on the new Additive Manufacturing File Format as well as other inclusions surrounding the standardization of AM with ASTM and ISO. We have also updated the terminology in the text to conform to terminology developed by the ASTM F42 committee, which has also been adopted as an ISO international standard. In this 2nd edition we have edited the text to, as much as possible, remove references to company-specific technologies and instead focus more on technological principles and general understanding. We split the original chapter on printing processes into two chapters on material jetting and on binder jetting to reflect the standard terminology and the evolution of these processes in different directions. As a result of these many additions and changes, we feel that this edition is now significantly more comprehensive than the first one.

Although we have worked hard to make this book as comprehensive as possible, we recognize that a book about such rapidly changing technology will not be up-to-date for very long. With this in mind, and to help educators and students better utilize this book, we will update our course website at http://www.springer.com/978-1-4419-1119-3, with additional homework exercises and other aids for educators. If you have comments, questions, or suggestions for improvement, they are welcome. We anticipate updating this book in the future, and we look forward to hearing how you have used these materials and how we might improve this book.

As mentioned earlier, each author is an established expert in Additive Manufacturing with many years of research experience. In addition, in many ways, this book is only possible due to the many students and colleagues with whom we have collaborated over the years. To introduce you to the authors and some of the others who have made this book possible, we will end this preface with brief author biographies and acknowledgements.

Singapore, Singapore — Ian Gibson
Atlanta, GA, USA — David Rosen
Louisville, KY, USA — Brent Stucker

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Gibson, I.; Rosen, D.; Stucker, B.

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