Preface

Ultra-precision single point diamond turning is a key technology in the manufacture of mechanical, optical and optoelectronics components with a surface roughness of a few nanometres and form accuracy in the sub-micrometric range. As a type of subtractive manufacturing, ultra-precision diamond turning technology was established on the pillars of materials science, machine tools, modelling and simulation technologies, etc., bestowing the intrinsic inter-disciplinary characteristics upon the study of such machining process. However, in contrast to the substantial advances that have been achieved in machine design, laser metrology and control systems, relatively little research has been conducted on material behaviour and its effect on surface finish, such as the material anisotropy of crystalline materials. The feature of the significantly reduced depth of cut of the order of a few micrometres or less, which is much smaller than the average grain size of work-piece materials, unavoidably renders the existing metal cutting theories to have only partial success in the investigation of the mechanism of the micro-cutting process in ultra-precision diamond turning. With such a background, this book is dedicated to an in-depth study and elucidation on the mechanism of the micro-cutting process, with a particular emphasis and a novel viewpoint on materials characterisation and its influences in ultraprecision machining.

This book probes into the two critical problems in ultra-precision diamond turning, i.e. materials characterisation and the mechanism of micro-cutting, and contributes to the development of metal cutting theory for ultraprecision diamond turning. As for the organisation of the book: In Chap. 1, an overview of ultra-precision machining technology and ultraprecision diamond turning is elaborated with the existing metal cutting theory tailor-made for conventional and precision machining and its unsolved problems. A detailed literature review on a variety of hot research topics in ultraprecision machining is presented in Chap. 2, which takes account of material characteristics and machinability, the mechanism of metal cutting, the dynamics of machine tools, surface generation and characterisation, modelling techniques, etc. This book began to unfold from the investigation on the machinability of single crystals in diamond turning in Chap. 3. The effect of crystallography on surface roughness and the variation in cutting force is studied by

the degree of roughness anisotropy (DRA) factor. The study of machined surface integrity and the deformation behaviour of diamond-turned surface layer is presented in Chap. 4, followed by the orientation changes of substrate materials that are characterised by X-ray texture study in Chap. 5. A novel technology involving electropulsing treatment (EPT) is explored to enhance the machinability of work materials in Chap. 6. A microplasticity analysis of shear angle and micro-cutting force variation is provided in Chap. 7. In Chap. 8, the mechanism of elastic strain induced shear bands and regularly space shear bands are presented and a generalised model for shear angle prediction is developed. In the final part of this book (Chap. 9), the high frequency tool-tip vibration and its effect on surface generation as well as the representative surface measurement method are presented. The integrated dynamic modelling of shear band formation and tool-tip vibration is elaborated in Chap. 10.

This book serves as a practical tool for investigating materials characterisation in ultra-precision machining with carefully documented experimental techniques and analytical methodology accumulated over the years through the authors' research endeavours. This book contributes to enhancing the understanding of the metal cutting theory of ultraprecision diamond turning from the perspective of materials science and machining dynamics. The multidisciplinary work in this book also covers the modelling approaches based on the theory of microplasticity.

The authors would like to thank the Research Committee and the Department of Industrial and Systems Engineering of The Hong Kong Polytechnic University and the Department of Mechanical Engineering, Faculty of Engineering, National University of Singapore for providing the financial support for this book. Many thanks are extended to the Guangdong Innovative Research Team Program and the National Natural Science Foundation of China for providing the partial financial support under the Project Nos. 201001G0104781202 and 51275434 respectively.

Hong Kong, China
Singapore

Sandy Suet To
Hao Wang

http://www.springer.com/978-3-662-54821-9

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To, S.; Wang, H.; Lee, W.B.

2018, X, 266 p. 199 illus., Hardcover
ISBN: 978-3-662-54821-9