

Editorial

Ultra-Precision Manufacturing Technology for Difficult-to-Machine Materials

Qi Liu ^{1,2}, Mingjun Chen ^{1,*}, Jian Cheng ¹ and Xichun Luo ²

¹ School of Mechatronics Engineering, Harbin Institute of Technology, Harbin 150001, China; q.liu@strath.ac.uk (Q.L.); cheng.826@hit.edu.cn (J.C.)

² Centre for Precision Manufacturing, Department of Design Manufacturing & Engineering Management (DMEM), University of Strathclyde, Glasgow G1 1XJ, UK; xichun.luo@strath.ac.uk

* Correspondence: chenmj@hit.edu.cn

Ultra-precision manufacturing requires superior components with an impeccable surface finish and accuracy. However, the need for ultra-precision equipment accuracy and problems in machining difficult-to-cut materials pose challenges. Specialized machine tools and understanding the process are vital to overcoming these challenges and improving the surface integrity and application performance.

This Special Issue comprises sixteen articles, including four studies on ultra-precision machining technology, four on tool design, four on non-traditional machining technology, and four on additive manufacturing.

In terms of ultra-precision machining technology, Yuanhang Liu et al. [1] developed an optimized grinding tool configuration and a comprehensive simulation model for wafer backside grinding, leading to effective total thickness variation control strategies. Marvin Groeb et al. [2] investigated the ductile regime face milling of sintered silicon carbide, revealing the influence of chip thickness and cutting speed on surface quality. Hongqing Lei et al. [3] developed a constitutive model considering KDP crystal anisotropy and utilized a 3D finite element model to analyze the impact of pre-existing micro defects during ball-end milling repair. Qi Liu et al. [4] performed fractal analysis on soft-brittle KDP crystal surfaces machined via micro ball end milling and identified fractal dimension as a means to distinguish between ductile and brittle material removal processes.

In terms of ultra-precision machine tool design, Zheng Qiao et al. [5] proposed an in situ measurement technique to solve the roundness error of a precision mandrel. By implementing the slow tool servo cutting technique, these errors were compensated and reduced to below 0.1 μm . Laiyun Song et al. [6] introduced a spiral-grooved structure to enhance the load capacity and stiffness of hybrid air journal bearings via frequency domain analysis. The study emphasized the significant influence of the spiral-groove length on spindle system stability. Additionally, Laiyun Song et al. [7] analyzed the nonlinear dynamic characteristics of the hybrid air bearing-rotor system at ultra-high speeds and theoretically investigated the rotor trajectory and non-linear behavior. Han Wang et al. [8] developed compliance equations for spatial elliptic-arc-beam spherical flexure hinges, providing a foundation for designing and modeling 3D elliptical vibration-assisted cutting mechanisms based on these hinges.

In terms of non-traditional precision machining technology, Boris Rajčić et al. [9] performed a picosecond laser treatment on nickel-based superalloy Nimonic 263 in different atmospheric conditions to enhance its service performance. The laser parameters and environmental conditions were optimized experimentally based on Taguchi's robust parameter design. Jainlei Cui et al. [10] proposed a two-step laser machining process for PCD skiving cutters. A high-quality PCD skiving cutter was obtained with an Rt of 5.6 μm and no phase transition damage. Rakesh Chaudhari et al. [11] experimentally investigated the effect of alumina (Al_2O_3) nano-powder on the electrical discharge machining (EDM)



Citation: Liu, Q.; Chen, M.; Cheng, J.; Luo, X. Ultra-Precision Manufacturing Technology for Difficult-to-Machine Materials. *Materials* **2023**, *16*, 4322. <https://doi.org/10.3390/ma16124322>

Received: 1 June 2023

Accepted: 5 June 2023

Published: 11 June 2023



Copyright: © 2023 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

process of a Nitinol shape memory alloy (SMA), and the related parameters were optimized via ANOVA analysis. Lida Heng et al. [12] summarized the recent advances in non-conventional finishing processes for difficult-to-machine ceramics.

In terms of precision additive manufacturing, Kaicheng Yu et al. [13] proposed a method to optimize the process parameters for improving the diameter accuracy of filaments extruded via 3D printing. Rongkai Tan et al. [14] adopted UEVC to cut SLM AlSi10Mg alloy post-process. The surface integrity and tool wear can be greatly improved. David Sommer et al. [15] investigated milling tool wear characteristics in a hybrid additive manufacturing process that comprises laser powder bed fusion and in situ high-speed milling, giving a potential solution for AM post-processing. Jian Cheng et al. [16] reviewed laser metal deposition for cladding from the defect formation mechanism to defect suppression methods. The performance improvements of laser cladding layers were also summarized.

Via this Special Issue, we hope that more scholars learn about the current research progress on the ultra-precision machining of difficult-to-machine materials and will be attracted to participate in it.

Acknowledgments: We would like to take this opportunity to thank all the authors for submitting their papers to this Special Issue, and all the reviewers for dedicating their time and helping to improve the quality of the submitted papers.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Liu, Y.; Tao, H.; Zhao, D.; Lu, X. An Investigation on the Total Thickness Variation Control and Optimization in the Wafer Backside Grinding Process. *Materials* **2022**, *15*, 4230. [[CrossRef](#)] [[PubMed](#)]
2. Groeb, M.; Hagelucken, L.; Groeb, J.; Ensinger, W. Experimental Analysis of Ductile Cutting Regime in Face Milling of Sintered Silicon Carbide. *Materials* **2022**, *15*, 2409. [[CrossRef](#)] [[PubMed](#)]
3. Lei, H.; Cheng, J.; Yang, D.; Zhao, L.; Chen, M.; Wang, J.; Liu, Q.; Ding, W.; Chen, G. Effect of Pre-Existing Micro-Defects on Cutting Force and Machined Surface Quality Involved in the Ball-End Milling Repairing of Flawed KDP Crystal Surfaces. *Materials* **2022**, *15*, 7407. [[CrossRef](#)] [[PubMed](#)]
4. Liu, Q.; Cheng, J.; Liao, Z.; Liu, M.; Chen, M.; Zhao, L.; Lei, H.; Ding, W. Fractal Analysis on Machined Surface Morphologies of Soft-Brittle KDP Crystals Processed by Micro Ball-End Milling. *Materials* **2023**, *16*, 1782. [[CrossRef](#)] [[PubMed](#)]
5. Qiao, Z.; Wu, Y.; Chen, W.; Jia, Y.; Wang, B. In-Situ Measurement and Slow-Tool-Servo Compensation Method of Roundness Error of a Precision Mandrel. *Materials* **2022**, *15*, 8037. [[CrossRef](#)] [[PubMed](#)]
6. Song, L.; Yuan, G.; Zhang, H.; Ding, Y.; Cheng, K. The Stability of Spiral-Grooved Air Journal Bearings in Ultrahigh Speeds. *Materials* **2022**, *15*, 1759. [[CrossRef](#)] [[PubMed](#)]
7. Song, L.; Yuan, G.; Zhang, H.; Ding, Y.; Cheng, K. Non-Linear Dynamic Analysis on Hybrid Air Bearing-Rotor System under Ultra-High Speed Condition. *Materials* **2022**, *15*, 675. [[CrossRef](#)] [[PubMed](#)]
8. Wang, H.; Wu, S.; Shao, Z. Analytical Compliance Equations of Generalized Elliptical-Arc-Beam Spherical Flexure Hinges for 3D Elliptical Vibration-Assisted Cutting Mechanisms. *Materials* **2021**, *14*, 5928. [[CrossRef](#)] [[PubMed](#)]
9. Rajcic, B.; Sibalija, T.; Nikolic, V.; Cekada, M.; Savovic, J.; Petronic, S.; Milovanovic, D. Structural and Functional Picosecond Laser Modification of the Nimonic 263 Superalloy in Different Environmental Conditions and Optimization of the Irradiation Process. *Materials* **2023**, *16*, 1021. [[CrossRef](#)] [[PubMed](#)]
10. Cui, J.; Fang, X.; Dong, X.; Mei, X.; Xu, K.; Fan, Z.; Sun, Z.; Wang, W. Fabrication of PCD Skiving Cutter by UV Nanosecond Laser. *Materials* **2021**, *14*, 4027. [[CrossRef](#)] [[PubMed](#)]
11. Chaudhari, R.; Shah, Y.; Khanna, S.; Patel, V.K.; Vora, J.; Pimenov, D.Y.; Giasin, K. Experimental Investigations and Effect of Nano-Powder-Mixed EDM Variables on Performance Measures of Nitinol SMA. *Materials* **2022**, *15*, 7392. [[CrossRef](#)]
12. Heng, L.; Kim, J.S.; Song, J.H.; Mun, S.D. A Review on Surface Finishing Techniques for Difficult-to-Machine Ceramics by Non-Conventional Finishing Processes. *Materials* **2022**, *15*, 1227. [[CrossRef](#)] [[PubMed](#)]
13. Yu, K.; Gao, Q.; Lu, L.; Zhang, P. A Process Parameter Design Method for Improving the Filament Diameter Accuracy of Extrusion 3D Printing. *Materials* **2022**, *15*, 2454. [[CrossRef](#)] [[PubMed](#)]
14. Tan, R.; Zhao, X.; Liu, Q.; Guo, X.; Lin, F.; Yang, L.; Sun, T. Investigation of Surface Integrity of Selective Laser Melting Additively Manufactured AlSi10Mg Alloy under Ultrasonic Elliptical Vibration-Assisted Ultra-Precision Cutting. *Materials* **2022**, *15*, 8910. [[CrossRef](#)] [[PubMed](#)]

15. Sommer, D.; Pape, D.; Esen, C.; Hellmann, R. Tool Wear and Milling Characteristics for Hybrid Additive Manufacturing Combining Laser Powder Bed Fusion and In Situ High-Speed Milling. *Materials* **2022**, *15*, 1236. [[CrossRef](#)] [[PubMed](#)]
16. Cheng, J.; Xing, Y.; Dong, E.; Zhao, L.; Liu, H.; Chang, T.; Chen, M.; Wang, J.; Lu, J.; Wan, J. An Overview of Laser Metal Deposition for Cladding: Defect Formation Mechanisms, Defect Suppression Methods and Performance Improvements of Laser-Cladded Layers. *Materials* **2022**, *15*, 5522. [[CrossRef](#)] [[PubMed](#)]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.