XIX National, X International Scientific and Technical Conference
Metrology in Manufacturing Technologies
Optical methods and artificial intelligence in metrology
Wrocław, 18th – 20th of September, 2024

Method for width evaluation of irregular grooves

Michał Ćwikła[1,*], Kacper Marciniak[1], Jacek Reiner[1]

[1]Faculty of Mechanical Engineering, Wroclaw University of Science and Technology, Wybrzeże Stanisława Wyspiańskiego 27, 50-370 Wrocław, Poland;
[*]corresponding author: michal.cwikla@pwr.edu.pl.

Keywords: image processing, groove width, irregular groove

Introduction

Cutting micro-grooves is applied for the production of MEMS, solar cells [1], lab-on-chip microfluidics [2] and textured grinding wheels [3]. However, manufacturing grooves by laser ablation often results in irregularities in the desired groove width due to the applied parameters and the composite or anisotropic nature of the processed material. Consequently, the average width analysis according to the ISO 5436 standard is often insufficient. Therefore, we propose a new method for determining and evaluating the width of irregularly shaped groove structures. This method includes image processing of the intensity map of surface topography to calculate the distance between the edges of the groove along the entire measurement length. Subsequently, the conformity of the produced groove to the desired width is evaluated using the mean squares from ANOVA analysis.

Materials and methods

A Nanosecond laser was used to produce a groove structure in a resin CBN grinding wheel (Fig. 1a-c). Surface topography was measured using the LEXT OLS4000 and analyzed with TalyMap 7. The image processing algorithm was developed in OpenCV using the NumPy library to analyze the 3D intensity map. Finally, Origin 2023 software was used to conduct ANOVA analysis.

Results and discussion

Due to the different properties of the resin and CBN grits, the groove is characterized by an irregular shape, and its width varies along the groove's length (Fig. 1a-c). The thresholded image was binarized (Fig. 1b) to detect groove contours (Fig. 1c). The groove widths were plotted for each lateral pixel position (Fig. 1e). Although the mode value corresponds to the desired width (210 μm), the width distribution is irregular and often multimodal (Fig. 1d). Calculated mean square values were 157 and 6733 for Groove 2 and Groove 1, respectively, indicating better production quality for Groove 2.

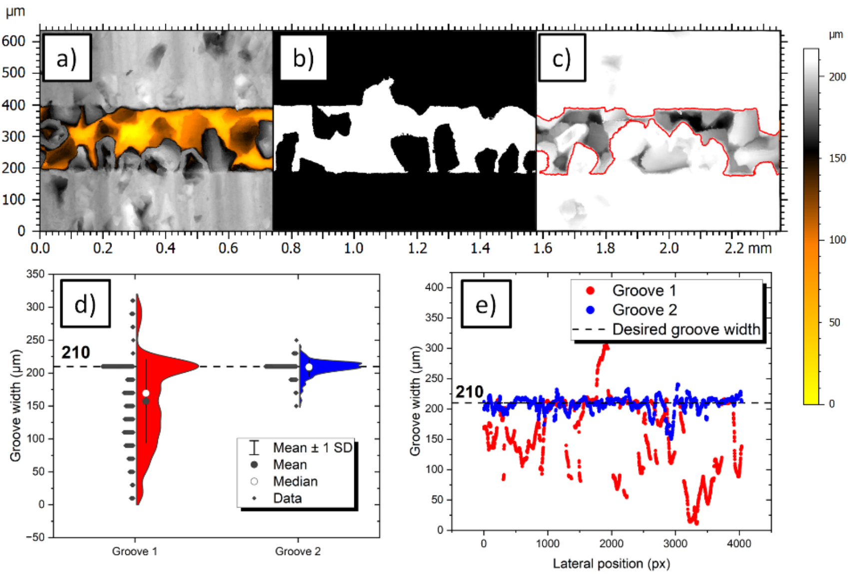

Fig. 1. (a) Top-view of the intensity map of the laser-ablated groove, (b) binarized image of the groove, (c) groove contours overlaid on the thresholded intensity map, (d) violin graph of the groove widths, (e) widths distribution over groove's length.

Conclusions

We propose a new procedure for evaluating the width of irregularly shaped grooves, which can be used to assess the quality of produced grooves relative to the desired shape. This procedure includes image processing of the groove's binarized 3D intensity map, followed by quantitative analysis of the mean squares of widths.

References

[1] T. Ner, P. Rana, and D. Marla, "Pulsed Laser Grooving of Silicon Under Different Ambient Media," Lasers in Manufacturing and Materials Processing, vol. 10, no. 4, pp. 626–644, 2023,

[2] A. G. Niculescu, C. Chircov, A. C. Bîrcă, and A. M. Grumezescu, "Fabrication and applications of microfluidic devices: A review," Int J Mol Sci, vol. 22, no. 4, pp. 1–26, 2021

[3] H. N. Li and D. Axinte, "Textured grinding wheels: A review," Int J Mach Tools Manuf, vol. 109, pp. 8–35, 2016