

Study on cutting performance of SiCp/Al composite using textured tool

Xu Wang

Changchun University of Science and Technology

Valentin L. Popov (✉ v.popov@tu-berlin.de)

Technische Universität Berlin

Zhanjiang Yu

Changchun University of Science and Technology

Yiquan Li

Changchun University of Science and Technology

Jingkai Xu

Changchun University of Science and Technology

Huadong Yu

Changchun University of Science and Technology

Research Article

Keywords: SiCp/Al composites, micro-textured cutting tool, secondary cutting

Posted Date: March 23rd, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-302368/v1>

License:   This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Abstract

In the micro cutting process of SiCp/Al composites, the tool wear is serious due to the existence of reinforcement phase in the material, which greatly affects the machined surface integrity. In order to reduce the friction and adhesion at the tool-chip interface, fabricating micro texture on the tool surface could be a feasible solution. This work focuses on the study of the cutting performance of the textured cutting tools through micro cutting of SiCp/Al composites. The experiments were carried out using NTK-KM1CCGW060202H uncoated cemented carbide tools with micro-hole textures developed by pulsed fiber laser. The results indicate that the micro-textured tools can reduce the wear, sticking and the contact length between the tool-chip. Also, the surface quality can be improved. It is observed from the chip's surface that the micro-textured tool can produce secondary cutting when machining SiCp/Al composite materials, the smaller the texture spacing, the more obvious the secondary cutting phenomenon. Furthermore, the cutting forces can be reduced using the micro-textured tool in most cases. However, when the texture spacing is too small the cutting force does not decrease. Finally, the surface roughness and surface residual stress of the machined workpiece are investigated. Textured tools have better results.

1 Introduction

The SiCp/Al composite material is mainly composed of aluminum alloy as the matrix and SiC particles as the reinforcing phase. Because of the special physical properties of this material, including high strength-to-weight ratio, high hardness, low thermal expansion coefficient, high thermal conductivity, and high corrosion resistance and wear resistance it has been widely used in aerospace, automotive, electronics, medical, optical instruments and other fields^[1-6]. The cutting process of SiCp/Al composite is pretty complicated. Due to the large elastoplasticity of the aluminum matrix and the large hardness of SiC particles, the tool wear is more quickly. For the better application of the SiCp/Al composite material under a harsh working condition, the machining problem of this material must be solved^[7]. At the high speed and with large feed rate in the cutting process, large friction between the tool-chip could occurs, which may increase the wear of the tool. Micro-textured tools can improve the tool's performance and reduce the frictional contact state between the workpieces and tools, thereby reducing the cutting force, the cutting temperature and the tool wear, which are of great significance for improving tool life and the quality of the machined surface^[8-10].

The Deng Jianxin team of Shandong University in China conducted a large number of experiments and theoretical explorations on the cutting performance of micro-textured tools and the lubrication performance of the surface of micro-textured tools. Liu et al^[11] produced textures with different parameters on the flank face of cemented carbide tools, and further studied the wear resistance and machining surface quality of micro-textured tools. They found that the flank face of the tool has textures, the wear resistance and surface machining quality are more excellent. Among them, the tool parameters with good cutting performance were: the groove width was 75 μm , the texture groove spacing was 100

μm , and the distance between the texture groove and the main cutting edge was $75\ \mu\text{m}$. Zhang et al.^[12] used laser technology to prepare a sinusoidal groove micro-texture on the surface of cemented carbide, they performed a linear reciprocating friction and wear test on the surface of the micro-textured cemented carbide performance research. The results showed that the surface of the sinusoidal micro-textured sample has the best anti-friction performance under the conditions of high load, high sliding speed at adding grease. Wu et al.^[13] used finite element method to simulate the cutting process of micro-textured tool cutting Ti-6Al-4V alloy, and carried out experimental verification. The results show that micro-textured tools can reduce cutting temperature, cutting force, and tool-chip contact length. At the same time, the micro-textured tool is easier to break the chips. In addition, compared with the rectangular cross-section groove, the V-shaped cross-section groove can reduce the severity of secondary cutting.

In addition, Zheng et al.^[14] studied the cutting performance of micro-textured tools for cutting Ti-6Al-4V Titanium Alloy. They selected YG8 tools and studied the cutting performance of four tools, namely non-microtexture tools, line texture tools, sinusoidal deformation tools and diamond texture tools. Among them, the groove width of the micro-textured tool is $159.599\ \mu\text{m}$ and the groove depth is $14.59\ \mu\text{m}$. Among them, the sinusoidal deformation tool has the best cutting effect under different cutting parameters, which can reduce the cutting force and surface roughness, and it also can extend the tool life.

Feng et al.^[15-16] conducted cutting experiments on AISI 1045 steel based on micro-textured tools with transverse micro-texture morphology. The dimensions of the microtexture are as follows: $0.2\ \text{mm}$ from the main cutting edge, $0.1\ \text{mm}$ spacing, $0.1\ \text{mm}$ width, and $0.1\ \text{mm}$ depth. By designing different positions, spacings and widths of micro-textures, the tool is finally obtained with the best cutting performance. They found that the secondary cutting phenomenon is not obvious with the groove width increasing, and the width of the micro-textured groove and the cutting speed were the key factors that affect the secondary cutting during the cutting process. They also selected the best parameters of three texture tools for cutting experiments on AISI1045 steel at different cutting speeds. The cutting force, cutting temperature, workpiece surface roughness and tool wear were measured. The results show that, compared with traditional tools, textured tools reduce cutting force, cutting temperature, tool wear significantly and workpiece roughness have been improved. Vasumathy et al.^[17] studied the friction of the tool-chip interface and the adhesion of the chip of AISI316 austenitic stainless steel during the cutting process, and they found that the micro-textured tool can reduce the adhesion and cutting force of the tool-chip. And this type of tool can minimize the friction between the tool and the chip interface. In order to study the effect of surface texture on Si₃N₄/TiC ceramics, Xing et al.^[18-19] used a laser to prepare regularly arranged micro-grooves on the surface of Si₃N₄/TiC ceramics. In addition, the tribological properties of the textured sample and the smooth sample were studied, and the results showed that compared with the smooth surface, the textured surface can reduce the friction coefficient and improve the wear resistance of the material. And they found that the tribological properties depend on the size and density of the micro grooves largely. In order to improve the friction and anti-sticking of the tool rake face in the dry cutting of aluminum alloy, they created three laser surface textures on the cemented carbide

rake face. It was found that the texture geometry has the greatest influence on the cutting force and friction coefficient in the cutting performance. Parida A. K. et al.^[20] evaluated the cutting performance of Ti-6Al-4V alloy micro-textured tools through a combination of experiment and simulation. The results found that the contact length, friction coefficient, cutting force and tool temperature distribution of the chip and the micro-textured tool are significantly reduced, compared with the flat tool. The cutting force, chip reduction coefficient and chip morphology in the square result are consistent with the experimental results better. Sivaiah et al.^[21] conducted a study on the cutting performance of the hybrid-textured tool and found that the friction between the textured tool and the chip was significantly reduced under wet cutting conditions, and the machined surface roughness was small. Elias et al.^[22] proposes a new method to make texture on the cutting tools using vickers microhardness indenter.

The larger cutting force and sever tool wear are prominent in traditional cutting produces^[23-24]. However, there are few researches on the cutting of SiCp/Al composites using micro-textured tools. Therefore, in this work, the machining experiments of SiCp/Al composites are performed to investigate the cutting performance of SiCp/Al composites with comparisons to that of the non-textured tool. The influence of hole array of micro-textured tool with different texture spacing cutting performance is analyzed. The secondary cutting and the surface properties of the workpiece is observed and analyzed during the machining of SiCp/Al composite to obtain the optimal texture parameters of the cutting tool.

2 Materials And Methods

The surface of the SiCp/Al composite after grinding and polishing is shown in Fig. 1. It can be seen that the SiCp/Al composite is composed of an aluminum matrix and SiC particles. After measuring the SiC particles, it is found that the size of the smaller SiC particles is about 2 μm , and the size of the larger SiC particles can reach about 12 μm . Moreover, some particles will be pulled out and broken during the machining. This is completely different from the cutting of traditional metal materials. These pulled out and broken SiC particles will interact with the textured tool, which makes the micro-textured tool cutting process more complicated. The high hardness of SiC particles makes the tool wear pretty serious during the machining. Micro-textured tools can reduce tool wear. Therefore, the research on micro-textured tools for cutting SiCp/Al composites is very meaningful.

The micro-cutting experiment setup is developed which can be used to perform orthogonal cutting experiment, as shown in Fig. 2 (a). Figure 2 (b) gives a schematic diagram of the cutting process. The overall size of the orthogonal cutting table is 300×400×300 mm, and size of the X and Y slide table is 70×110 mm. The stroke of slid table is 50 mm, and its positioning accuracy is 2 μm , the repeated positioning accuracy is 0.5 μm , and the maximum feed speed is 400 mm/s. The size of the Z-direction lifting slide is 120×120 mm, the maximum ascent stroke is 12 mm, the repeated positioning accuracy is 0.5 μm , and the bearing capacity is 20 kg. The cutting force is measured by the Kistler cutting force measuring instrument.

In the experiment we used NTK-KM1CCGW060202H uncoated cemented carbide tool with a rake angle of 7°, a flank angle of 3°, and a cutting edge radius of 2 μm. Nanosecond pulsed fiber laser is used to manufacture the micro-hole texture on the rake face near the main cutting edge. The laser wavelength is 1.064 μm, the maximum output power is 20W, and the pulse frequency is 20-200KHz.

The textured holes are as shown in Fig. 3. The holes are regularly distributed on the rake surface with different spacings. In this work we investigate five different values of hole spacing: 100μm, 80μm, 60μm, 40μm, 20μm. The other parameters are presented as follows. The diameter of the hole is around 5 μm (green spot in Fig. 3 (a)), the depth is around 30 μm (Fig. 3 (b)).The distance between the hole and the cutting edge is around 20 μm (Fig. 3(c)). The workpiece size is 10×10×1 mm, the cutting speed is set constant with 400 mm/s, the cutting depth is constant with 30 μm, and the number of cutting is 10 times. The numbering of tools and workpieces and corresponding values of hole spacing are given in Table 1.

Table 1
Numbers of tools and workpieces.

Tool Number	T-1	T-2	T-3	T-4	T-5	T-6
Texture Spacing	Non-textured	100μm	80μm	60μm	40μm	20μm
Workpiece Number	W-1	W-2	W-3	W-4	W-5	W-6

3 Results And Discussion

Based on the experimental results, the wear of tool, contact length, secondary cutting, cutting force and surface topography of workpieces were analyzed.

The surface of the tools was observed and inspected using a scanning electron microscope (SEM) after ten times cuttings. Figure 4 (a) shows the surface of non-textured tool (T-1) after ten times cuttings, and (b)-(f) micro-textured tools with different spacing from 100 μm to 20 μm corresponding to T-2 to T-6. It can be evaluated that the wear of tools and tool-chip adhesion are very serious during machining SiCp/Al composite material. In these six tools the non-textured tool is worn most near the tool tip. Moreover, the amount of chip adhesion on the surface of the non-textured tool is also the largest among the six tools. It can be clearly seen from Fig. 4 (b)-(f) that the micro-textured tool reduces not only tool wear during machining, but also effectively the adhesion of tool surface. The reduction of tool wear can be mainly attributed to the effect of the hole array which decreases the stress generated by the contact between the tool-chip during the cutting process, thereby reduces the friction between the tool and the chip as well as the tool wear. The decrease in surface adhesion of the tool may be due to the effect of holes and SiC particles on chips during the cutting process. Observing Fig. 4 (e), it can be seen that the surface of the tool with a hole spacing of 40 μm has very small amount of adhesion, and there is no adhesion around the micro-hole at the edge of the tool. Although some holes are blocked, the micro structure still plays an important role in the adhesive condition of the cutting tool and chips.

Another reason for the decrease in the amount of tool surface adhesion may be the combination of holes and SiC particles on the chip during the secondary cutting process. For that, the energy spectrum analysis of the adhesive area on the surface of the micro-textured tool was carried out. As shown in Fig. 5, in addition to the elements of the tool material, the selected elements and the remaining elements are Al and Si. From the distribution of Si, it is likely that some of the smaller SiC particles enter the hole of the micro-textured tool during the cutting process, then the SiC particles in the hole interact with the chip, which reduces the direct contact between the chip and the tool, resulting in a decrease in the amount of adhesion on the surface of the micro-textured tool.

Contact length

The tool-chip contact length of T-1 to T-6 tools during the cutting process is shown in Fig. 6. It can be seen that the micro-textured tool can reduce the tool-chip contact length compared to the non-textured tool. The contact length is reduced by 39%, 22%, 30%, 32%, and 9% for T-2 to T-6 tools, respectively. The results show that the contact length for T-2 to T-5 tools are reduced significantly, and for T-2 tool it is the smallest. The main reason for the reduction in cutting length is that the texture will produce secondary cutting during the cutting process. During the machining of non-textured tools, the chips will break when they reach a certain wear state. However, the secondary cutting accelerates the chip's fracture. After the main cutting edge is machined, the micro-texture acts on the chip once again, which causes the breaking of chip before reaching the previous contact length.

Secondary cutting

Secondary cutting is a common phenomenon in the cutting process of micro-textured tools. As shown in Fig. 7, secondary cutting phenomenon appeared during cutting SiCp/Al composite materials with micro-textured tools. However, this phenomenon is not so obvious as for traditional metal. The main disadvantage of secondary cutting is that the chips will be cut again and new chips will be generated, leading to reducing the effectiveness of the microtexture. From Fig. 7 (b)-(f), it can be seen that with the decrease of the micro-texture spacing, the phenomenon of secondary cutting becomes more obvious, which shows that adjusting the micro-texture spacing can reduce secondary cutting. From Fig. 7 (c) and (e), T-3 and T-5 tools are more likely to break the chips during the cutting process, and then produce chips. T-2 and T-4 tools produce secondary cutting during the cutting process. The phenomenon is not obvious, and the chips are not easily broken.

Due to the particularity of the SiCp/Al composites, the secondary cutting process in its machining could be divided into two stages, as illustrated in Fig. 8. In the first stage, the micro-texture holes are not blocked, so the micro-texture will directly interact with the chips during the cutting process. Then some of the holes will be blocked, which greatly reduces the effect of the holes in the second stage. In the second stage, some SiC particles will be broken from the matrix during the cutting process and SiC particles of different sizes will be generated, some of which will enter the hole and directly interact with the chips, thereby reducing tool wear and surface adhesion. Since the second stage works differently from the first

stage, the reduction in contact length should be due to the simultaneous action of these two stages. However, due to the property of the material, the second stage could play a major role.

Cutting force

Cutting force is the main factor affecting tool wear. In the experiment, the machining direction is set as the direction of main cutting force, and its values are averaged after ten times cuttings. The results are shown in Fig. 9. It is seen that T-2 to T-6 tools produce smaller cutting forces than T-1 tool. The micro-textured tool reduces the friction between the tool and the chip during the machining, thereby reducing the cutting force. With the decrease in the micro-texture spacing, the cutting force of the micro-textured tool is reduced by 13%, 9%, 17%, 4%, 5%, respectively. It can be clearly seen that the cutting force of the tool with a micro texture space of 60 μ m has the largest reduction in cutting force. But cutting force does not decrease monotonically. The cutting forces of T-5 and T-6 tools are not reduced significantly due to the secondary cutting during the cutting process. In the cutting process, for the T-3 tool it is easy to produce chips, which has a certain influence on the effect of chip. Observing the chip morphology produced by T-2 and T-4 tools, one can evaluate that these two micro-textured tools are more stable during the cutting process, which will result in a significant reduction in cutting force. From the results of chip shape and cutting force, secondary cutting is the main factor affecting the reduction of cutting force.

Workpiece surface test

Figure 10 presents the SEM images of the surface of the workpiece after cutting. It can be seen that the surfaces machined by the micro-textured tools are generally smooth and have a few cracks relatively (Fig. 10 (b)(c)(e)(f)). In the following it will be shown that the residual SiC particles on the machining surface of micro-textured tools are much less than non-textured tool, and part of the SiC particles remain in the hole and interact with the chips during the cutting process.

Surface roughness

Surface roughness is an important criterion for measuring the quality of workpiece machining. Figure 11 shows the Ra values of surface roughness workpieces W-1 to W-6. Ra is the arithmetic average of the absolute value of the contour deviation along the measurement direction and the distance from the center line, and can be used to evaluate the smoothness of machined parts. The roughness of surface is averaged from five measurements. It can be seen that the surface roughness of W-1 and W-4 workpieces is relatively large, and smaller for W-2, W-3, W-5 and W-6, which is consistent with the behavior of the surface micro-topography (Fig. 10). If considering only the factor of the tool wear and surface roughness, the cutting effect of the T-2 tool is the most excellent.

Residual Stress

The residual stress of the machined workpiece is measured by a residual stress measuring instrument, it has a certain effect on the residual stress of the machined surface. It can be seen from Fig. 12 that the compressive stress is generated on the surface of the SiCp/Al composite after the cutting. Select 5 points

on the surface of the workpiece, with an interval of 0.25 cm, the leftmost point is 0 cm, and the rightmost point is 1 cm. Among them, T-5 and T-6 tools cause greater residual stress on the workpiece's surface, and W-3 and W-4 less.

Conclusion

In this paper, the tool wear and workpiece surface in dry cutting of SiCp/Al composites by micro-textured tools and non-textured tools were studied experimentally. The micro-textured tool can improve cutting performance, and different cutting effects can be achieved by modifying the spacing of texture. And it has a great influence on the surface of the workpiece. The conclusions are as follows:

1. Sever tool wear and tool sticking occur during dry cutting the SiCp/Al composite, however, when using micro-textured tools the performance can be improved significantly in these two It is attributed to the particles remaining in the holes and the interaction between the particles and the chips.
2. The contact length between the non-textured tool and the chip is the largest during the cutting process. The micro-textured tools can reduce the contact length by adjusting the spacing of the micro-texture
3. Micro-textured tools produce secondary cutting during machining. Increasing the hole spacing of micro-textures tool can reduce the impact of secondary Main cutting force is reduced by use of micro-texture, where tool T-4 tool is most effective and the cutting force is reduced by 17%.
4. Micro-textured tools have a certain effect on the surface roughness and residual stress of the Micro-textured tools produced the smoother surface (especially T-2, T-3, T-5 and T-6), and reduced the residual stress of SiC particles on the machined surface. However, the most obvious reduction in residual stress on the machined surface is the T-3 and T-4 tools (T-3 is the best).

Declarations

Ethical Approval

Not applicable

Consent to Participate

Not applicable

Consent to Publish

Not applicable

Authors Contributions

V. Popov and Xu Wang designed the experimental plan, and Zhanjiang Yu and Jinkai Xu designed and adjusted the experiment set-up. The measurement was performed by Jinkai Xu, Yiquan Li and Xu Wang.

V. Popov and Zhanjiang Yu processed and analyzed the experimental data. Huadong Yu supervised the project and the collaboration.

Funding

This work was supported by the National Key Research and Development Plan Project (No.2018YFB1107400), the National Key Research and Development Plan Project (No.2018YFB1107403), the “111” Project of China (No.D17017), Jilin Province Scientific and Technological Development Program (No.20190101005JH, No.20180201057GX, No.20190302076GX), and Science Fund for Youth Scholar of Changchun University of Science Technology (No.XQNJJ-2018-09).

Competing Interests

The authors declare that they have no competing financial interests.

Availability of data and materials

The data that support the findings of this study are available from the corresponding author upon reasonable request.

References

1. Muthukrishnan N, Murugan M, Rao KP (2008) Machinability issues in turning of Al-SiC (10p) metal matrix composites. *Int J Adv Manuf Technol* 39(3–4):211–218
2. Goo B-C. Al/SiCp Brake Discs Produced by Dissimilar Cast-Bonding. *Materials and Manufacturing Processes*, 2016, 1–6
3. Hong SJ, Kim HM, Huh D, Suryanarayana C, Chun BS (2003) Effect of clustering on the mechanical properties of SiC particulate-reinforced aluminum alloy 2024 metal matrix composites. *Materials Science Engineering A* 347(1–2):198–204
4. Gül T (2011) Statistical analysis of process parameters in drilling of Al/SiCp metal matrix composite. *The International Journal of Advanced Manufacturing Technology* 55(5–8):477–485
5. Zhou M, Wang M, Dong GJ. Experimental investigation on rotary ultrasonic face grinding of SiCp/Al composites. *Materials and Manufacturing Processes*, 2015
6. John R, Lin R, Jayaraman K, Bhattacharyya D (2020) Effects of machining parameters on surface quality of composites reinforced with natural fibers. *Mater Manuf Processes* 36(2):1–11
7. Seeman M, Ganesan G, Karthikeyan R, Vealyudham A (2010) Study on tool wear and surface roughness in machining of particulate aluminum metal matrix composite-response surface methodology approach. *Int J Adv Manuf Technol* 48(5–8):613–624
8. Gajrani KK, Sankar MR (2020) Sustainable Machining With Self-Lubricating Coated Mechanical Micro-Textured Cutting Tools. *Encyclopedia of Renewable Sustainable Materials* 1:853–866

9. Mohanty S, Das AK, Dixit AR (2021) Surface integrity and residual stress analysis of μ EDM coated Ti-alloy miniature components. *Mater Manuf Processes* 36(1):48–58
10. Dheeraj N, Sanjay S, Kiran Bhargav K, Jagadesh T. Investigations into solid lubricant filled textured tools on hole geometry and surface integrity during drilling of aluminium alloy. *Materials Today: Proceedings*, 2020, 1–7
11. Liu Y, Deng J, Wang W, Duan R, Meng R, Ge D, Li X. Effect of texture parameters on cutting performance of flank-faced textured carbide tools in dry cutting of green Al₂O₃ ceramics. *Ceramics International*, 2018, 13205–13217
12. Zhang GL, Deng JX, Ge DL, Wang W, Zhang X, Liu YY (2018) Effect of sine-type surface macrotexture on tribological property of carbide. *Tool Engineering* 52(2):12–17
13. Wu Z, Bao H, Liu L, Xing YQ, Huang P, Zhao GL (2020) Numerical investigation of the performance of micro-textured cutting tools in cutting of Ti-6Al-4V alloys. *Int J Adv Manuf Technol* 108(10):463–474
14. Zheng KR, Yang FZ, Zhang N, Liu QY, Jiang FL. Study on the cutting performance of micro textured tools on cutting Ti-6Al-4V Titanium Alloy. *Micromachines*, 2020, 11(2), 1–12
15. Feng YH, Zhang JY, Wang L, Zhang WQ, Dong YP (2019) Study on secondary cutting phenomenon of micro-textured self-lubricating ceramic cutting tools with different morphology parameters formed via in situ forming of Al₂O₃-TiC. *International Journal of Advanced Manufacturing Technology* 104(3):1–13
16. Feng YH, Yuan PD, Wang L, Zhang JY, Zhang JH, Zhou X (2020) Experimental investigation of different morphology textured ceramic tools by in-situ formed for the dry cutting. *Int J Appl Ceram Technol* 17(3):1–11
17. Vasumathy D, Meena A. Influence of micro scale textured tools on tribological properties at tool-chip interface in turning AISI 316 austenitic stainless steel. *Wear*, 2017, 376–377:1747–1758
18. Xing YQ, Deng JX, Feng XT, Yu S (2013) Effect of laser surface texturing on Si₃N₄/TiC ceramic sliding against steel under dry friction. *Materials Design* 52(Complete):234–245
19. Xing YQ, Deng JX, Wang XS, Ehmann K, Cao J. Experimental assessment of laser textured cutting tools in dry cutting of aluminum alloys. *Journal of Manufacturing and Engineering*, 2016
20. Parida AK, Rao PV, Ghosh S (2020) Performance of textured tool in turning of Ti-6Al-4V alloy: numerical analysis and experimental validation. *Journal of the Brazilian Society of Mechanical Sciences Engineering* 42(5):715–725
21. Sivaiah P, Muralidhar SM, Venkatesu S, Yoganjaneyulu G (2020) Investigation on turning process performance using hybrid-textured tools under dry and conventional cooling environment. *Mater Manuf Processes* 35(16):1852–1859
22. Elias JV, Prasanna VN, Deepak LK, Jose M (2021) Tool texturing for micro-turning applications - an approach using mechanical micro indentation. *Mater Manuf Processes* 36(1):84–93
23. Dandekar CR, Shin YC (2009) Multi-step 3-D finite element modeling of subsurface damage in machining particulate reinforced metal matrix composites. *Composites Part A: Applied Science Manufacturing* 40(8):1231–1239

24. Tang DW, Zhang WM, Zhao RL, Lv XJ (2017) Machining of SiCp/Al composites: effect of tool corner radius on residual stresses, cutting force and temperature. Adv Mater Res 1142:265–270. DOI:10.4028/www.scientific.net/AMR.1142.265

Figures

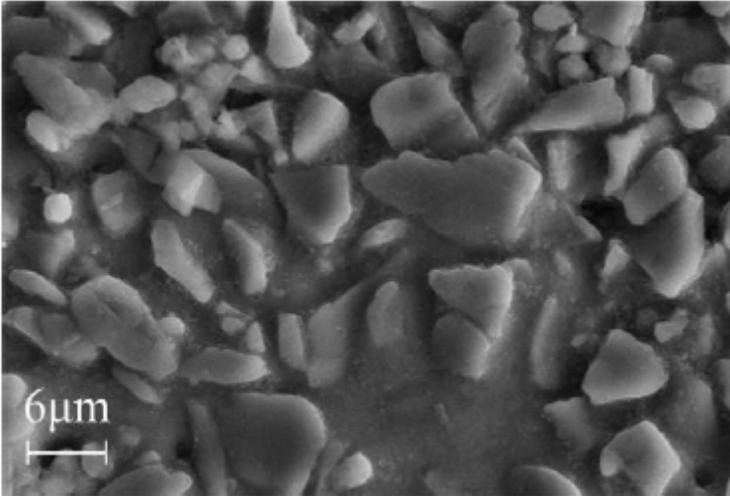
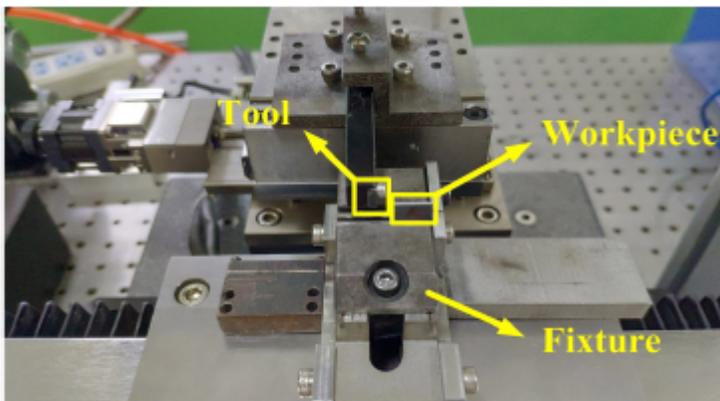
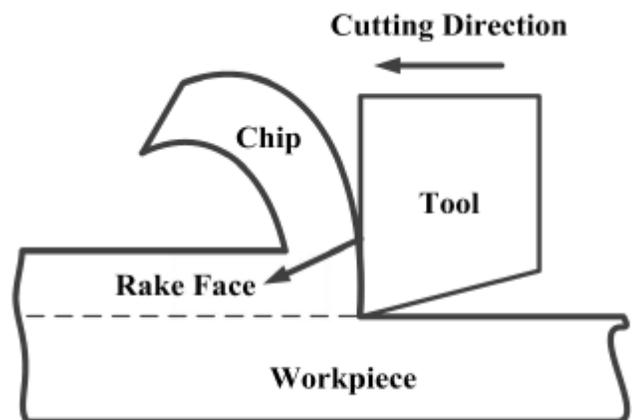


Figure 1

SiCp/Al composites material structure



(a)



(b)

Figure 2

(a) Orthogonal cutting experiment table, (b) Schematic diagram of machining.

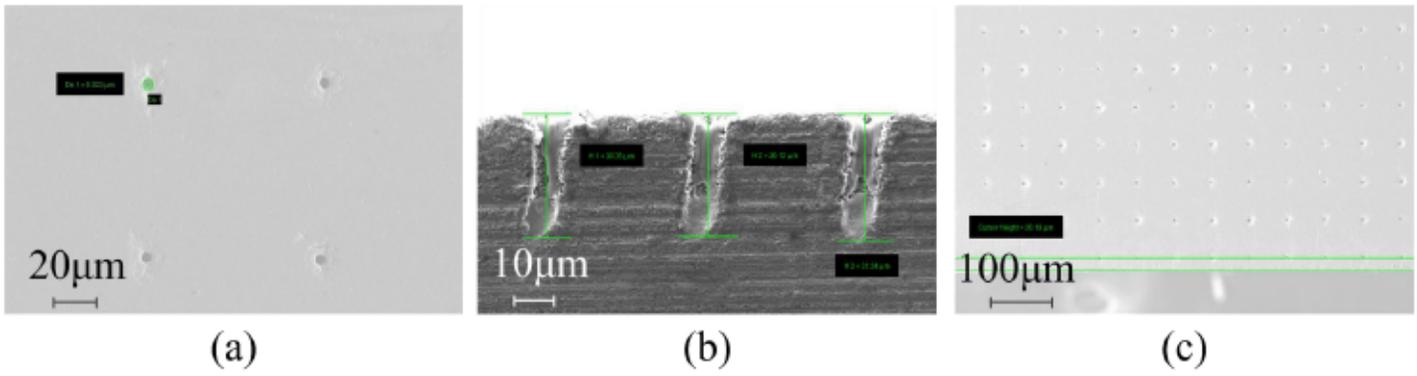


Figure 3

(a) Top view of micro-textured hole diameter; (b) Profile of hole depth (3) Distance between the micro texture and the main cutting edge.

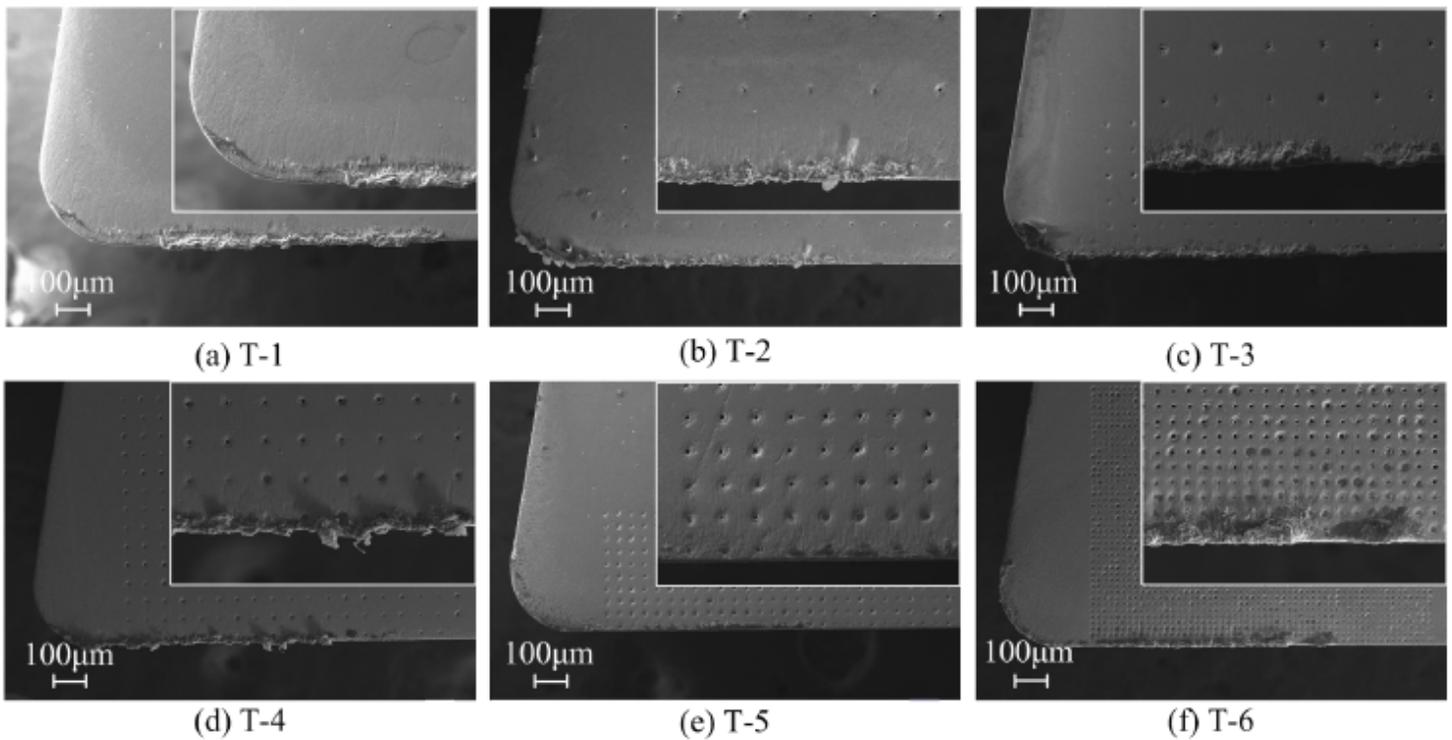


Figure 4

SEM images of surfaces of non-textured and micro-textured tools after ten cuttings (a) non-textured tools, (b) micro-textured tools with a hole spacing of 100 μm, (c) 80 μm, (d) 60 μm, (e) 40 μm, (f) 20 μm.

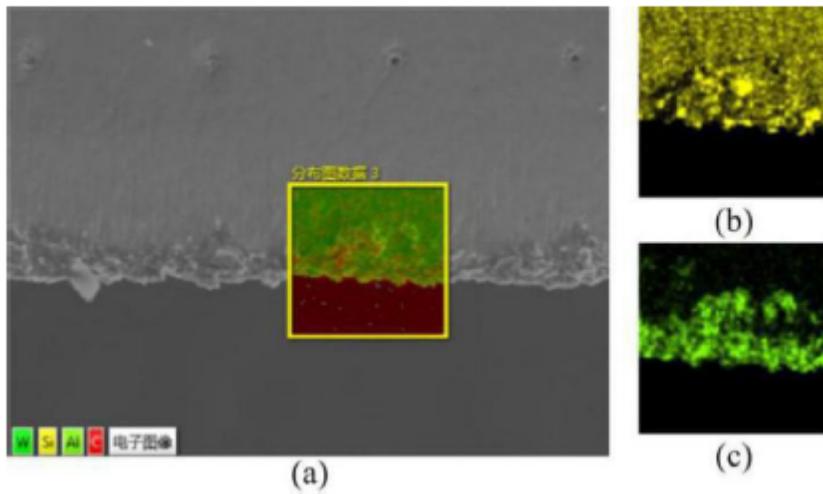


Figure 5

(a) Energy spectrum analysis of micro-textured tool surface distribution of elements on the surface of micro-textured tools' edge, (b) Distribution of Al elements on the surface of micro-textured tools' edge, (c) Distribution of Si elements on the surface of micro-textured tools' edge.

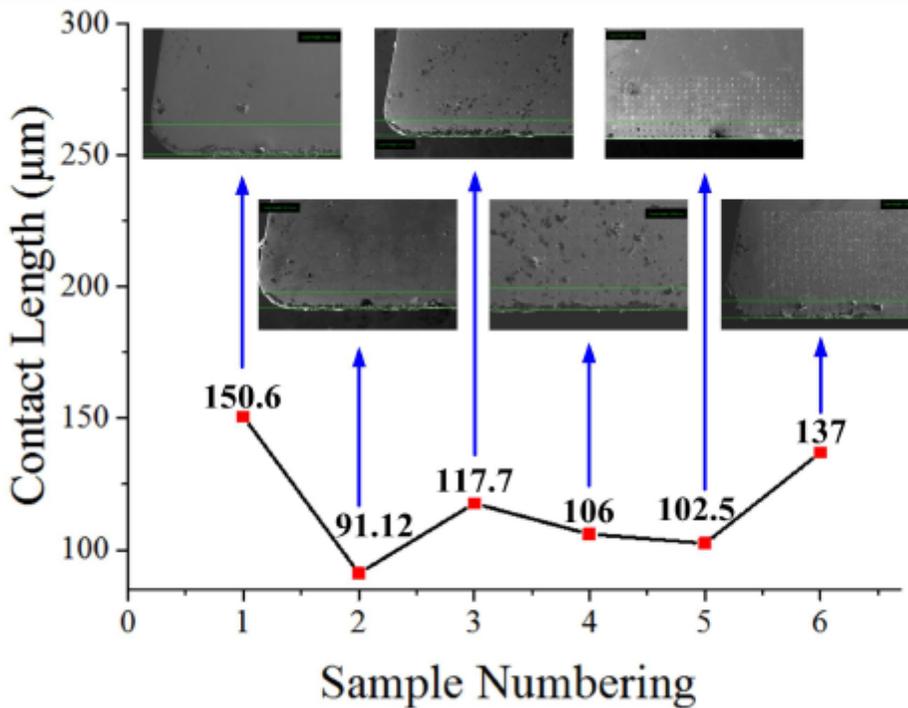


Figure 6

Tool-chip contact length during the cutting process of non-textured tool and micro-textured tool. Numbering 1-6 correspond Tool T-1 to T-6 respectively.

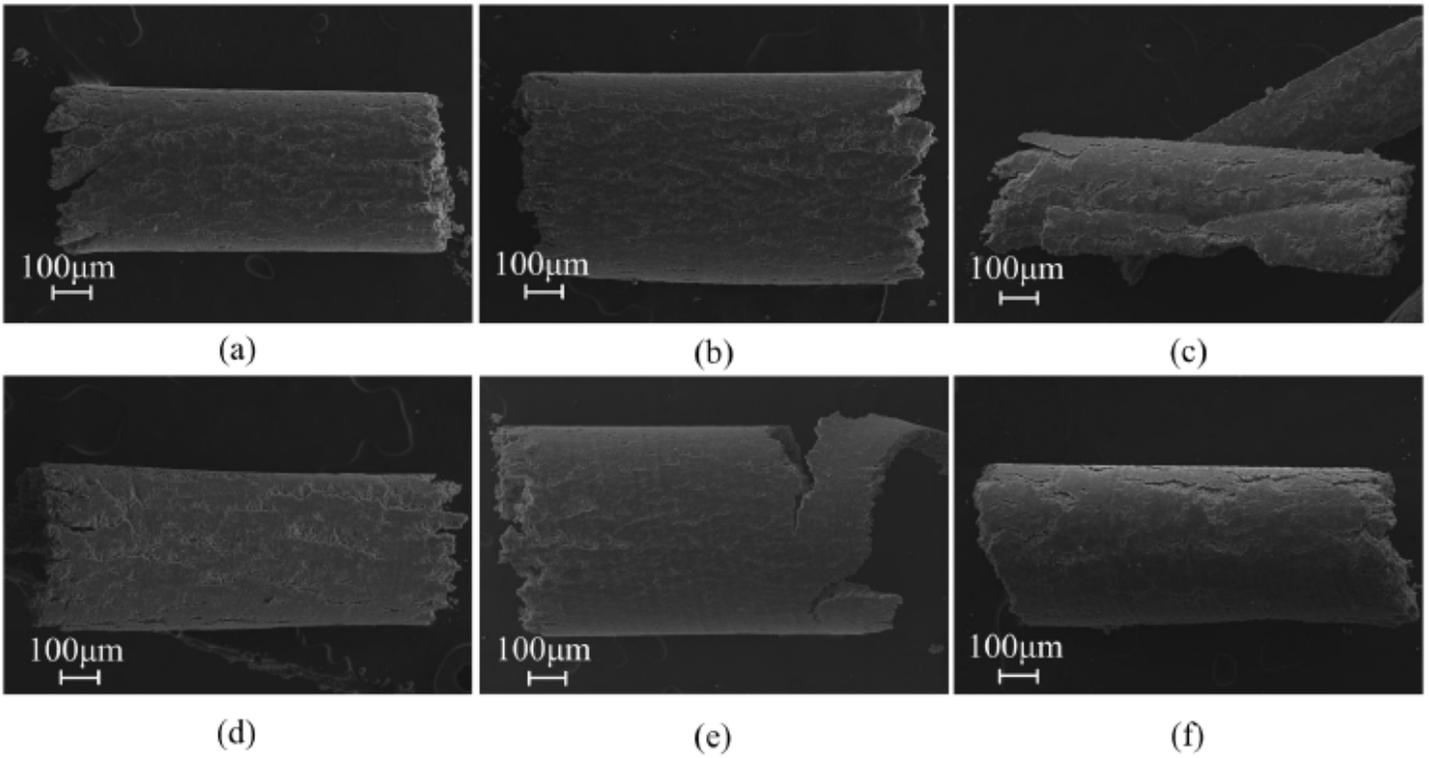


Figure 7

SEM images of chips generated during the cutting process of non-textured tools and micro-textured tools. Chips produced by (a) T-1 tool, (b) T-2 tool, (c) T-3 tool, (d) T-4 tool, (e) T-5 tool, (f) T-6 tool

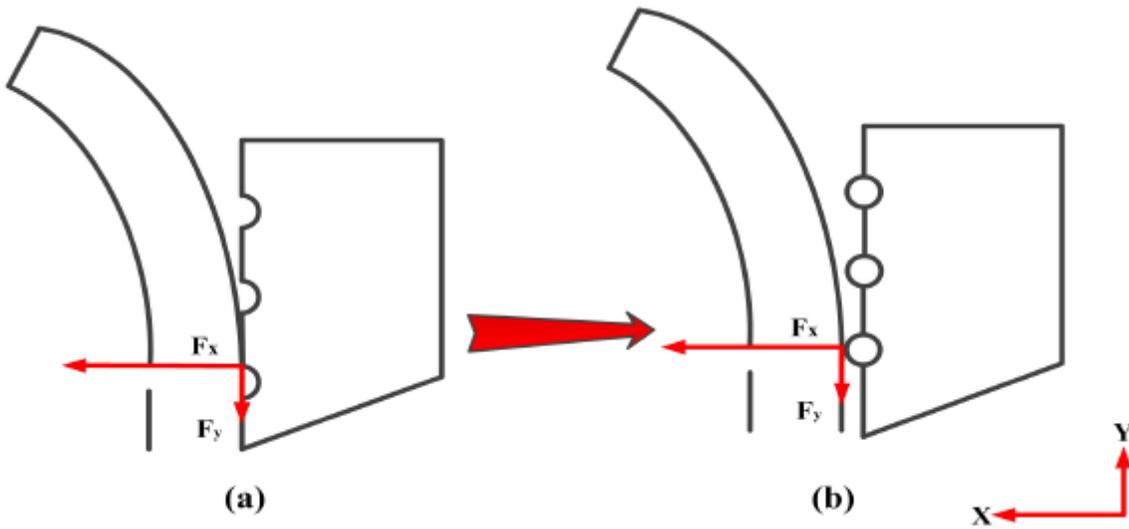


Figure 8

Schematic diagram of secondary cutting of SiCp/Al composite with micro-textured tool. (a) Initial stage of secondary cutting, (b) Stable stage of secondary cutting.

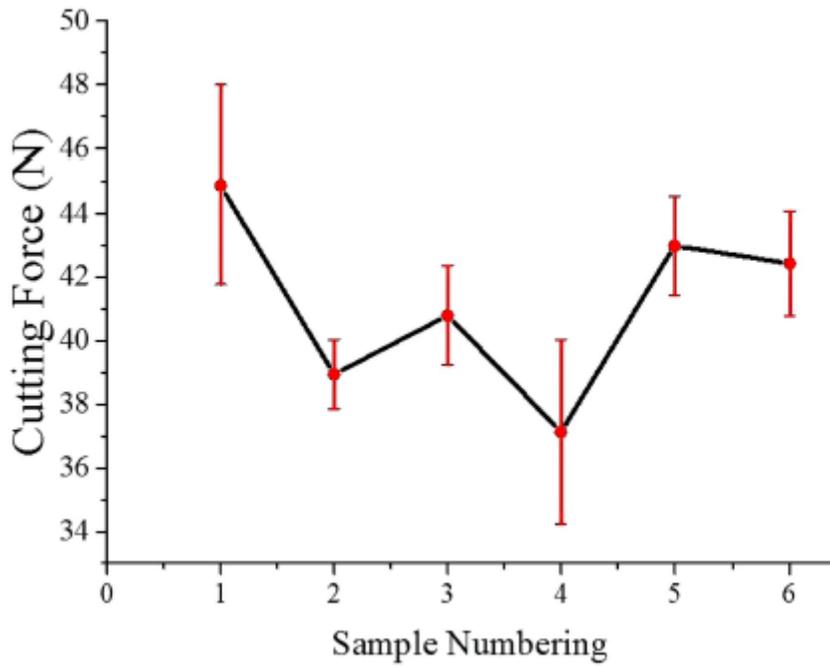


Figure 9

The average value of the main cutting force during the cutting process of the non-textured tool and the micro-textured tool. Numbering 1-6 represents the cutting force generated by the T-1 to T-6 tools.

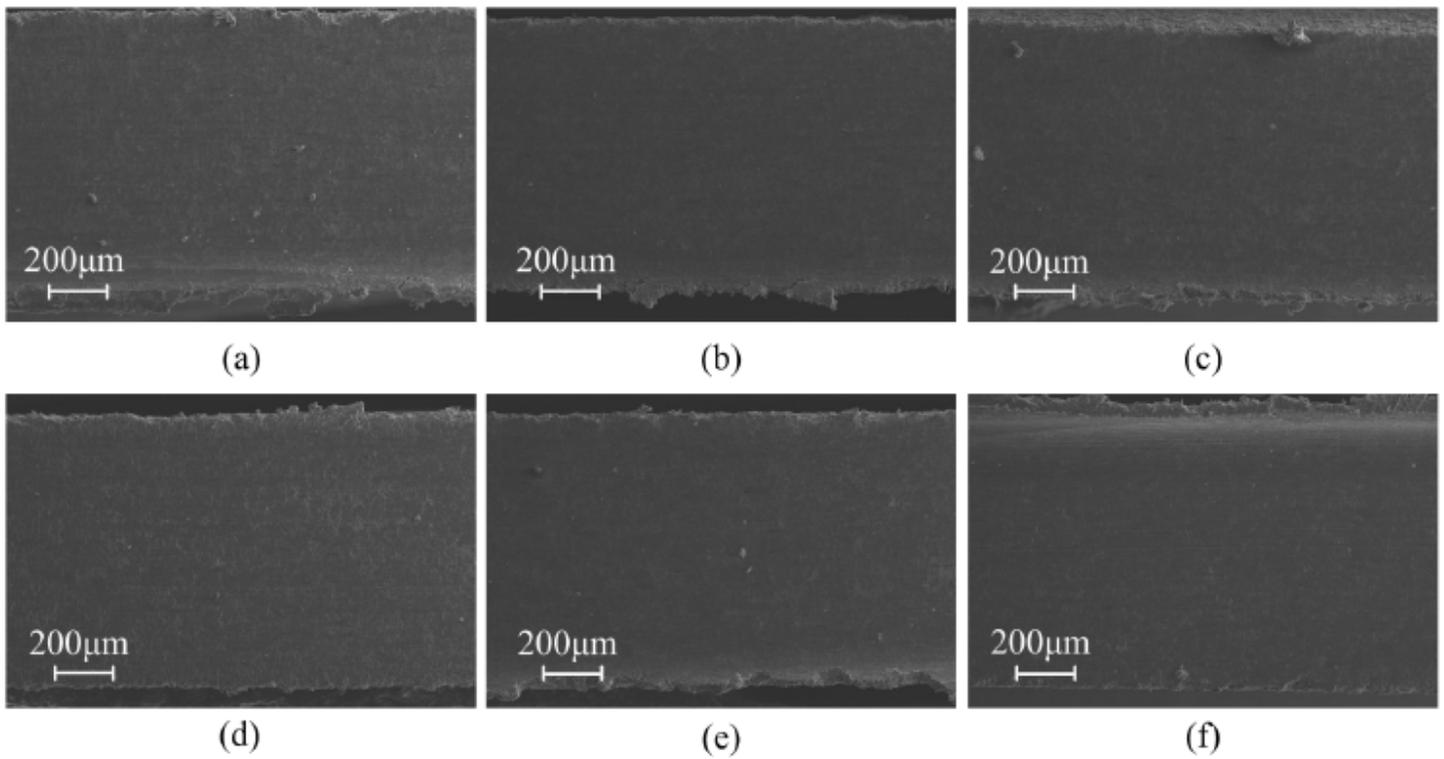


Figure 10

SEM images of non-textured tool and micro-textured tool surface (a) W-1, (b) W-2, (c) W-3, (d) W-4, (e) W-5, (f) W-6.

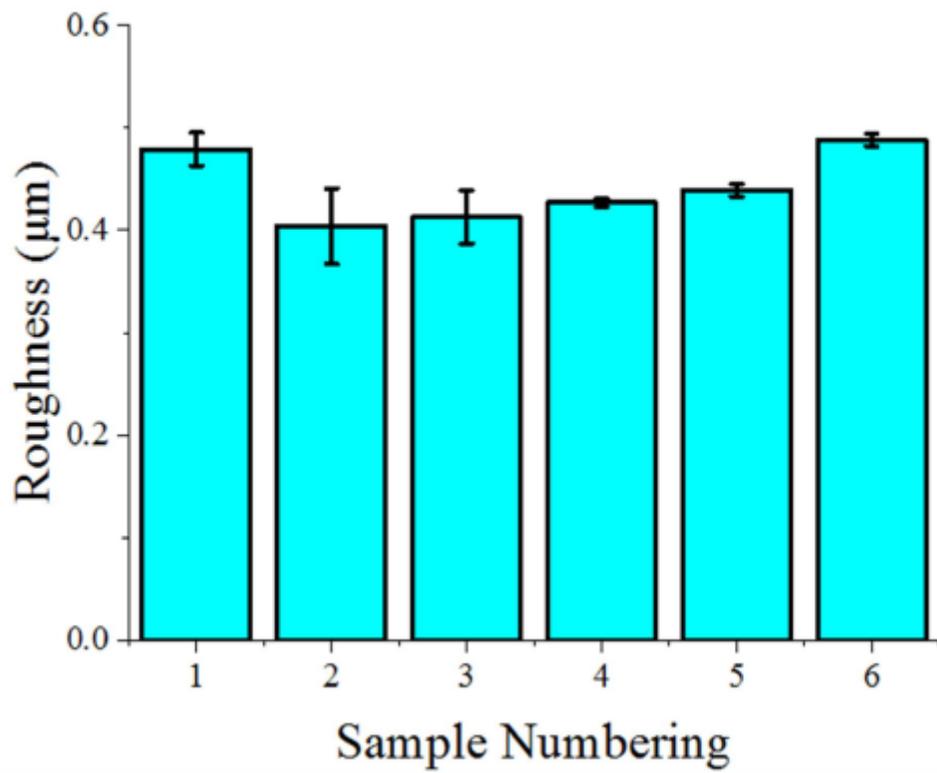


Figure 11

Surface roughness of workpieces machined by non-textured tool and micro-textured tools. (a) W-1, (b) W-2, (c) W-3, (d) W-4, (e) W-5, (f) W-6.

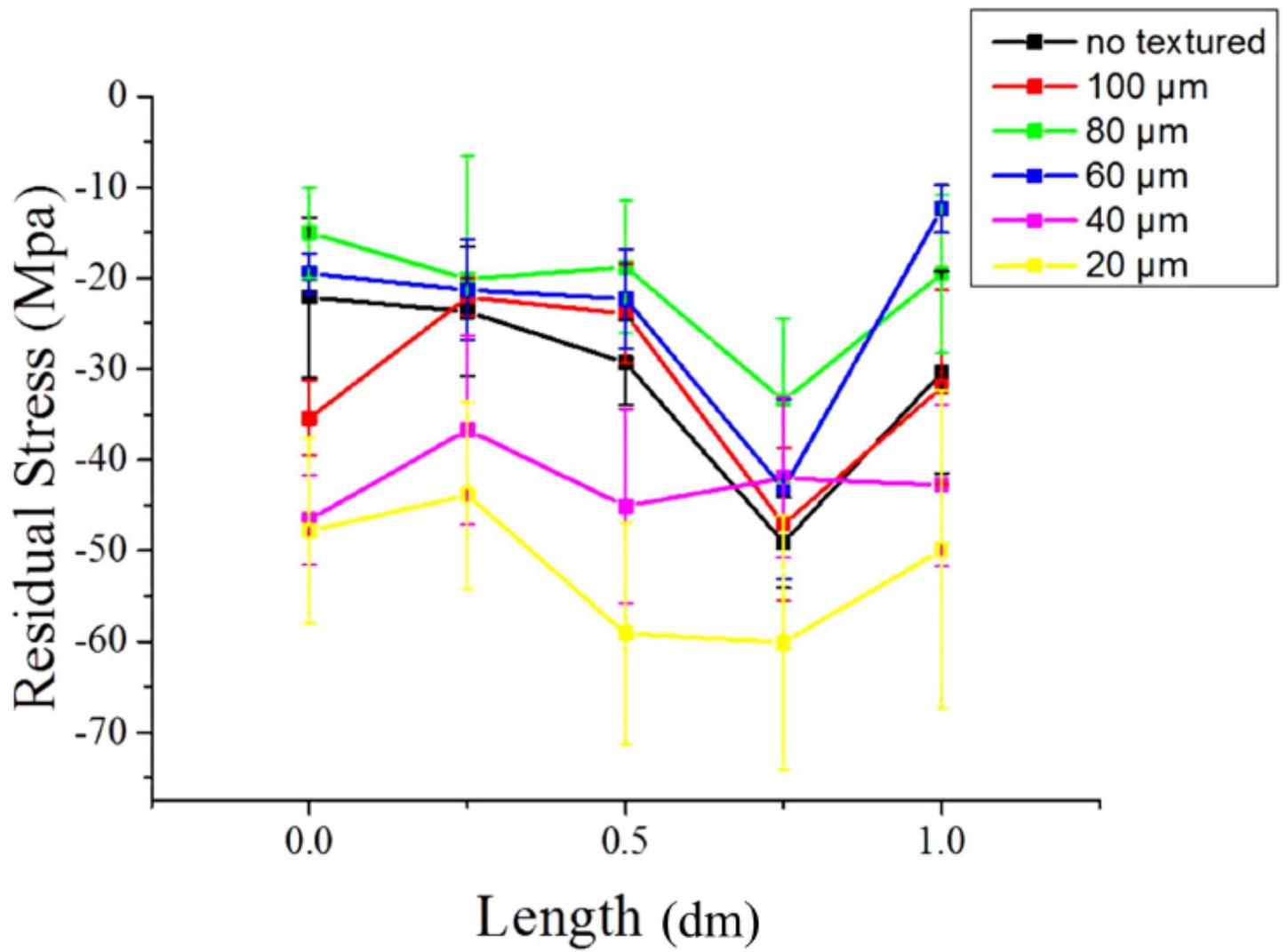


Figure 12

Surface residual stress of workpieces machined by non-textured tools and micro-textured tools