Surface Texture Monitoring in Ultraprecision Cutting of OFHC Copper

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Abstract—The texture of diamond-machined optical-quality surfaces on polycrystalline metals is strongly influenced by the anisotropic elastic and plastic properties of the work material. Micro-scratching tests were carried out on coarse-grained OFHC copper specimens to examine the correlation between surface topography and process forces. In agreement with previous work performed by other researchers [1] the grain boundary has been found to be a potential source of surface defects. When the force reaches a high level it's possible to detect rough ares starting from the grain boundary.

Experiment

The experiment was performed on a Pneumo precision lathe, with diamond tools and coarse-grain OFHC copper workpieces. The depth of cut is constant and the scratch starts at the edge of the specimen and ends at an intentional stop.The cutting force was measured with a load cell fixed on the tool-holder.

Several experiments have been done with different tools and different depth of cut,with the intent to control the average cutting force by the material removal. Depth of cut and tool nose radius have been kept to values low enough to cut primaraly on a single grain at the time.

A sample is shown in Fig. 1. Rough areas are easily correlated to high forces and distinct grains; wide smooth areas are clearly associated with lower forces.

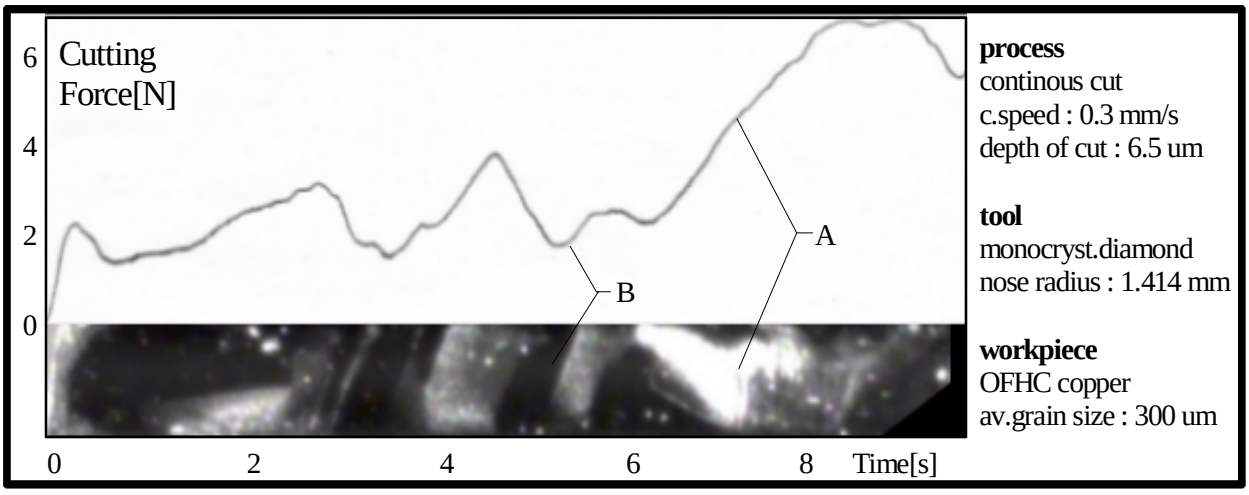

Figure 1.

Different grain orientations lead to different cutting forces and different surface textures. The tool structure accumulates energy when traversing a grain with unfavorable crystallographic orientation.The accumulation of energy is characterized by unstable cutting, and large areas with high roughness are found. When decreasing the depth of cut the surface texture tends to be more homogeneous. This is in accord with the theory that damage occurs only when the tool structure reaches certain energy levels.

Fig. 2 shows a magnified views of a rough and smooth area. The picture to the left is from point “A” in Fig. 1. The force varies from 2.9 to 3.8 N at this point, up to 6.6 N within the same grain. The area around point “B” is magnified in the right image in Fig. 2. The force here is only about 1.6 N. A microscopic waviness is still detected.

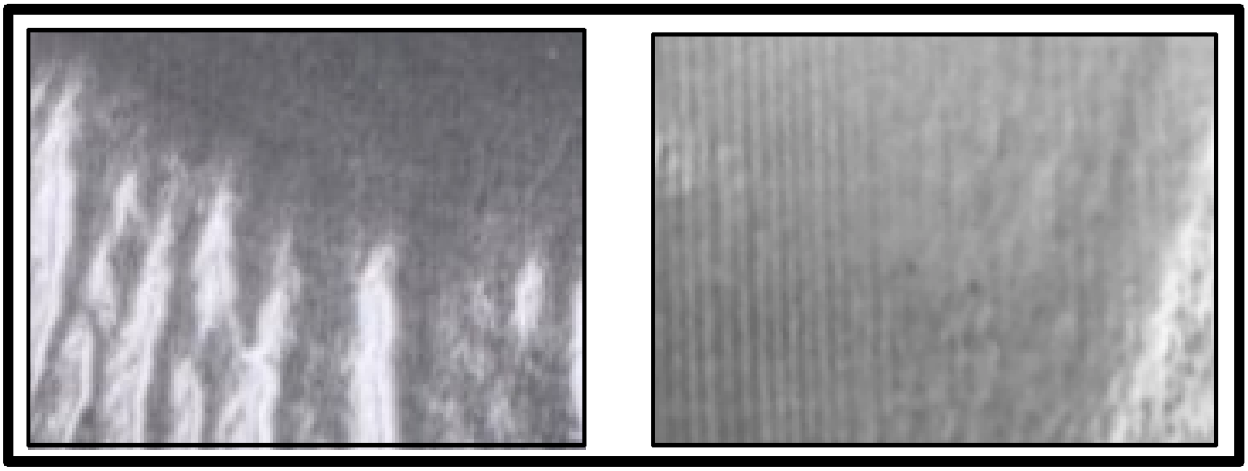

Figure 2.

Conclusions

Scratching tests were performed on OFHC copper. The machined surfaces exhibit different characteristic microtopographies. Force measurements demonstrate that high force levels due to passing over a grain with different orientation can be the cause of increasing surface roughness. The rough areas start at the grain boundary, and their surface areas are variable. Experiments demonstrate the feasibility of using force as a means for process monitoring, and explanation of the phenomena can contribute to the modelling of ultraprecision cutting processes.

References

[1] E. Brinksmeier and J. Schmutz,”*Generation and texture of surfaces in ultraprecision cutting of copper”* Machining Science and Technology, Vol.1, No.2, pp.185-193, 1997.