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Influence of Orientation on Small Scale Wear Response

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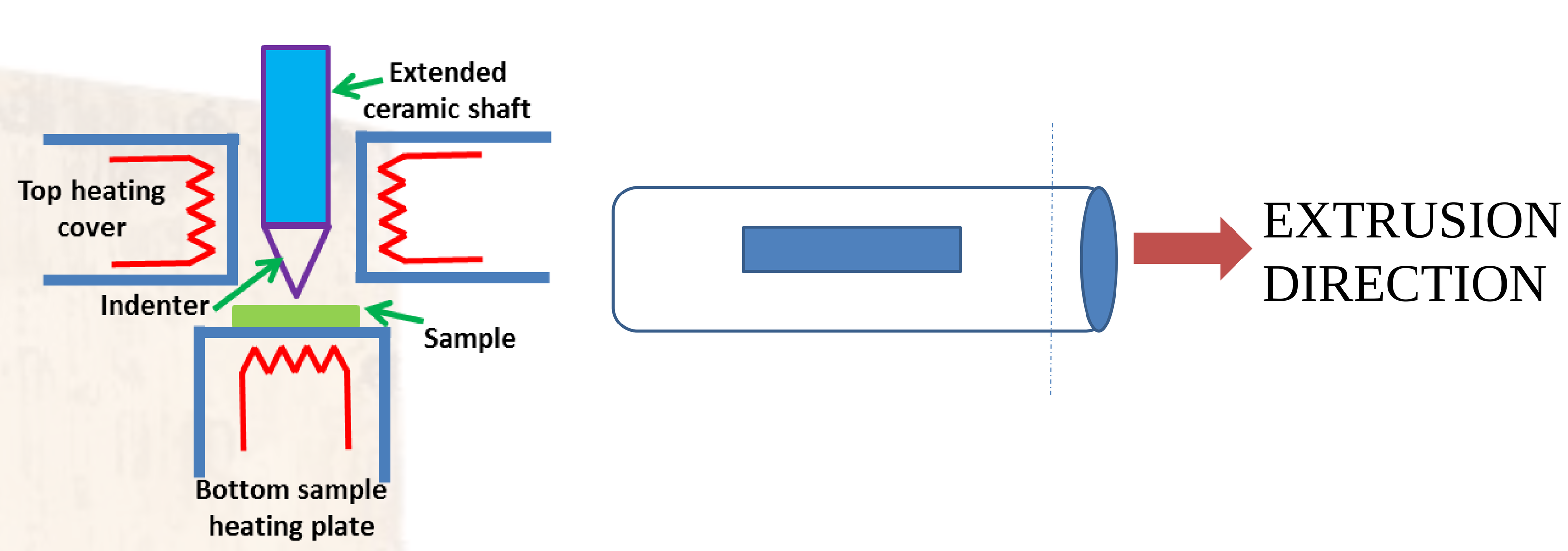
Abstract

The effect of orientation on the wear response is often overlooked in the bulk wear testing. In the present research the effect of texture and temperature on the wear response investigated in an extruded rod of pure zinc. Formation of chips at higher temperature marked the transition of wear mechanism from micro-ploughing to micro-cutting. Suppression of twinning at high temperature was also observed suggesting a complete slip dominated deformation at high temperature. The effect of texture was evident at high temperature and high loads.

Introduction

Wear is an omnipresent phenomenon in engineering service life of a product. From machining to micro-fabrication the component undergoes wear in some way or the other. However, in some cases, like precision machining, the wear and presence of surface damage becomes critical in deciding the performance of the material/component. Besides being used as a coating, zinc is also used in small electrical housing and medical implants. In a material, its intrinsic Young's modulus and hardness have a strong crystallographic correlation and needs to be exploited for better usage and design of material from wear/tribology point of view. Zinc has an hcp structure and high degree of anisotropy. Many researchers have clearly demonstrated the effect of orientation on the Young's modulus, hardness and deformation mechanisms and brought out a strong crystallographic correlation. Motivated by the fact that harder will resist better, the present work demonstrates the effect of texture anisotropy and temperature on the scratch wear behavior.

Materials and Methods



Conclusions

Scratch wear tests was performed on surfaces parallel and perpendicular to ED. For scratches made parallel to ED the chip formation was pronounced than the other case. Wear resistance for scratches made parallel to ED was more. At high temperature and load, the effect becomes more pronounced and surface parallel to ED gives a better wear resistance. Slip was found to be the major deformation mechanism however suppression of twin was observed at high temperature besides GBS. A nearly UFG structure on Zn surface can be produced through high temperature indentation scratching. The $\{10\bar{1}2\} < 10\bar{1}1 >$ contraction twin was found to play a key role in deformation and recrystallization at 150 °C.

Industrial Significance

Intrinsic hardness due to crystallography of the material or grains can be exploited to improve the wear resistance of the surfaces. Gradient in microstructure can be produced using this technique for small scale application.

Technology Readiness Level

TRL 2

References

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Gokhale, A., Sarvesha, R., Prasad, R., Singh, S. S., & Jain, J. (2019). A novel approach to refine surface grains in pure zinc using indentation scratch. *Materials Letters*, *247*, 151-154.

Acknowledgement

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Result

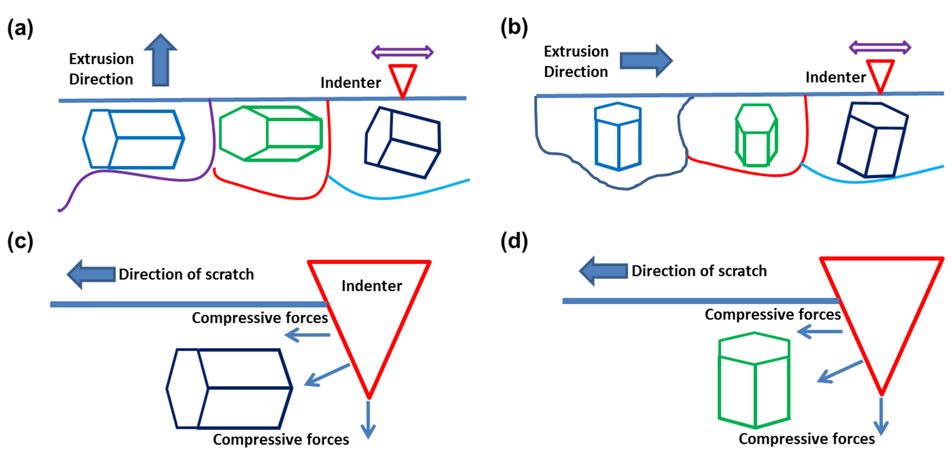

Fig. 1 Scratching direction with respect to orientation of grains

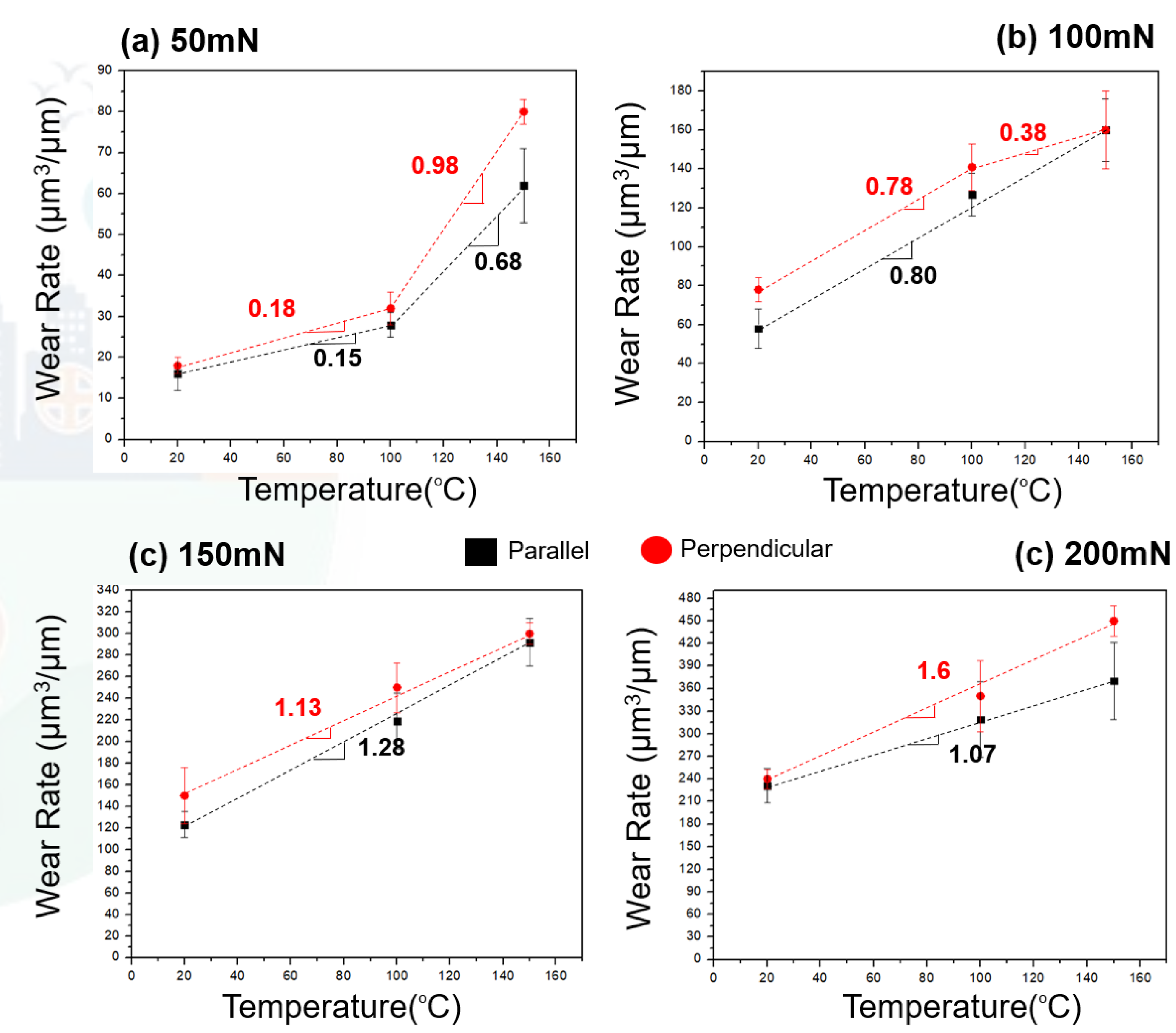

Fig. 2 Wear rate at different temperatures for different orientations.

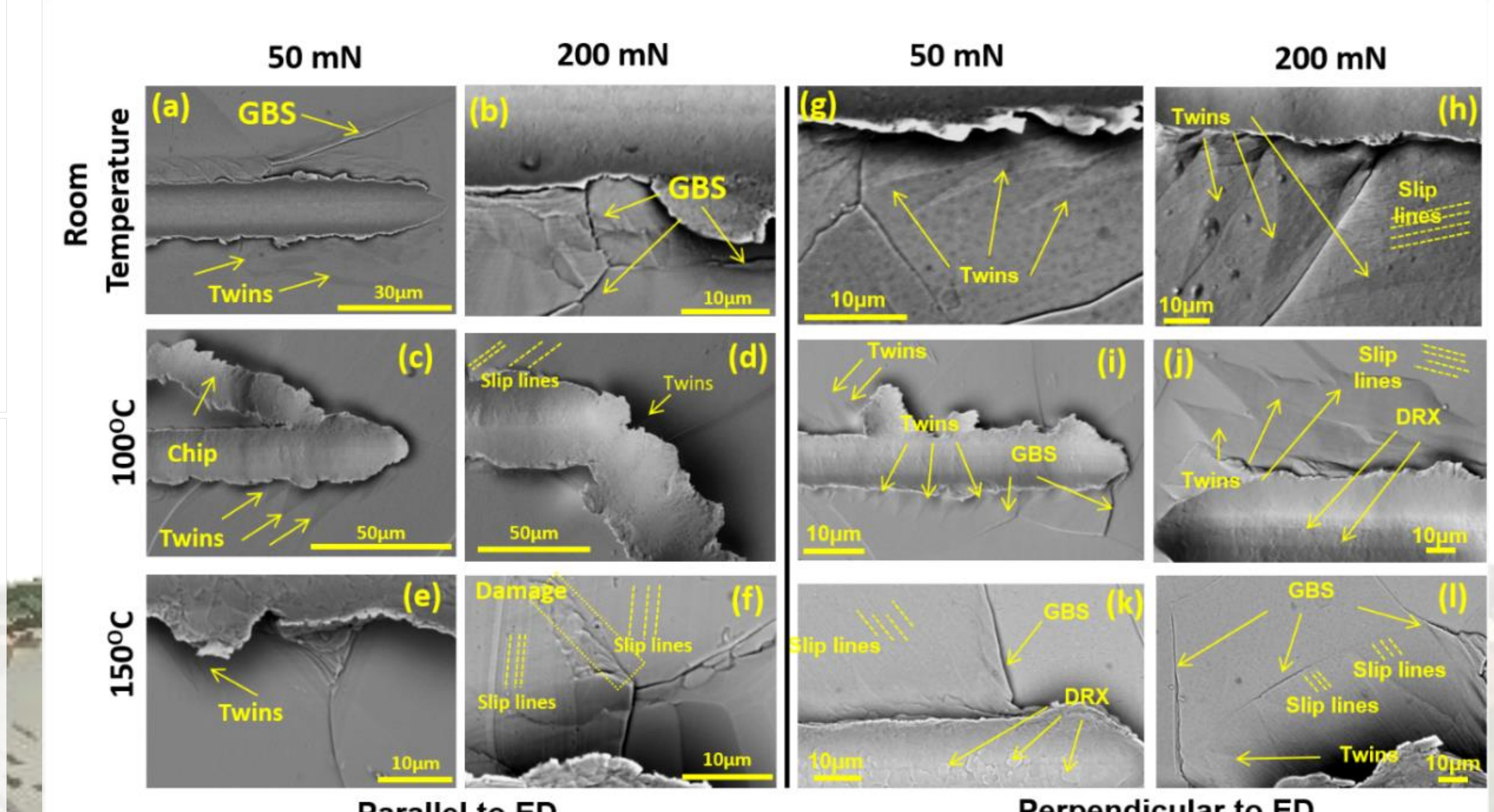

Fig. 3 Wear track showing deformation mechanisms for scratches, made at different temperatures, (a-f) parallel to ED and (g-l) perpendicular to ED.

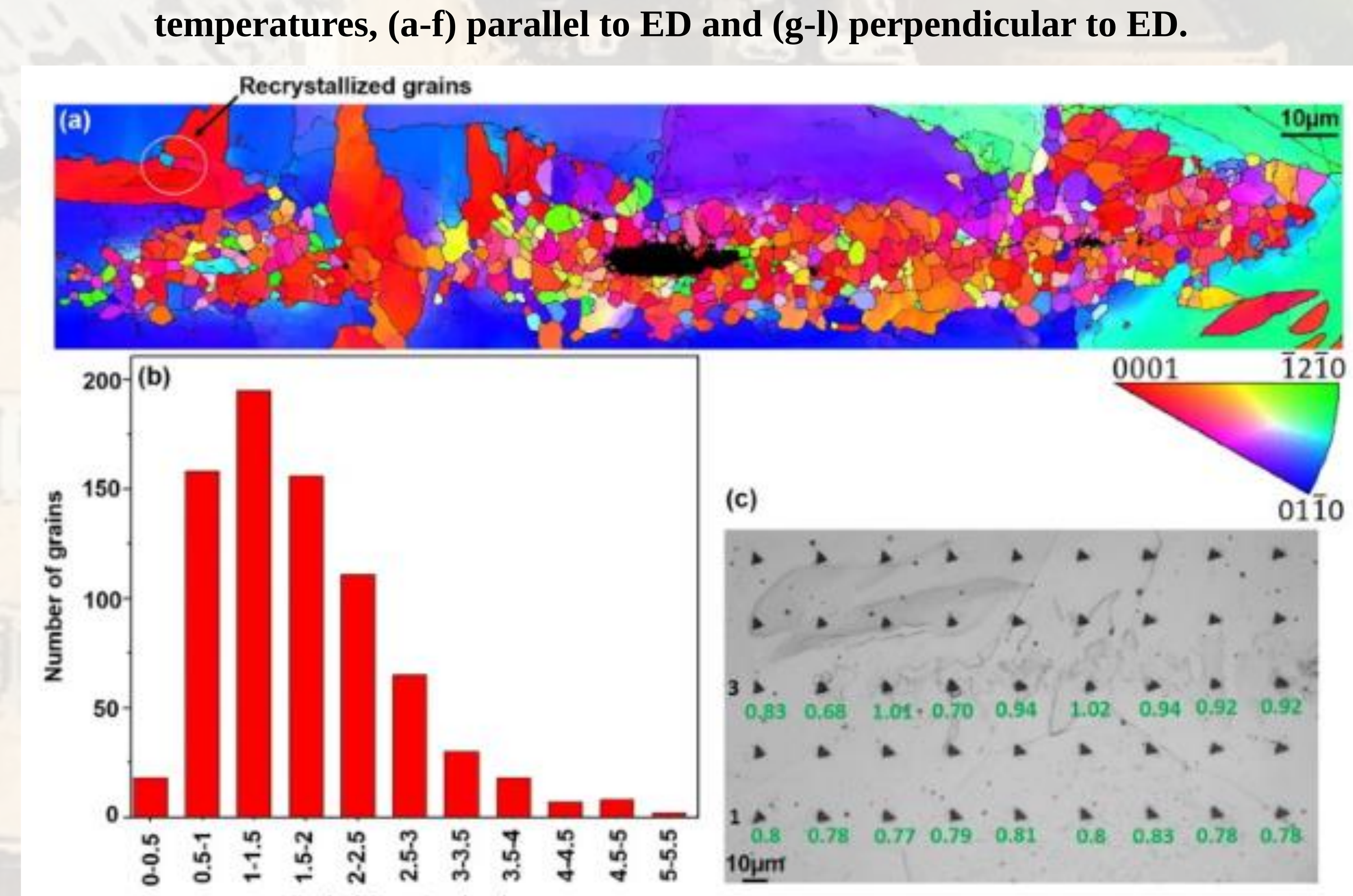

Fig. 4 (a) Extrusion direction IPF map of the scratched region showing the texture evolution of the recrystallized grains, (b) grain size distribution of the recrystallized grains and (c) hardness, in GPa, of the scratched and adjoining region.