FABRICATION AND SUPERIOR PERFORMANCE OF FLATTENED NETWORK STRUCTURED TIC/TI COMPOSITES

Fengbo Sun, Lujun Huang, Lin Geng

School of materials science and engineering, Harbin Institute of Technology, Harbin 150001, China

ABSTRACT

In order to enhance the elastic modulus and strength, novel continuous network structured TiC particles reinforced Ti composites were successfully fabricated by hot pressing sintering based on diamond-Ti system. High energy ball milling process of 300rpm/10h/10:1 can be employed due to excessive diamond powders, which can result in TiC/Ti composites with a novel flattened network microstructure. The composite introduced by 10vol% diamond exhibited the highest elastic modulus of 184GPa, which was increased by 64% compared with pure Ti. The composites with 5vol% and 7.5vol.% diamond presented 830MPa and 1480MPa compressive yield strengths respectively, which were 1.9- and 3.4 fold that of pure Ti. The superior mechanical properties were mainly attributed to the continuous TiC network and remained reinforcement-lean region based on the Hashin-Shtrikman theory. Then, we focused on the hot working of TMCs with high elastic modulus. Titanium carbide can deform simultaneously with Ti during hot working.

INTRODUCTION

Titanium matrix composites (TMCs), especially discontinuously reinforced titanium matrix composites (DRTMCs) are attractive engineering materials for the application of aerospace owing to low density and high specific strength. Most of the investigations concentrated on TMCs with a low fraction of reinforcement. Though the strength of these TMCs has been significantly enhanced, their elastic properties remain to be improved. As reported previously, tailoring the reinforcement inhomogeneous distribution can improve the comprehensive properties of composites. When the reinforcements distribute as a network structure, the composites can achieve the upper bound of Hashin-Shtrikman theory. The present findings can provide guidance for the design of high elastic modulus TMCs.

RESULTS

Evolution of mixed powders

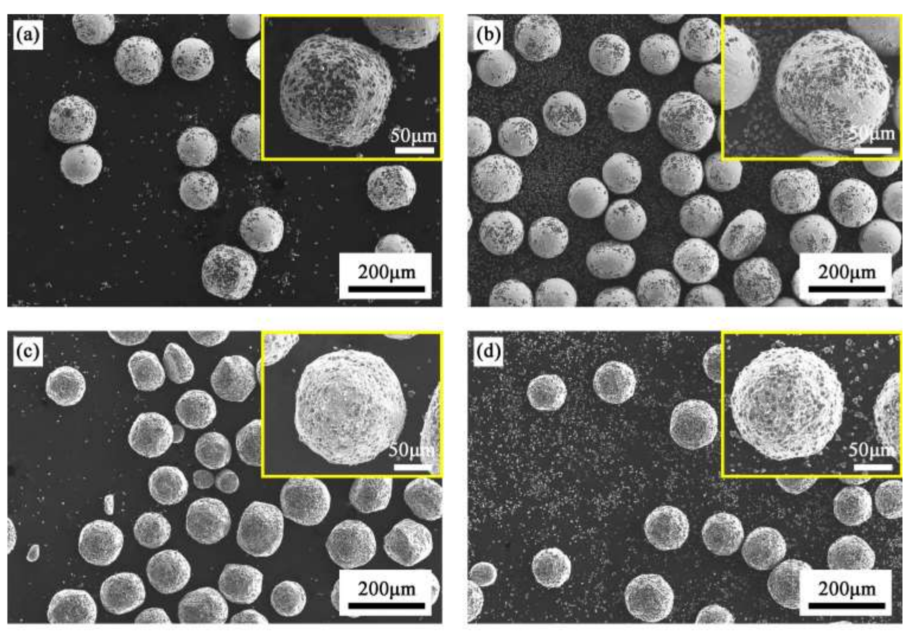

Figure 1. Mixed powders with different diamond contents and ball milling speed.

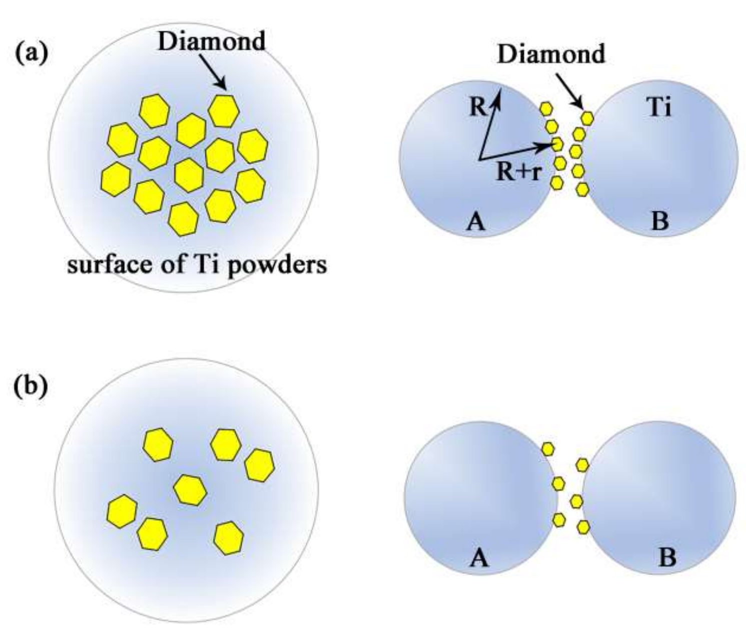

Figure 2. Schematic illustrations of fine diamond powders on the surface of large Ti particles.

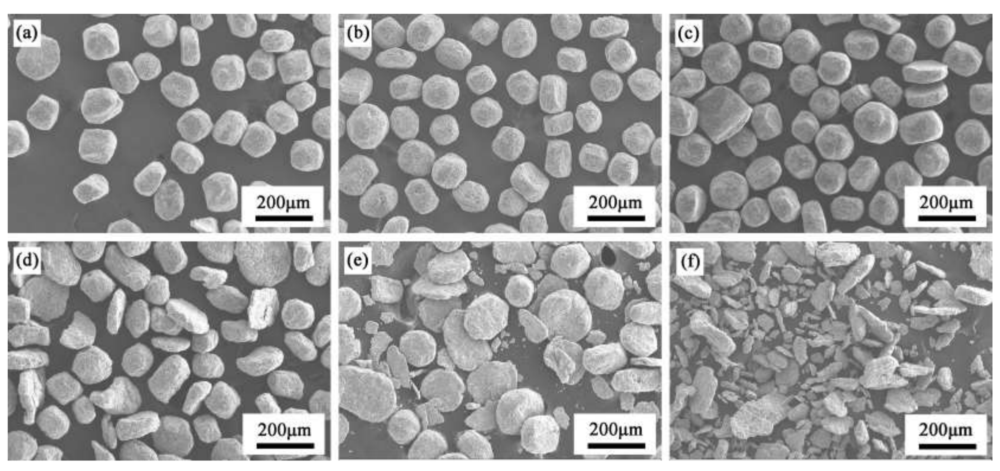

Figure 3. Mixed 10vol% powders with different milling conditions.

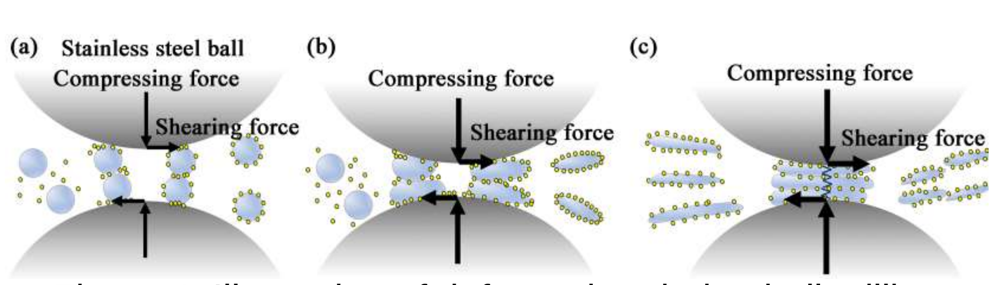

Figure 4. Illustration of deformation during ball milling.

RESULTS

Network structure

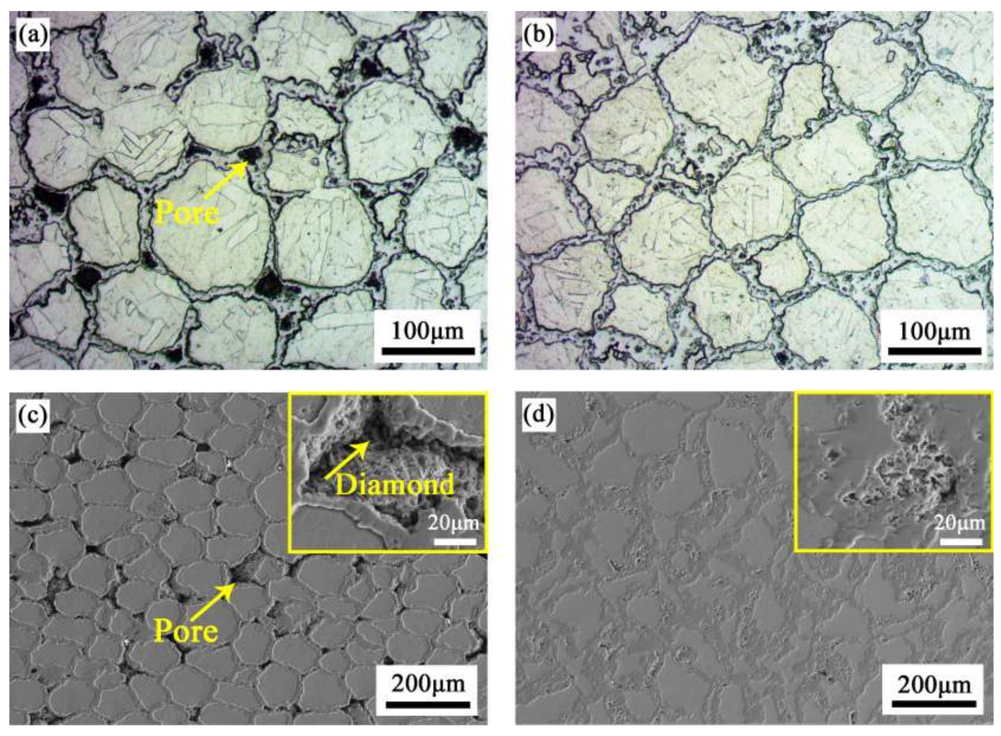

Figure 5. Composites with different network structures.

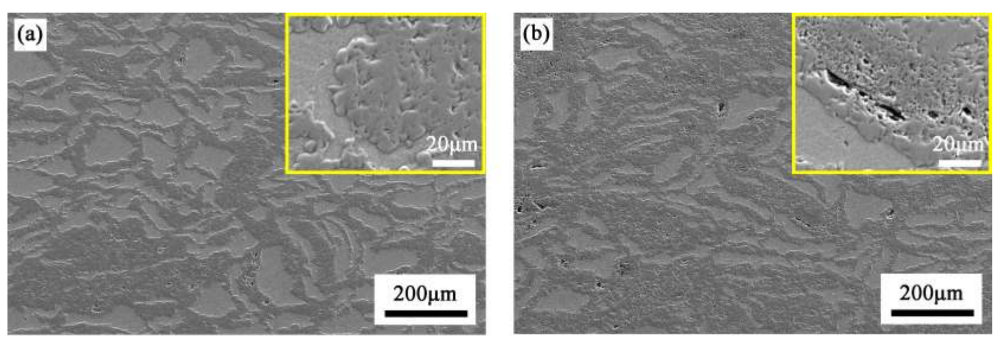

Figure 6. SEM micrographs of flattened continuous network structured composites with different contents of diamond.

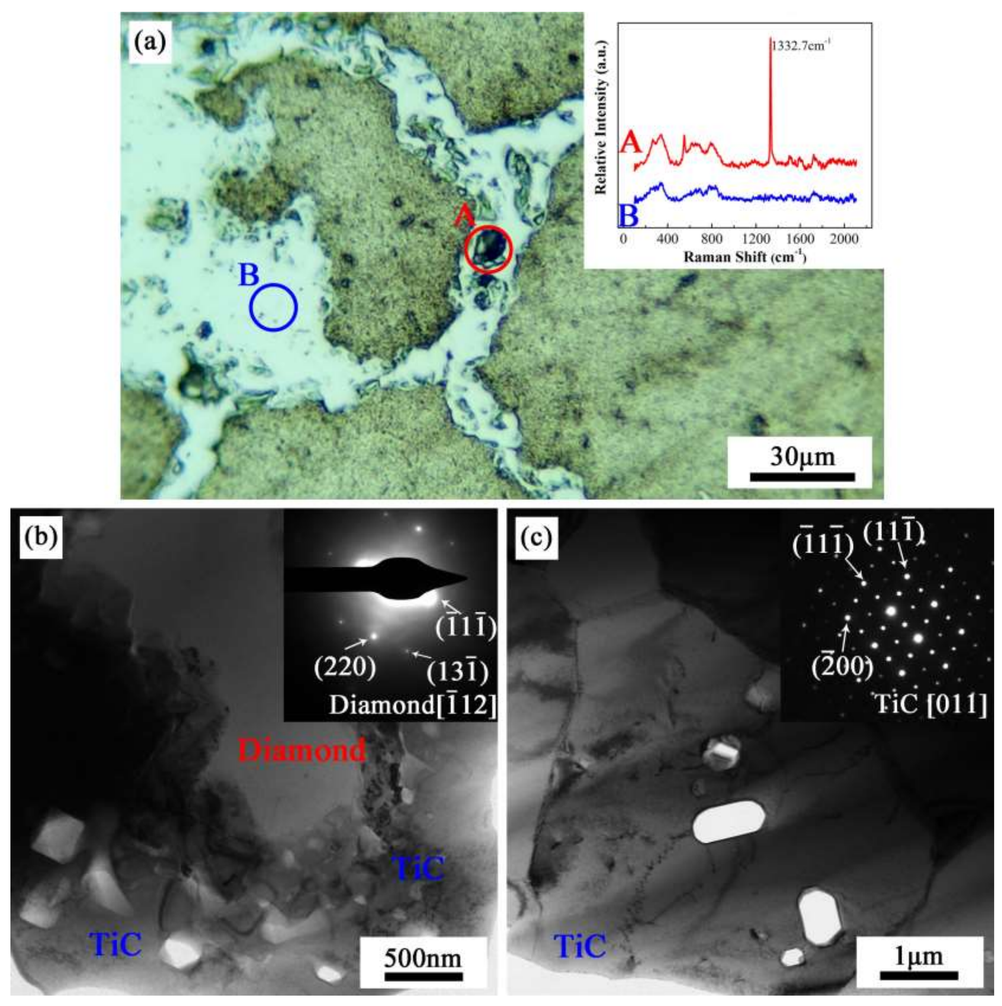

Figure 7. Raman spectra and TEM analysis of composites.

Superhigh performance

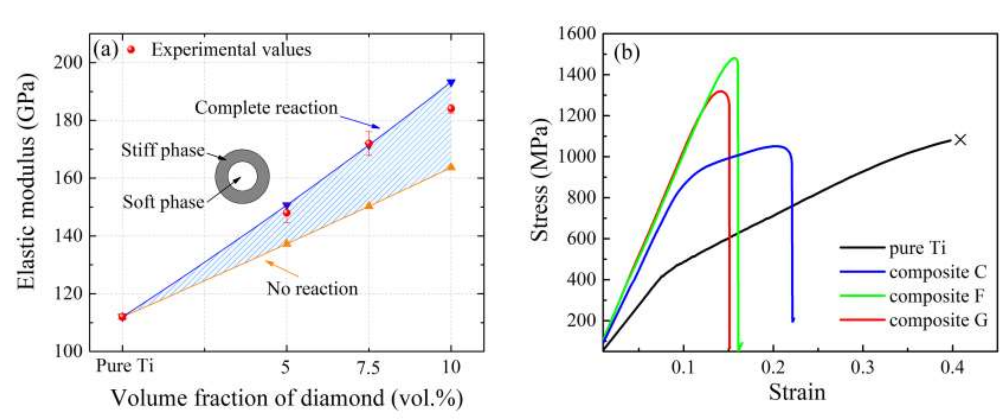

Figure 8. Mechanical properties of the composites: elastic modulus and compressive stress-strain curves.

SUMMARY

5vol% fine diamond powders can homogeneously adhere on the surface of large Ti powders by lower energy ball milling of 250rpm/5h/3:1. The mixed powders resulted in equiaxed network microstructure of TiC/Ti composites formed by continuous TiC particle reinforcement around large Ti powders. However, high energy ball milling process of 300rpm/10h/10:1 must be employed due to excessive diamond powders, which can result in TiC/Ti composites with a novel flattened network structure.

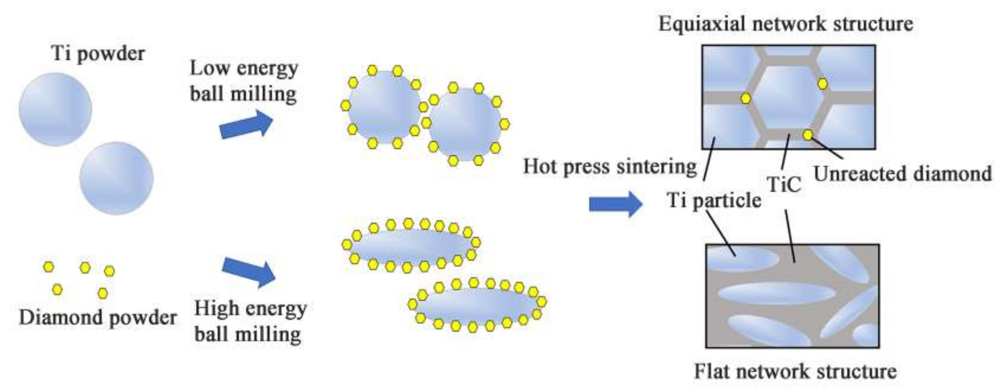

Figure 9. Schematic illustrations of the formation mechanism of the TiC/Ti

FUTURE WORK

Hot working of TMCs with high elastic modulus is challenging due to the high fraction of brittle ceramic phase. Introduction of large Ti particles can improve the deformability at high temperatures. During hot deformation, the titanium carbide can deform slightly.

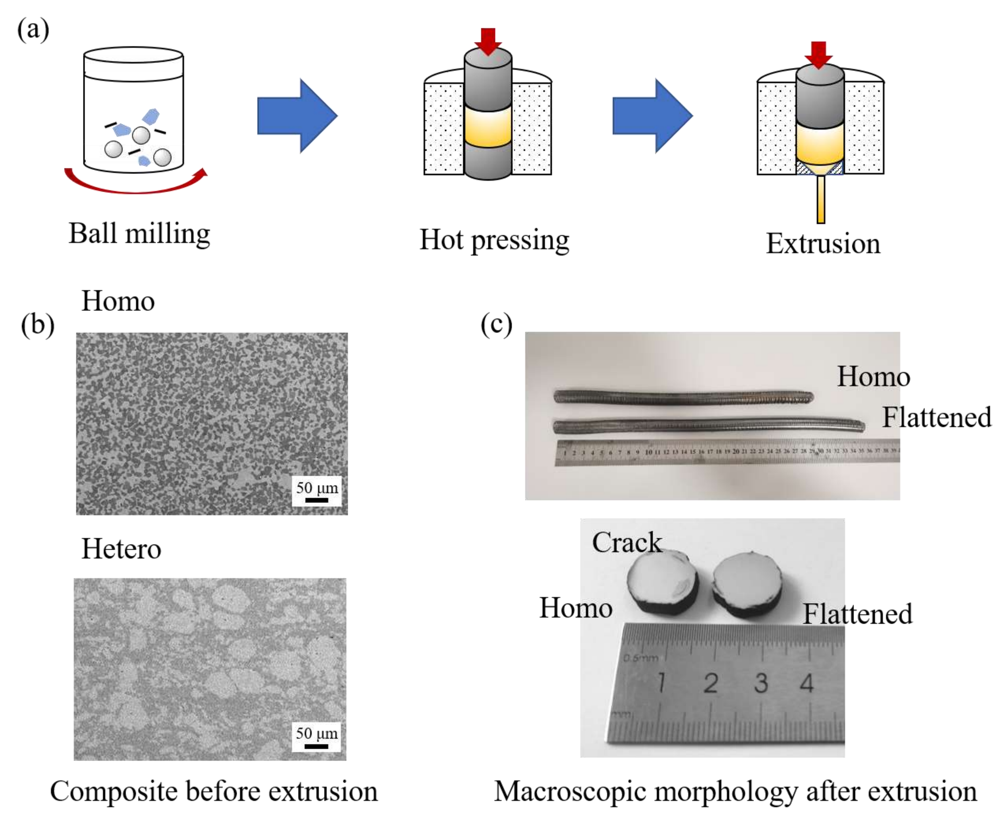

Figure 10. Schematic of the preparation process, microstructures of composites before extrusion, and macroscopic morphology of composites after extrusion.

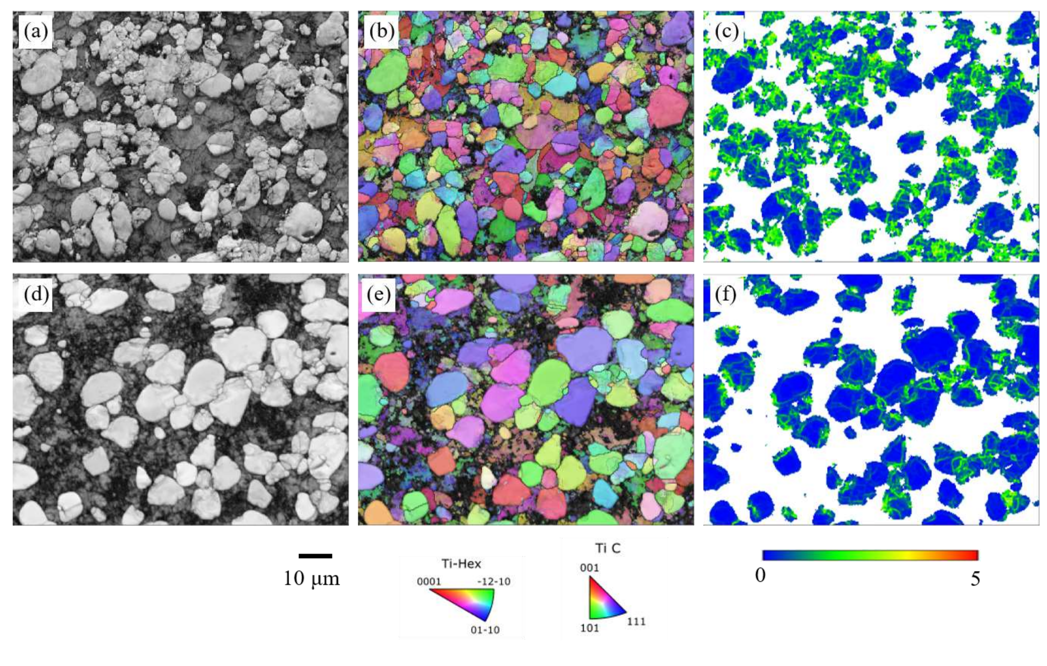

Figure 11. EBSD analysis of homogeneous and flattened network composites

Email: 15774501857@163.com, huanglujun@hit,edu.cn