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Investigation on the nano-structured materials by high-energy shock method

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Abstract: The structure of Fe/Cu composite plate made under the special conditions of strong explosive shock was investigated by metallograph, TEM and HRTEM. Based on the important roles of the interfacial properties in the use of composite materials, the main emphasis of investigation was put on the change of the interfacial structure. From the HRTEM image of an interfacial area and its electron diffraction pattern, it can be clearly seen that the structure near the interface has been nano-crystallized and even amorphized. The results indicate that because of the influences of high shock, high plastic deformation speed and instant temperature change resulted from the super-conventional condition of explosive shock, many significant changes occurred in the final composite structure. Besides the increase in dislocation density and twin grains structures, nano-crystal and even amorphous structure can also be observed near the composite interface. This result is of significance to manufacture some nano-structured composite material with special applications.

Key words: nano-structure, explosive composition, junction interface

1. Introduction

As an important method of producing composite materials, explosive composition is being used widely, especially in producing composite plates. Because the interface of explosive junction is waveform and the bonded plates are all much thick in practice, junction interface's wavelength and amplitude are usually big in size. Although some scholars have researched and reported on the structure change near interfacial area, because of the difficulty in sample preparation and test methods, the report on the structure change of thin area near interface is few. But this area's structure is much more important to the properties of interface. In this paper different metal foils and proper explosive shock were selected, in the situation of the same plastic deformation speed in the sections along thickness, to realize small waveform junction that was similar with plane bond. Each bonded foil was prepared by mechanical method and chemical method, and then studied.

2. Experimental

Experimental materials were industrial pure Cu(200×150×0.25mm), Fe(200×150×0.10mm) and Al(200×150×1.6mm). They were jointed by explosive shock of ammonia dynamite. Samples were obtained in the middle of the plates where junction state is well, and then were investigated by metallograph, TEM and HRTEM.

3. Result and discussion

The macroscopic image after composition is shown in Figure 1. It can be seen that junction state is well. The junction interface of Cu and Fe is small waveform that is similar with plane bond.

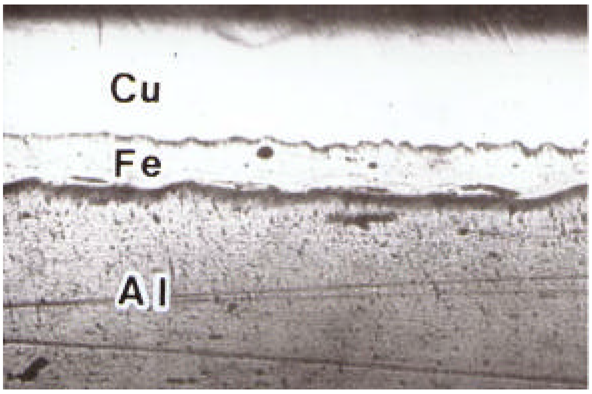

Figure 1 metallograph image of Cu/Fe/Al composite plate interface

Figure 2 shows the structure image of Cu after composition and Figure 3 is that of Fe. As shown in the figures, it can be clearly seen that original big crystalline grains have broken into small parts with size of 100 nm by high-density dislocation.

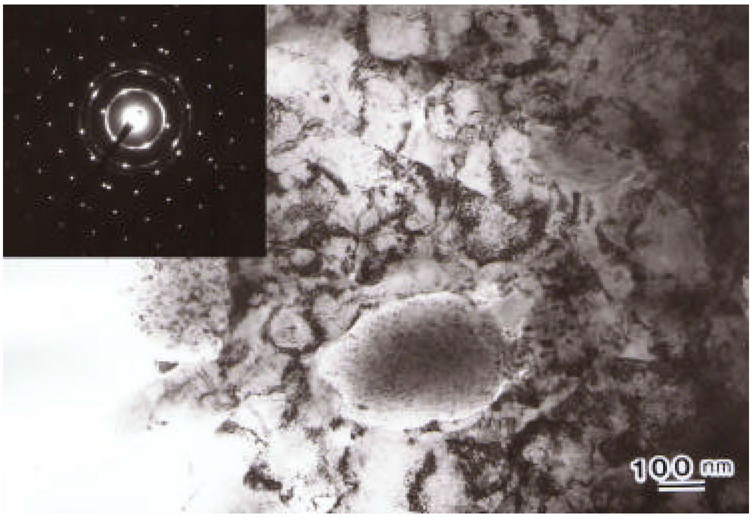

Figure 2 TEM image of Cu and its electron diffraction pattern after explosive composition

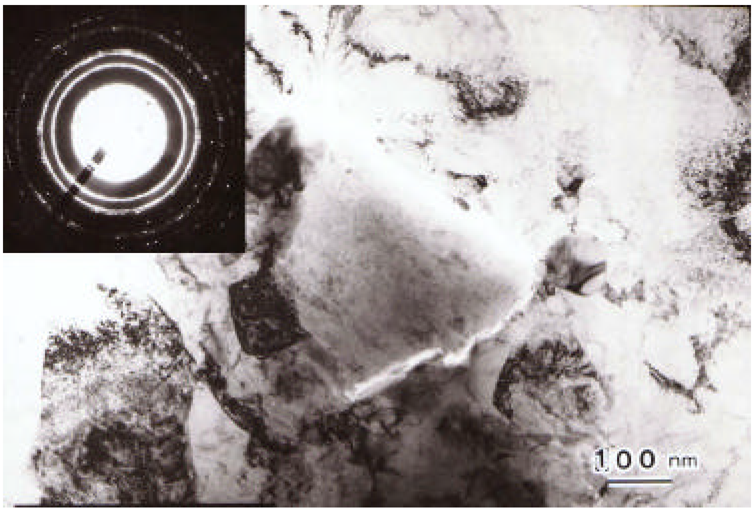

Figure 3 TEM image of Fe and its electron diffraction pattern after explosive composition

From these experimental results, it can be seen that under the situation of high shock, high plastic deformation speed and instant temperature change resulted from the super-conventional condition of explosive shock, the structure of metal foil materials can be changed into nano-crystal in certain thickness.

HRTEM was used to observe the structure change of materials after explosive composition more clearly. Figure 4 and Figure 5 show the atom arrangement of Cu and Fe after explosive composition, respectively. As shown in the figures, most atoms show ordered small part arrangement, with size about 10 nm or smaller, and even amorphized structure also appears. The difference lies in that the change of Fe is more significant than Cu. It is suggested that during junction the thinner Fe foil was shocked by Cu foil and then put shock on base plate, finally resulted in its significant change in microscopic structure.

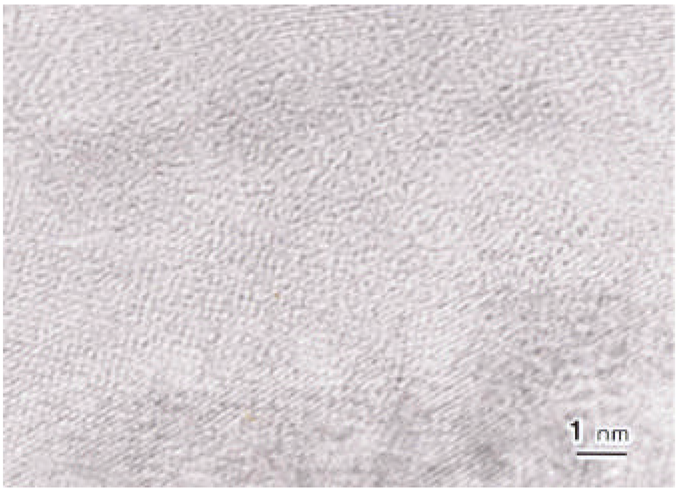

Figure 4 HRTEM image of Cu after explosive composition

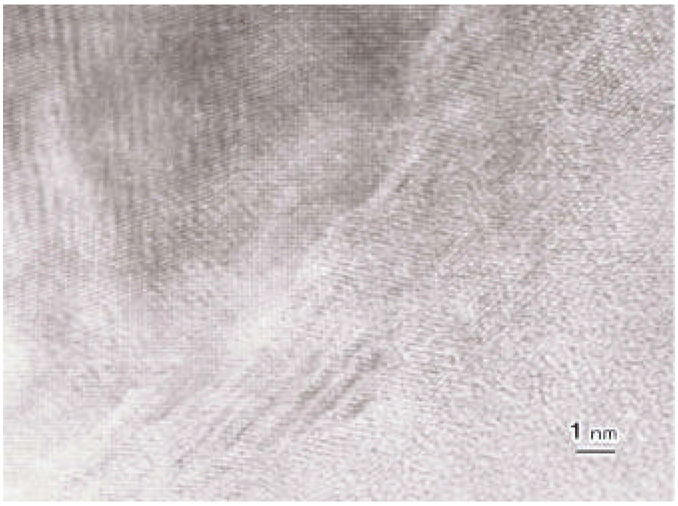

Figure 5 HRTEM image of Fe after explosive composition

4. Conclusion

The technology of the explosive composition has almost extreme properties such as huge shock high-density plastic deformation and high deformation speed, instant temperature change, state of heat insulation and so on. They lead not only the dislocation density to increase greatly, move and pile but also the vacancy density to increase radically. When the composite metal plate is thin enough, it could be thought that these changes are consistent on the whole thickness section. The result shows that it is possible to obtain the nano-crystal structure film materials and nano-structured block materials by this method. The thickness and properties of the nano-crystal structure materials depend on the factors such as the intensity of explosive shock, the properties of the composite metals, etc.

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Reference:

1. Stone J M. The properties and applications of explosive-bonded clads, Select conference on explosive welding(1968), hove(the welding institute), paper No.10, 55-62.
2. Crossland B. Metals and materials, DEC, 1971,401-403.
3. Abrahamson G R, J.APPL.MECH, 1961,519-528.
4. Baharani A S, Black T J and Crossland B. PROC. ROY. SOC.A296, 1967, 123-136.
5. Hunt J N. PHIL.MAG.1968, 17: 669-680.
6. Onzawa T and Ishi Y. Proc. 5^{th} INT. CONF. Of the center for high energy rate forming, university of Denver, Colorado, 1975.
7. A S Bahrani, T J Black, B Crossland. Proc. Of the royal society, 1445, 17, Jan. 293, P123, 1967.
8. M Hammerschmidt, H Kreye. Microstructure and bonding mechanism in explosive welding shock waves and high-strain rate phenomena in metal,1981.
9. Bullelieuwma C W T, Coene W, and Dejong A F (1991) High-resolution electron-microscopy of semiconductors and metals . Advanced Materials 3:368-378.
10. Eastmann J A, Beno, et al. Nanostructured Mat. 6, 981, 1995.
11. Lu K. Nano-crystallized from amorphous solids: nanocrystallization, structure and properties [J]. Mater Sci Eng, 1996, R16(4): 161-212.
12. Wang Y N, Feng X M and Huang Y. Investigation on the wave-interfacial micro-area structure in explosive composites, Journal of Taiyuan University of Technology, Vol. 31 Sup. May 2000.