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Nanostructures and Defects in Several Materials under Electropulsing

W. Zhang, M.L. Sui, and D.X. Li

Shenyang National Laboratory for Materials Science, Institute of Metal Research, Chinese Academy of Sciences, 72 Wenhua Road, Shenyang 110016, China.

Electropulsing process was first proposed by Avramescu. [1] Many important electropulsing effects have been confirmed, such as electroplasticity, electromigration, amorphous crystallization, crack healing and etc. Microstructural investigations at atomic scale in materials under electropulsing, however, are seldom reported. In this paper the formation of local nanostructures and configuration of defects in some routine materials under the electropulsing were presented.

The electropulsing was performed at ambient conditions, by the capacitor (1200μf) discharging with Xe flasher triggering. The current intensity is ~10^9 A/m^2 with a period of about 200 μs.

After the electropulsing, local nanostructures with α (A1 type) and β′ (B2 type) phases have been found in H62 copper alloy with original α (A1 type) coarse-grained grains, as shown in Fig 1 (a). These two nanophases formed by Joule heating effect possess random crystallographic orientations. In the NiCr-TiC alloy after the electropulsing, however, nanosized TiC crystallites marked as circled areas in Fig 2 (a), gave a nearly coincident orientation <100>, possible from a giant stress field. [2] And these small crystallites are separated by strained areas signed as “o”. In the Ti6Al4V alloy under the electropulsing, some microregions consisting of nanosized twin martensites shown in Fig 3 (a) have been found, due likely to rapid electric heating and cooling. In short, electropulsing can be one special method to refine grains involving a comprehensive effect of force, electronic and thermal energies.

On the other hand, after the electropulsing, large amounts of twin bands and some rearranged defects in the H62 alloy, regular dislocation networks in the matrix of NiCr-TiC alloy and Ti6Al4V alloy were observed as shown in Fig 1(b), 2(b) and 3(b), respectively. These configurations of dislocations newly-formed can be treated as a non-equilibrium self-organization phenomena. [3] Obviously, these results reveal that electropulsing is also particular recovery means.

To conclude, two distinctive effects of electropulsing, i.e., grain-refinement and recovery, have been clearly illustrated by TEM investigations. [4]

References

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[3] A. Seeger, Strength of metals and alloys, Oxford: Pergamon Press, 1988.

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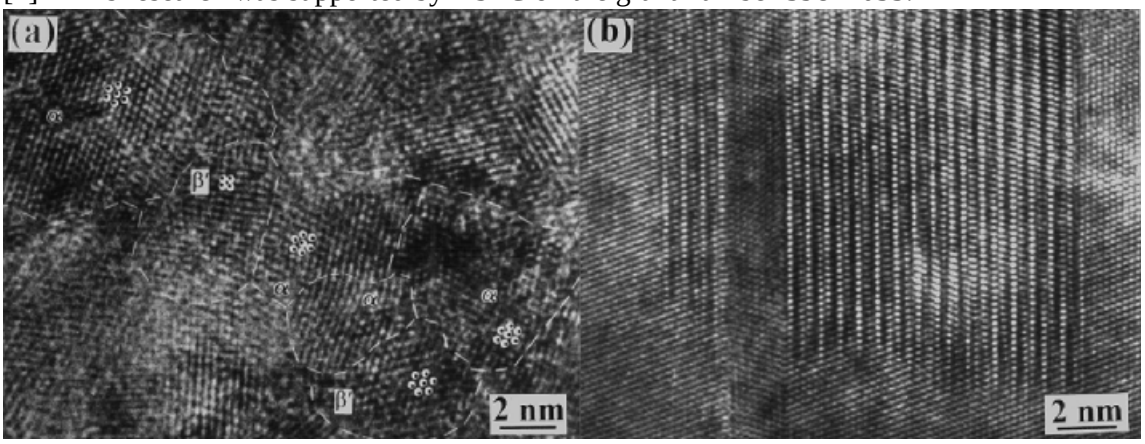

FIG. 1. HRTEM images of nanostructures (a), twin bands and some rearranged defects (b) in the H62 copper alloy after the electropulsing.

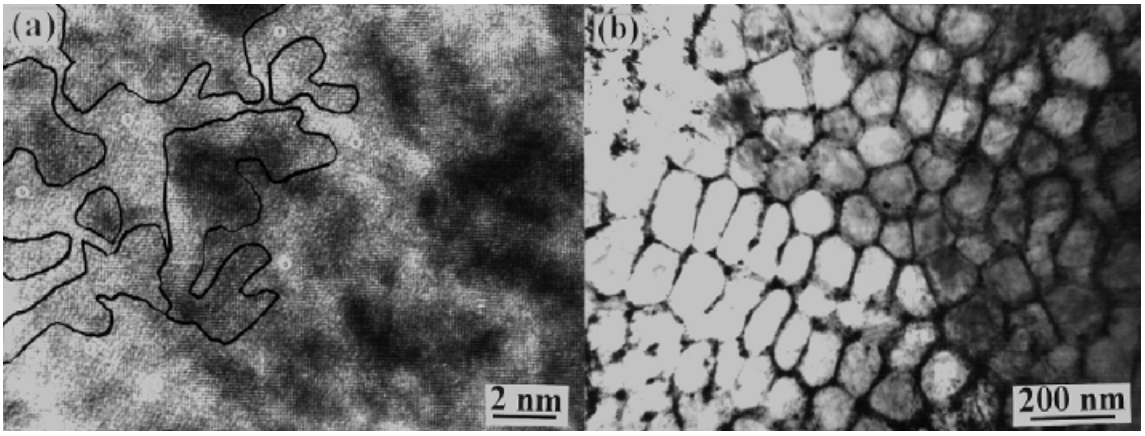

FIG. 2. TEM images of nanostructured TiC crystallites (a), and hexagonal dislocation nets in the matrix (b) from the NiCr-TiC alloy under the electropulsing.

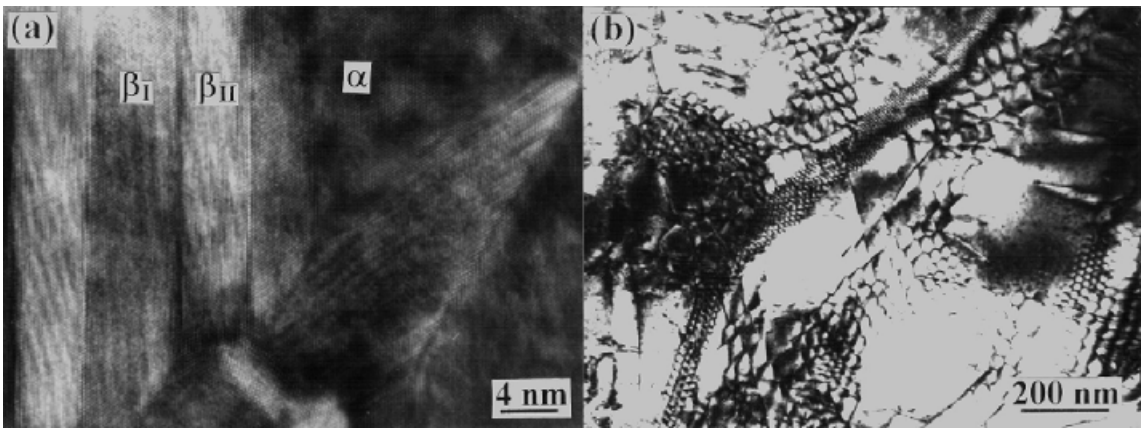

FIG. 3. TEM images of nanosized twin martensites (a), and regular dislocation networks in the Ti6Al4V alloy by the electropulsing.

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