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# ENHANCEMENT OF FATIGUE LIFE AND ELONGATION OF METALLIC MATERIALS BY HIGH-DENSITY PULSED ELECTRIC-CURRENT

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## ABSTRACT

A new technique that can be used to enhance the fatigue life and elongation of metallic materials by applying a controlled, high-density pulsed current was introduced. Austenitic stainless steel, titanium-aluminum alloy and aluminum alloy were used as the test materials under the conditions of with and without fatigue crack, with and without prestrain, and standard. The effects of high-density pulsed current on the healing of fatigue crack, and the delay of crack initiation, as well as the recovery of plastic damage were investigated in detail. Furthermore, the effects of high-density pulsed current on the change of Vickers hardness, residual stress, and dislocation density, as well as crystal size and orientation of the materials were analyzed thoroughly to clarify the mechanism.

***Keywords:*** fatigue life, elongation, high density current, fatigue crack, strain plastic damage, dislocation.

## INTRODUCTION

Fatigue fracture is an extremely important phenomenon in metal structures because most mechanical components experience cyclic loads. Therefore, the improvement of long-term durability and reliability of mechanical structures is required against fatigue fracture. On the other hand, elongation is an important mechanical property of metallic materials which affect the formability of mechanical components, especially for high-temperature resistance materials. Therefore, it is necessary to develop a new method to enhance the elongation of metallic materials.

## SAMPLE RESULTS AND CONCLUSIONS

Figure 1 shows SEM images of the crack closure resulted by different numbers of the application of high-density electric current. It is observed that the crack was closed at all stages. The crack width was measured from the SEM images before and after the application of the electric current. Comparing the width before the electric current and after the 35th cycle, the crack width near the notch decreased from approximately 18.1 to 3.7 µm, corresponding to a 79-89% closure. The bonding of the crack surfaces was confirmed by cutting the sample vertically in the direction of crack propagation.

The behavior of the crack growth was evaluated quantitatively in order to research the effect of the crack healing. It was observed that the crack growth rate decreased from $4.17\times10^{-8}$ to $3.01\times10^{-8}$ m/cycle immediately after the application of the electric current. After the 20th application of electropusling, the crack growth rate was lower than that before the electric current until the crack had grown to 3.6 mm.

It was also found that fatigue crack initiation was delayed after the application of the electric current. The delay effect tends to increase with the decrease of maximum net stress. The application of the electric current is more effective at the lower stress.

The TEM photographs of the typical dislocation structures are shown in Figure 2. The density of dislocation after the application of the electric current was much lower than that before the application of the electric current. The decreasing of dislocation density was concluded on the basis of the observation of the three samples. The lower dislocation density verifies that the electrical stimulation has an effect on the disappearance of dislocations.

The closure of the fatigue crack and the bonding between the crack surfaces were realized by applying the high-density electric current. Decreasing the crack growth rate temporarily was also succeeded. In addition, the delay of fatigue crack initiation was realized due to the decrease of dislocation density. It was found that the technique with the electrical stimulation has the potential to heal a fatigue crack and to restore fatigue damage.

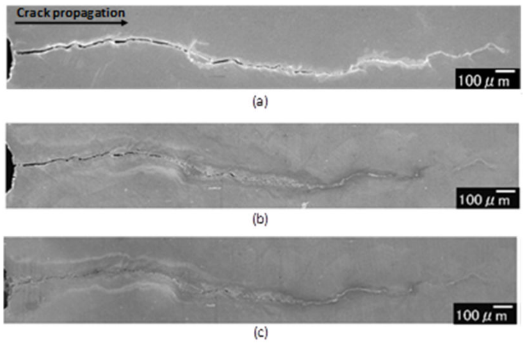


Fig. 1 - Fatigue crack closure resulted by the high-density electric current: (a) before; (b) after 8th; (c) after 35th applications of the electric current [1].

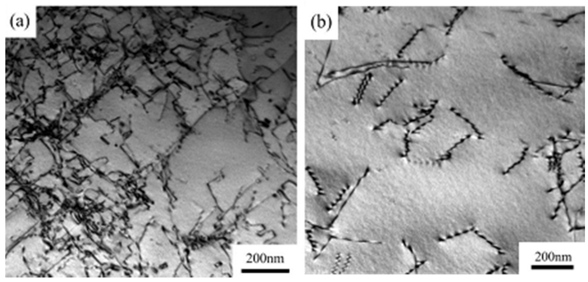


Fig. 2 - The dislocation structure after the fatigue test: (a) before; (b) after the application of the electric current [2]

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