STRUCTURE OF THE MARTENSITE–AUSTENITE TRANSITION ZONE AFTER A LOCAL PULSE HEATING OF THE MARTENSITE

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Using electron microscopy, the structure of the transition region between austenite and martensite in an austenitic-martensitic iron–chromium–nickel alloy is investigated following a local pulse heating of the martensite. It is found out that the martensite-austenite transition area has a complex structure consisting of a few regions with different phase compositions and degree of defect structure relaxation.

Keywords: martensite, austenite, pulse heating, plastic deformation, transition area, laser.

Most of the practically used alloys are binary and multi-phase alloys. Their properties are controlled by the proportion of the phases, their composition and properties of interphase boundaries.

Martensitic-austenitic alloys present an example of the alloys in question. Both phases in these alloys (austenite and martensite) have the same chemical composition and, which is particularly critical, the properties of these phases can be investigated experimentally, thus simplifying an analysis of the characteristics of a two-phase material. In this case the main factor requiring an experimental investigation is the structure of the interphase regions.

A challenging issue not investigated so far is the structure of the transition regions between austenite and martensite in the alloys subjected to a local pulse heating, resulting in the formation of patches of austenite inside the martensitic matrix in the transition area between them.

It is the purpose of this work to study the transition zone between the initial martensite and regions of austenite formed under a local pulse heating of the former.

MATERIAL AND EXPERIMENTAL PROCEDURE

The experimental material was prepared using a scheme involving cold plastic deformation, ensuring the formation of martensite in the alloy, followed by laser heat processing, which resulted in the formation of patches of austenite in the material. This scheme provided a natural composite material with predetermined distribution of macroscopic austenitic regions inside a high-strength martensitic matrix.

For the investigations we selected an austenitic-martensitic alloy of the Fe–Cr–Ni system having the following composition: 17.4% Cr, 7.0% Ni, 0.13% C, 0.91% Mn, 0.61% Si, Fe – remaining part. Earlier [1], the authors demonstrated a possibility of producing such material via the use of cold plastic deformation (by rolling) followed by laser heat treatment.

Under cold plastic deformation, there is a $\gamma \rightarrow \alpha$ martensitic transformation, which results in the formation of strain-induced martensite [2]. Given the reduction ratio over 65%, the value of magnetization saturation reaches 1.2 T, which corresponds to the presence of 92–95% martensite in the alloy under study.

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Temperatures of the direct and reverse martensitic transformations were determined magnetometrically [3]. Figure 1 presents a thermal magnetogram from the alloy under study, which was initially in the martensitic state. It implies that the reverse $\alpha \rightarrow \gamma$-transformation occurs within the temperature interval 600–685°C.

In order to induce paramagnetic regions inside the martensite formed by cold deformation, use was made of point heating by laser irradiation up to the temperature exceeding the final temperature of the reverse martensitic transformation (685°C).

The specimens cut for the experiments on a cold-strained alloy with a 75% reduction measured $70 \times 20 \times 1$ mm. The central part of each specimen was heated by laser radiation. The laser heated area was $15 \times 20$ mm (Fig. 2). Heating was performed with a TL-1.5 CO$_2$-laser. Its power was sufficient to uniformly heat the entire specimen through (1 mm thick).

Metallographic sections for TEM examination were cut both from the periphery of the specimen (Fig. 2, region 1) and from the central part (Fig. 2, region 5). In addition, sections were cut from the transition zone (Fig. 2, regions 2–4). In order to determine the length of the transition zone, use was made of the method for measuring Vickers microhardness ($H_V$) in a PMT-3 device with a step of 0.5 mm with 10 measurements per point.

Fig. 1. Thermal magnetogram of the reverse martensitic transformation in the alloy under study.

Fig. 2. Scheme of electron-microscopy of the structure in the transition zone between the ferromagnetic (martensitic) matrix and paramagnetic (austenitic) patch.