Recrystalization and Grain Growth: Development and application of a theoretical model based on the Cellular Automata algorithm.

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Abstract

The application of heat treatment of annealing in cold worked metallic materials can result in phenomena of recovery, recrystallization and grain growth. Such heat treatment results in the transformation of the microstructure and, therefore, of the physical and mechanical properties of the material. The objective of this work is to determine the characteristics parameters of the process of recrystallization and grain growth of Commercially Pure Titanium (cp-Ti), through the development and application of a theoretical model based on the Cellular Automata algorithm. This theoretical model will consider the reduction of interfacial energy on the grains boundaries in each time step as driving force of the process, as well as the influence of a potential barrier.

Key words:

Titanium, Cellular Automata, Annealing.

Introduction

Titanium and its alloys present great technological relevance, being utilized on Chemical and Aerospace industry due its excellent corrosion resistance and high resistance-weight relation. Besides that, the good biocompatibility of the titanium and its alloys is an essential requirement for its utilization in Surgical and orthopedic implants.

The processing of titanium and its alloys can involve the cold and hot laminations, that can result in microstructural alterations which involves nucleation and growth. So, it is important to have a rigorous microstructural control to avoid problems due these transformations. Such control is not easy, because during the process there are a lot of variables that must be understood and controlled at the same time. Models for simulation can help on the understanding of the involved mechanisms and the relations of the variables of the process, avoiding sometimes the waste of time and material.

The Cellular Automata algorithm is an option to describe the evolution of complex systems in space and time. The Automate consists in a cell network, called lattice, arranged in one, two or three dimensions, and can present diverse geometrical forms and each cell has a finite number of properties which give them characteristics and define their state. The Cellular Automata evolves in discrete time steps and, in each time step, the values of the properties associated to the cell is updated according a well-defined rule of transformation. The rules used on the Cellular Automata in the material science are based on rules and properties associated with the material and phenomena which is being simulated.

Results and Discussion

The obtained results are coherent with what was expected based on other authors. The evolution of the Recrystallized fraction over time respects the Avrami Equation for the transformation of solids.

In the final results, there are some gravitations of the recrystallization of the lattice along the curvature of the grains, and it is probably due the probabilistic nature of the recrystallization.

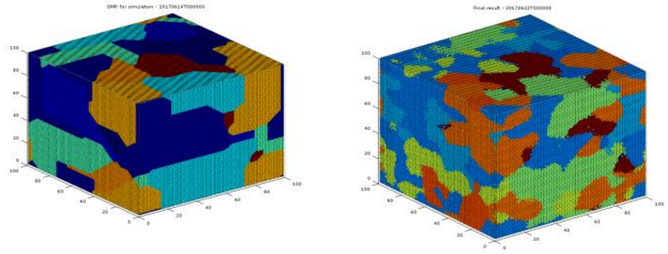

Image 1. Model for simulation and model after simulation

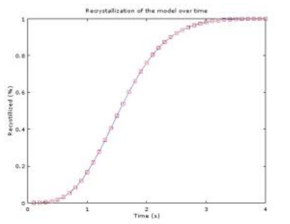

Image 2. Graph of Recrystallized fraction over time

Conclusions

The model developed shows coherence with the behavior of the microstructure under the annealing process, based on the results found on the literature. All the process of interaction between grains are satisfactory

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