THE EFFECT OF HIGH CURRENT DENSITIES ON IRON-CARBON ALLOY THIN FILMS

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The recently discovered flash sintering method for preparing high quality oxide materials can be applied to the preparation of high performance nanocrystalline metals as well. Just as for the oxide materials, it is possible to use electric fields and currents to enhance densification of metal powders while limiting grain growth, however, the exact mechanism is still under discussion. The goal of our study is to understand how electric currents effect impurity redistribution and grain growth in fine grained metals.

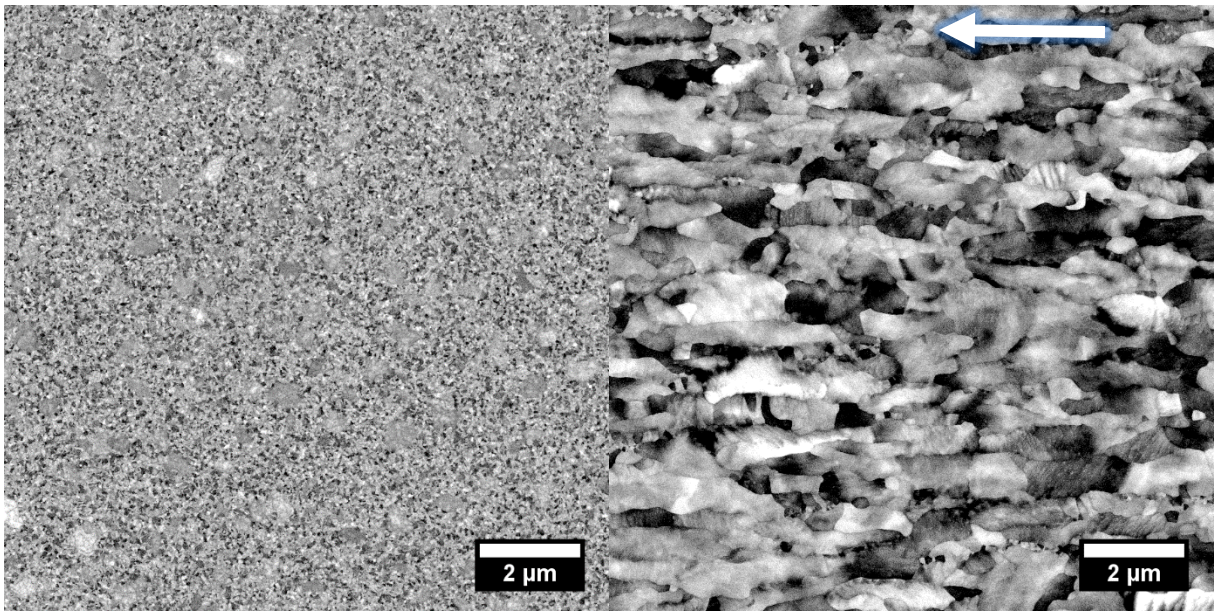

Figure 1 - Microstructure of a 110 nm thick iron-carbon film before (left) and after (right) current treatment of 4 MA/cm^2 at 550°C. The arrow shows the direction of current flow.

Thin nanocrystalline iron films with carbon concentrations of up to 1 wt.% are prepared as a model system and to compare with the behavior of nanocrystalline bulk samples. The films are then annealed at 460°C to allow for grain growth before they are heated to a temperature between 470 and 650°C and exposed to high current densities comparable to those experienced during the sintering process of bulk materials. The evolution of the microstructure, morphology and carbon concentration are investigated using electron microscopy and x-ray diffraction as a function of temperature, current density and time. Extensive effects of the electrical current on C redistribution and grain growth are observed, including strong coupling between grain growth and C content. The formation of microstructures comparable to rolled materials with grains that are elongated along the direction of the current are found. The various microstructural observations will be summarized and possible explanations will be discussed.

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