4th JOINT MMM-INTERMAG CONFERENCE, Pittsburgh, Pennsylvania, June 18-21, 1991

MAGNETIC PROPERTIES OF Fe-6.4wt%Si RIBBONS

M.V.P. Altoé, M.S. Lancarotte, R. Cohen, F.P. Missell
Instituto de Física, Universidade de São Paulo, C.P. 20516, São Paulo, S.P. Brazil
W. A. Monteiro
Instituto de Pesquisas Energéticas e Nucleares, São Paulo, S.P., Brazil
J. Degauque and M. Fagot
Lab. Physique des Solides, INSA, Avenue de Rangueil, 31077 Toulouse-Cedex, France

ABSTRACT - Thin Fe-6.4wt.%Si ribbons were produced by melt spinning. High temperature recrystallizations, performed at 1025°C in a hydrogen atmosphere, were found to produce the lowest H_c values (19 A/m). Further agings were carried out at 50°C intervals in the range 400-700°C to optimize the magnetic properties. For all ribbons we measured H_c (60 Hz and DC), the maximum permeability μ_{max}, the saturation magnetostriction λ_s, and the effective anisotropy constant K_{eff}. In general, the agings did little to improve the magnetic properties, and those around 600°C resulted in their deterioration. Extensive TEM investigations of the ribbons indicate that the dendritic structure of the as-cast material disappears after recrystallization, leading to a more uniform distribution of Si as well as a more homogeneous ordering. The 600°C aging results in a marked anisotropy in the B2 antiphase boundaries and the growth of oxide particles, which lead to a deterioration of the magnetic properties.

I. INTRODUCTION

Adding silicon to electrical steels has become common because silicon increases the electrical resistivity with a consequent reduction in magnetic losses. For compositions around 6.5wt%Si, the magnetostriction is practically zero and hysteresis loss is minimum. However, for compositions above 4.5wt%Si there is a drastic reduction in the ductility of the alloy, making it impossible to use conventional casting and cold rolling techniques. The development of rapid solidification technology, on the other hand, has made it possible to obtain ribbons of Fe-6.5wt%Si with excellent magnetic properties [1].

For compositions above about 5wt%Si, the disordered bcc structure (A2) gives rise to ordered phases with the CsCl (B2) or the $Fe_3Al(DO_3)$ structures [2]. These phases in principle influence the mechanical and magnetic [3] properties of the ribbons and their presence has been commented on by various authors. *Narita et al.* [4] studied the effect of the order-disorder reaction on sheets of Fe-6.5wt%Si which had been forged and rolled, concluding that an aging at 500°C was more effective in improving the magnetic properties than treatments at higher temperatures, which presumably produced B2 ordering. X-ray diffraction spectra indicated DO_3 order caused by the aging at 500°C. More recently, *Degauque et al.* [3] studied the influence of ordering on the coercivity and hysteresis loss of rapidly solidified Fe-6.5wt%Si. These authors found losses to be lower in ribbons aged at 700°C than in those aged at 500°C. TEM showed that the high temperature aging (700°C) promoted the growth of the B2 structure, which was beneficial for the magnetic properties. In the present work, we study the effect of aging treatments in the temperature range 400-700°C on the microstructure and magnetic properties of Fe-6.4wt%Si ribbons produced by meltspinning. Extensive TEM investigations were carried out to follow the microstructure changes induced by these treatments.

Manuscript received April 15, 1991. Work supported by FINEP, FAPESP, CNPq, and USP/BID.

II. EXPERIMENT

Master ingots were prepared by arc melting electrolytic iron (99.99%) and pure silicon (99.999%) under an argon atmosphere. Ribbons were produced by planar flow casting onto a low carbon steel wheel, using flowing argon gas to protect the ribbons from oxidation. Continuous ribbons of 3mm width and 20μm thickness were produced with exceptionally clean surfaces, indicating the absence of oxidation. Wet chemical analysis of the ribbons indicated 6.4wt%Si, 0.022%C, 0.006%Mn, 0.003%Al, and 0.003%P. The as-cast ribbons were cut into 150mm long pieces and recrystallized between 950 and 1150°C for 1h in flowing H_2 gas (1 mbar). Ribbons recrystallized at 1025°C for 1h were then annealed for 2h between 400 and 700°C, also in a H_2 atmosphere, in order to develop the B2 and/or DO_3 ordered structures.

Measurements of the coercive field (60 Hz and DC) and the maximum permeability (μ_{max}) were made with a hysteresis loop tracer on 150mm long samples inserted into a solenoid. The saturation magnetization (M_s) was obtained from a vibrating sample magnetometer (VSM) and the saturation magnetostriction λ_s was determined using the small-angle-magnetization-rotation method [5]. The effective anisotropy energy was obtained from the initial magnetization curve using the relation

$$K_{eff} = \int (M_s - M)dH \qquad (1)$$

Microstructural characterization was carried out with a JEOL TEMSCAN-200kV having EDAX capability. The samples were prepared by mechanical polishing, followed by the [illegible] in an electrolyte consisting of 5% perchloric acid in 2 but[illegible]ethanol (T = -10°C, 50V).

COLEÇÃO PTC
DEVOLVER AO BALCÃO DE EMPRÉSTIMO
IPEN-DOC- 4252