LETTERS TO THE EDITORS

(100) [001] Secondary Recrystallization in Silicon Steel by "Low Vacuum" Annealing*

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The author studied the development of the cube texture in 3 percent Silicon steel, after annealing in a Hydrogen atmosphere or in (3×10^{-4} mmHg), (5×10^{-3} mmHg) or (1×10^{-1} mmHg) vacuum pressures. 3 percent Silicon steel developed a remarkable cube texture after annealing in a vacuum with a pressure of 5×10^{-3} mmHg. The specimens were prepared from commercial (110) [001] grain-oriented 3 percent Si-Fe sheets of 0.35 mm thickness. Specimens "A" were cold rolled in a single rolling process to 0.05 mm. Specimens "B" were cold rolled, annealed for 30 minutes at 700°C and cold rolled the second time to 0.05 mm. After degreasing they were annealed in a dry Hydrogen atmosphere or in the above vacuum pressures. The secondary recrystallization was found to

time.

It has been reported that small quantities of Oxygen are necessary to decrease the surface energy of the (100) plane⁽¹⁾⁽²⁾⁽³⁾. A vacuum of 3×10^{-4} mmHg is also an oxidizing atmosphere for Iron at the experimental temperature from the view point of the equilibrium constant. But it is not positively known whether enough Oxygen atoms are supplied or not to contaminate the surface during the period of time the specimen is in a vacuum and reduce the surface energy of the (100) plane. However, when too many Oxygen atoms are present in a vacuum of 1×10^{-1} mmHg, an inhibiting grain boundary migration action may be predominant. Since vacuum pressures of 10^{-3} to 10^{-1} mmHg can be easily pro-

Table 1 The effects of annealing atmosphere on (100) [001] secondary recrystallization in 3 percent Silicon Steel.

Specimen	Annealing atmosphere	Annealing temperature		
		1050°C	1100°C	1150°C
A	Hydrogen	Normal growth	Normal growth	Normal growth
	3×10^{-4} mmHg	Normal growth	Normal growth	Normal growth
	5×10^{-3} mmHg	Normal growth	Sec. recryst. completed in 3 hours	Sec. recryst. completed in 2 hours
	1×10^{-1} mmHg	Normal growth	Sec. recryst. approx. 10 %	Sec. recryst. approx. 10 %
B	Hydrogen	Normal growth	Normal growth	Normal growth
	3×10^{-4} mmHg	Normal growth	Normal growth	Normal growth
	5×10^{-3} mmHg	Normal growth	Sec. recryst. completed in 6 hours	Sec. recryst. completed in 3 hours
	1×10^{-1} mmHg	Normal growth	Sec. recryst. approx. 10 %	Sec. recryst. approx. 10 %

Sec. recryst. = secondary recrystallization.

proceed only by annealing in a vacuum of 5×10^{-3} mmHg. By annealing in a dry Hydrogen atmosphere or in a vacuum of 3×10^{-4} mmHg the selective growth of (100) [001] oriented grain did not take place, but the normal grain growth proceeded slightly further. Development of the secondary recrystallization was not completed by annealing in a vacuum of 1×10^{-1} mmHg. Table 1 summarizes the aspects of secondary recrystallization upon temperature and annealing

duced by simple vacuum systems, the above process may be useful for manufacturing double oriented Silicon steel sheets. Typical magnetic torque test results for sheets prepared by this method are shown in Table 2.

Table 2 Typical magnetic torque test result.

Specimen	Maximum peak value (dyne-cm/cm ³)	Peak ratio
A	9.1×10^4	0.96
B	14.2×10^4	0.95

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