The control of magnetic properties for Mn-Zn single crystals by continuous feeding Bridgman process

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1. Introduction

The magnetic properties in the frequency range 4-6MHz and the outstanding wear resistance of manganese zinc ferrous (Mn-Zn) ferrite single crystals have promoted their use as a material for Video Cassette Recording heads[1,2]. However, there are strong requirements on the homogeneity of the crystal because the allowed variations of the magnetic properties are limited..

In this study, the Bridgman process was selected to grow single crystals of this Mn-Zn ferrite single cystal. A problem arises if a binary system forms a complete simple solid solution. A solution is proposed here in which a reliable feeding mechanism and a feeding material are used.

2. Experimental

Two coexisting compositions A and B were chosen, based on the data of the phase diagram[3] and on the results of preliminary experiment for crystal growth. The composition of the initial melt was Fe : Mn : Zn = 50 : 30 : 20 (composition A) to which granulated ferrite Fe : Mn : Zn = 54 : 28 : 18

(composition B) was to be added.

The very pure raw materials were mixed and well-milled for 8 h. The mixed powders were granulated and calcined at 1570 K in air for 3 h. The seed crystal with composition B was made from a previous crystal in the desired crystallographic orientation.

The chemical composition of the crystals was determined by cutting them into 0.5 mm thick sliced perpendicular to the growth direction. The relative concentration of Mn, Zn and Fe was determined by X-ray fluorescence analysis with reference to a standard. The magnetic permeability μe was measured at 0.5 MHz and 5 MHz on toroids in the (110) plane. The resistivity was determined by the 4-point method.

3. Results and Discussion.

The furnace by continuous feeding Bridgman is used a vertical pipe kiln(Fig. 1). The heating element was separated from the crystal growing chamber by the alumina tube. Oxygen flowed through the chamber during the crystal growth, a temperature gradient of about 0.67 K/mm with a top temperature of 1930 K was achieved by means of different heating zones. A platinium crucible supported by refractory holder was placed on a supporting tube, which could move vertically. The feeding equipment consisted of a storage drum filled with composition B and a controlled vibrator which is connected to a feeding pipe.

The seed crystal and some amount of composition A were placed in the crucible at the start of the run. The volume of the melt should be limited in order to end up with small rest melt. As a compromise the height of the liquid column was kept 45 mm. During the crystal growth composition B was added at such a rate that the height of the liquid column was maintained constant. The Growth rate was 3 mm/h during the run, and cooling rate was 40 K/h.

The scaling-up has been carried out successfully and well-usable crystals have been grown 70 mm in diameter and 550 mm in length. A constant composition in these crystals could be accomplished within 0.6 mol% over 350mm length as shown in Fig. 2.

Fig. 3 shows the magnetic permeability of a grown crystal along the growth length.

The compositional gradient observed in Bridgman-grown Mn-Zn ferrite crystals is almost completely due to the formation of the complete simple solid solution found in the phase diagram. Homogeneous Mn-Zn Ferrite single crystals grown by the composition-controlled growth method proposed here.

Reference

[1] H. Sugaya, IEEE Trans. Magn., **MAG-4**(1968) 295

[2] M. Mizushima, IEEE Trans. Magn., Proc. INTERMAG. Conf.(1971) 342

[3] Th. J. Berben et al., Proc. Int. Conf. Ferrites (1980) 722

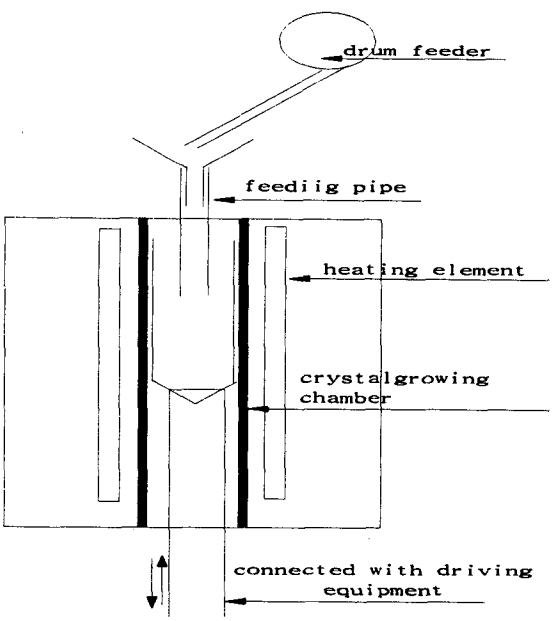

Fig. 1. Schematic Diagram of Continuous Feeding Bridgman Growth Apparatus.

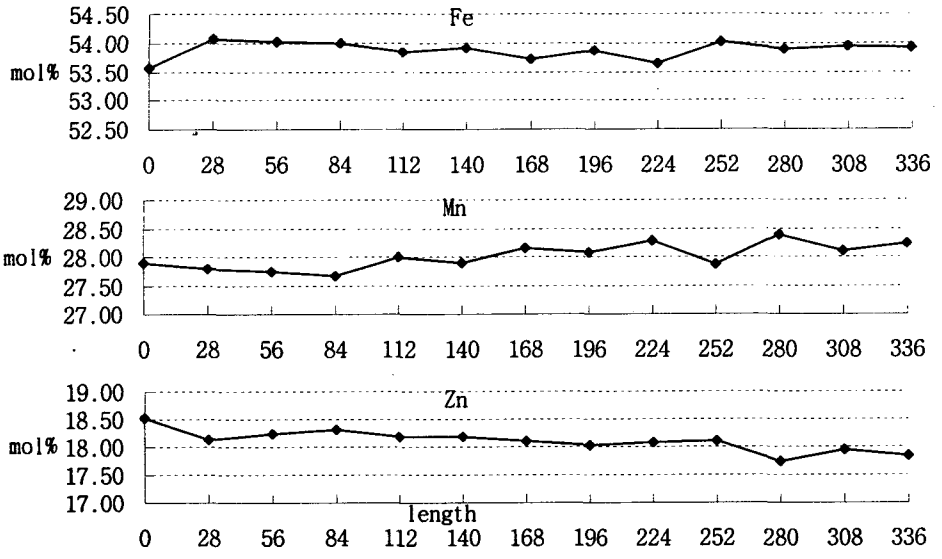

Fig 2. Variation of chemical composition of Mn-Zn Ferrite Single crystal to growth length direction.

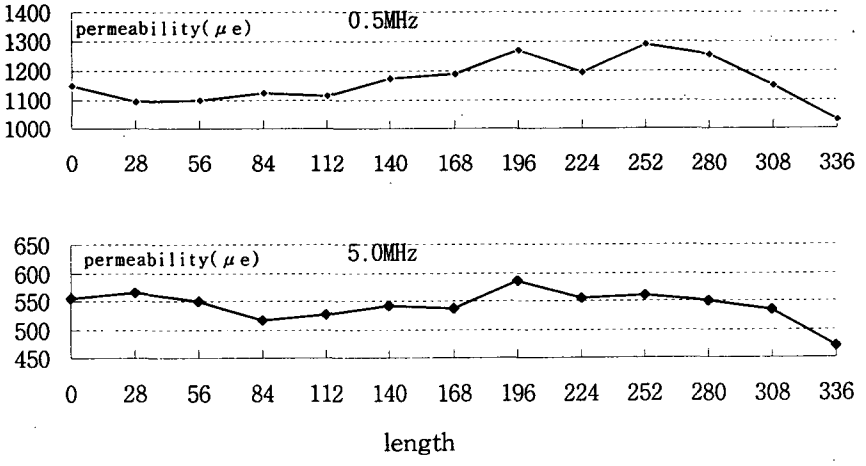

Fig. 3. Compositional homogeneity measured by initial effective magnetic permeability.