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JOURNAL DE PHYSIQUE
Colloque C8, Supplément au n° 12, Tome 49, décembre 1988

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Abstract. – Amorphous magnetic fiber of 10 μm in diameter was developed, which shows high value and desirable frequency characteristic of the permeability. The cloth transformer of thickness less than 1 mm could be made. The transformer operated up to 10 MHz. Stray capacitance could be reduced.

Introduction

A small and thin transformer enables to reduce the size of electronic circuits composed of IC chips and magnetic elements. We prepared amorphous magnetic fibers of 10 μm in diameter and proposed cloth-structured transformer, in which the primary and the secondary windings were arranged in order to reduce the stray capacitance. The analysis based on equivalent circuit technique has made it clear that it exists the suitable arrangement of these windings.

Thin amorphous magnetic fiber

We used Co-based amorphous magnetic fiber with zero magneto-striction. Diameter of the amorphous magnetic fiber is about 120 μm in diameter with uniform circular cross section by wire drawing technique.

Tensile stress was applied to the amorphous fiber when the wire was annealed. Figure 1 shows the effect of tensile stress on the magnetic relative permeability of the wire. As shown in the figure, the magnetic permeability varies with the strength of the stress applied. Based on the experimental result, we have annealed amorphous fiber of 10 μm in diameter, giving the tensile stress of 12.5 kg/mm^2, constantly.

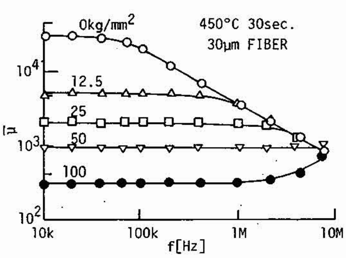

Fig. 1. – Effect of tensile stress on the relative permeability.

Figure 2 shows frequency characteristics of the relative permeability of the annealed amorphous fiber, comparing with that of the fiber as drawn. The value

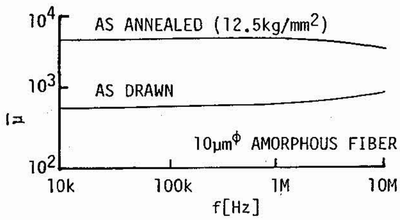

Fig. 2. – Frequency characteristic of relative permeability of the fiber of 10 μm in diameter.

over 4000 of the relative permeability and frequency characteristic in flatness near 10 MHz were realized.

Structure of cloth transformer

Figure 3 illustrates the structure of cloth transformer proposed in this paper and the outlook of the transformer made as a trial ($11 \times 14 \times 1$ mm^3). The copper wire of 70 μm were used as a conductive fiber. As shown in the figure, the transformer has a plain weave structure. A "warp" is a bundle of amorphous fibers and a "weft" is a conductive fiber. A weft to go and return back crossing warps forms a winding of "one turn" for each warp. Because of a plain weave structure magnetic fluxes in warps adjacent to each other flow in anti-parallel direction and the radiation interference is reduced [1].

Conductive fibers are divided to several groups and arranged at the same spacing in order to reduce stray

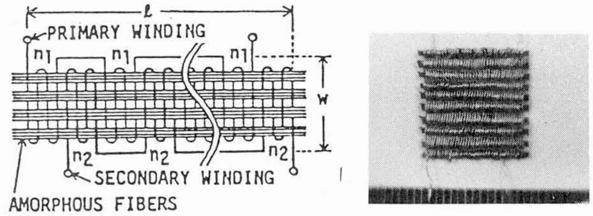

Fig. 3. – Structure and outlook of the cloth transformer made as a trial ($11 \times 14 \times 1$ mm^3).

Article published online by EDP Sciences and available at http://dx.doi.org/10.1051/jphyscol:19888914

capacitance. Each group of windings has n_1 turns in the primary winding and n_2 turns in the secondary one. Let the number of groups be m, the number N_1 of the primary winding and N_2 of the secondary one are expressed:

$$N_1 = m \times n_1, \quad N_2 = m \times n_2. \tag{1}$$

Figure 4 shows an equivalent circuit of the transformer. For simplicity, the number of primary winding N_1 is assumed to be equal to that of the secondary winding N_2. In the figure, R_c represents resistance of windings and X_2 leakage reactance. R_f is equivalent resistance representing iron loss and X_1 exciting reactance. C_1 and C_2 are stray capacitance.

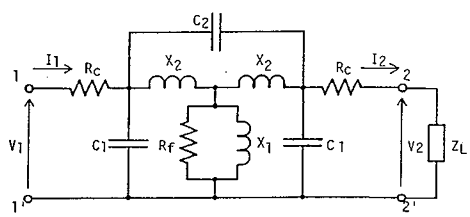

Fig. 4. – Equivalent circuit of the transformer.

Figure 5 shows n_1 dependence of voltage ratio V_2/V_1, stray capacitance C_1, C_2 and leakage reactance X_2 for the cloth transformer ($N_1 = N_2 = 20$ turns) at 1 MHz. Figure 6 shows frequency dependence of

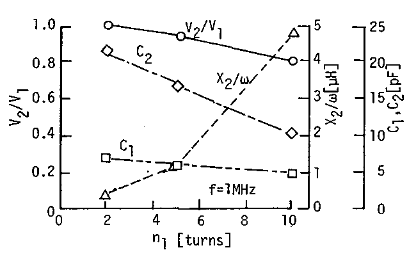

Fig. 5. – n_1 *vs.* V_2/V_1, C_1, C_2 and X_2 relation. $N_1 = N_2 = 20$. $f = 1$ MHz.

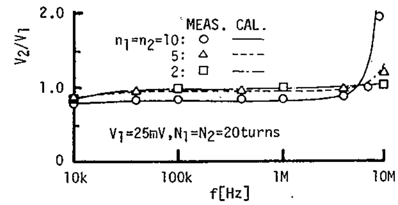

Fig. 6. – Frequency dependence of voltage ratio V_2/V_1.

voltage ratio V_2/V_1. From these figures it reveals that suitable value of n_1 enables to improve characteristics of the cloth transformer.

Figure 7 shows the load characteristics of the cloth transformer. In the figure broken lines show calculated values obtained from equivalent circuit analysis. The efficiency exceeded 90 % .

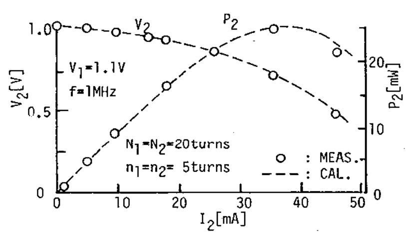

Fig. 7. – Load characteristics of the cloth transformer.

Conclusion

An amorphous magnetic fiber of 10 μm in diameter has been developed and cloth transformer using the amorphous fiber were proposed. Analysis based on equivalent circuit is successful for presenting characteristics of the transformer.

[1] Matsuki, H., Murakami, K. and Yamamoto, T., *IEEE Trans. Magn.* **MAG-22** (1986) 415.

[2] Matsuki, H. and Murakami, K., *IEEE Trans. Magn.* **MAG-21** (1985) 1738.