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LITHIUM TITANIUM BISMUTH FERRITES

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ABSTRACT OF THE DISCLOSURE

Microwave ferrites with narrow resonance linewidths, good temperature performance, low losses, low costs, and rectangular hysteresis loops are made from a lithium-titanium ferrite containing a small amount of bismuth. In addition, small amounts of zinc, copper or manganese can be present in the ferrites.

The invention described herein was made in the course of a contract with the United States Department of the Air Force.

SUMMARY OF THE INVENTION

At the present time, garnets are ordinarily employed at microwave frequencies. However, garnets are expensive and have poor temperature performance. Although it has been suggested that ferrites might be used, the losses have been high, the densities have been low or the coercive forces have been too high.

In accordance with the present invention, these difficulties are obviated by employing at microwave frequencies, ferrites which have narrow resonance linewidths, good temperature performance, low losses, low costs and rectangular hysteresis loops. This is accomplished by making a ferrite containing lithium and titanium with a small amount of bismuth. Copper, zinc and manganese may also be present.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The following preparative procedure is used in compounding ferrite materials in accordance with the present invention:

Oxides of the constituent metal ions are generally employed when possible. In instances where the chemical instability of the oxide of a particular metal ion causes said oxide to be an impure and unreliable compound, the anhydrous carbonate of the metal ion is used. The raw materials are weighed out in stoichiometric proportions and are wet mixed for one hour or more in a ball mill. The resulting slurry is then dried at around 100° C. and the dried raw material mixture is then forced through a standard 20 mesh for ease of handling.

The screened oxide mixture is then loaded into refractory boats. The boats are placed in a box type furnace, and heated to a predetermined temperature. The exact temperature can vary from 700° to 900° C. The object of this step is twofold: the primary object is to provide sufficient energy to react the oxide mixture to a 70% ferrite 30% oxide mixture by a solid state reaction. The secondary objective is the simple thermal decomposition of any carbonates used.

The reacted mixture is generally characterized by a relatively large predominant particle size. Before the mixture can be shaped and sintered into a single phase ferrite body the particle size must be reduced. Ball milling is employed in essentially the same manner as outlined above. The ferrite-oxide slurry is then dried at around 80° C. to a fine powder.

The powder is then mixed with a binder as is well known to those skilled in the art. Wide latitude is permissible in the selection of binders. A typical binder is polyvinyl alcohol.

The addition of the binder can be carried out in the second ball milling step, or in an additional step employing any sort of method facilitating uniform distribution of the substance used as a binder. The binder impregnated powder is then shaped in tool steel dies with enough pressure to facilitate uniform compaction.

The pressed shapes are then sintered at temperatures ranging from 950° C. to 1150° C. in atmospheres of oxygen or air.

The novel ferrites of the present invention have the following composition.

$$\mathrm{Li}\ 0.5+\left(\frac{x-y-w}{2}\right)\mathrm{Fe}\ 2.5-\left(\frac{3x+y+2z+w}{2}\right)-B\ \mathrm{Ti}\ x\ \mathrm{Cu}\ y\ \mathrm{Mn}\ z\ \mathrm{Zn}\ w\ \mathrm{Bi}\ B\ \mathrm{O}\ 4$$

where

$$0.0005 \leq B \leq 0.065$$

and

$$0.30 \leq x \leq 0.95$$
$$0 \leq y \leq 0.2$$
$$0 \leq z \leq 0.2$$
$$0 \leq w \leq 0.3$$

and

$$B+x+y+z+w+\left[0.5+\left(\frac{x-y-w}{2}\right)\right]+\left[2.5-\left(\frac{3x+y+2z+w}{2}\right)\right]-B=3$$

The following non-limiting examples illustrate various preferred embodiments of the invention. In the examples, Examples 1 and 3 illustrate compositions which contain bismuth while Examples 2 and 4 show substantially the same compositions without the addition of bismuth showing the beneficial effect of the bismuth addition.

Example 1

A ferrite having the composition where $x=0.55$, $y=0.1$, $z=0.1$, $w=0.1$ and B=0.002 was prepared by the above procedure. The reaction step was performed at 800° C. The sintering step was performed at 1025° C. in an air atmosphere. The ferrite had a coercive force of 1.8 oersteds, a remanence of 930 gauss, a saturation magnetization of 1259 gauss, a dielectric loss of 0.4 decibels per inch, a resonance linewidth of 210 oersteds, and a density of 4.37 grams per cubic centimeter.

Example 2

A ferrite was prepared where $x=0.55$, $y=0.1$, $z=0.1$, $w=0.1$ and B=0. It had a coercive force of 4.0 oersteds, a remanence of 620 gauss, a saturation magnetization of 940 gauss, a dielectric loss of 0.4 decibels per inch, a resonance linewith of 435 oersteds, and a density of 3.94 grams per cubic centimeter.

Example 1 contains bismuth while Example 2 does not. Example 1 is a superior material because it has a lower coercive force, a higher remanence, a narrower resonance linewidth, and a higher density than does 2.

Example 3

A ferrite was prepare where $x=0.7$, $y=0$, $z=0.05$, $w=0.1$ and B=0.002. It had a coerceive force of 1.8 oersteds, a remanence of 714 gauss, a saturation magnetization of 850 gauss, a magnetic loss of 0.24 decibels per inch, a dielectric loss of 0.5 decibes per inch, a resonance linewidth of 198 oersteds, and a density of 4.16 grams per cubic centimeter.

Example 4

A ferrite was prepared where $x=0.7$, $y=0$, $z=0.05$, $w=0.1$ and B=0. It had a coercive force of 4.57 oersteds, a remanence of 424 gauss, a saturation magnetization of 645 gauss, a magnetic loss of 0.05 decibels per inch, a dielectric loss of 0.45 decibels per inch, a resonance linewidth of 418 oersteds, and a density of 3.0 grams per cubic centimeter.

Example 3 contains bismuth while Example 4 does not. Example 3 is superior material because it has a lower coercive force, a higher remanence, a lower magnetic loss, a narrower resonance linewidth, and a higher density than does 4.

We claims:

1. A lithium-titanium-bismuth ferrite having the following composition:

$$\text{Li } 0.5+\left(\frac{x-y-w}{2}\right)\text{Fe } 2.5-\left(\frac{3x+y+2z+w}{2}\right)-B\ \text{Ti}\ x\ \text{Cu}\ y\ \text{Mn}\ z\ \text{Zn}\ w\ \text{Bi}\ B\ \text{O}\ 4$$

where

$$0.0005\leq B\leq 0.065$$

and

$$0.30\leq x\leq 0.95$$
$$0\leq y\leq 0.2$$
$$0\leq z\leq 0.2$$
$$0\leq w\leq 0.3$$

and

$$B+x+y+z+w+\left[0.5+\left(\frac{x-y-w}{2}\right)\right]+\left[2.5-\left(\frac{3x+y+2z+w}{2}\right)\right]-B=3$$

2. A ferrite in accordance with claim 1 wherein $x=0.55$, $y=0.1$, $z=0.1$, $w=0.1$ and B=0.002.

3. A ferrite in accordance with claim 1 wherein $x=0.7$, $y=0$, $z=0.05$, $w=0.1$ and B=0.002.

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