between the rod and cylinder is a reason that both the outside surface of the rod and the inside surface of the cylinder are machined to precise tolerances.

[0005] At step **26**, epoxy adhesive is applied to the one or both of the rod and cylinder. At step **28**, the rod is inserted inside the cylinder to form a rod-and-cylinder assembly, and the epoxy is allowed to cure (harden), as indicated by step **30**. At step **32**, the outside surface of the rod-and-cylinder assembly is again machined to a precise OD. Lastly, at step **34**, the rod-and-cylinder assembly is sliced into a number of disc assemblies. Each disc assembly thus comprises a magnetic ceramic disc disposed concentrically within a dielectric ceramic ring. Each disc assembly is typically several millimeters in thickness.

[0006] The time involved in machining the inside surface of the cylinder to promote adhesion, applying epoxy to the parts, carefully handling and assembling the epoxy-laden parts, and curing the epoxy, contributes to inefficiency in the process. It would be desirable to provide a more efficient method for making composite magnetic-dielectric disc assemblies.

SUMMARY

[0007] Disclosed herein are embodiments of a composite material for use as a radiofrequency component comprising a magnetic garnet material rod, and a ring surrounding the magnetic garnet material rod, the ring being formed from a scheelite material having a firing temperature of 950 °C or below. In an aspect, there is provided a composite material for use as a radiofrequency component comprising: a rod including a magnetic garnet material; and a ring surrounding the rod, the ring being formed from a scheelite material having a firing temperature of 950 °C or below. In an aspect, there is provided a method of forming a composite material for use as an isolator or circulator in a rad °frequency device, the method comprising: providing a rod including a magnetic garnet material; providing an outer ring having a scheelite crystalline structure, the outer ring having a firing temperature of 950 °C or below; entering the rod within an aperture in the outer ring; and co-firing the outer ring and the rod together at a temperature of 950 °C or below to shrink the outer ring around an outer surface of the magnetic garnet material rod without the use of adhesive or glue and form a composite material.

[0008] In some embodiments, the scheelite material can have the chemical formula $Li_{0.05}Bi_{0.95}Mo_{0.1}V_{0.9}O_4$. In some embodiments, the scheelite material can have the chemical formula $Bi_{1-2x-z}R_zM'_xV_{1-x}M''_xO_4$, R being a rare earth element La, Ce, Pr, Sm, Nd, Gd, Dy, Tb, Ho, Er, Tm, Yb, Lu, Y or Sc, M' being Li, Na, or K, and M" being Mo or W. In some embodiments, the scheelite material can have the chemical formula $(Na,Li)_{0.5x}Bi_{1-0.5x}(Mo,W)_xV_{1-x}O_4$, x being between 0 and 0.5. In some embodiments, the scheelite material can include between 1 and 10 wt. % aluminum oxide. In some embodiments, the scheelite material can include between 2 and 6 wt. % aluminum oxide. In some embodiments, the magnetic garnet material rod can include Bi, Ca, Zr, Y, Fe, and O. In some embodiments, the scheelite material can include $BiVO_4$. In some embodiments, the ring can reduce in diameter around the magnetic garnet material rod during firing so that no adhesive is used to connect

WHAT IS CLAIMED IS:

1. A composite material for use as a radiofrequency component comprising:

a rod including a magnetic garnet material; and

a ring surrounding the rod, the ring being formed from a scheelite material having a firing temperature of 950 °C or below.

2. The composite material of claim 1 wherein the scheelite material has the chemical formula $Li_{0.05}Bi_{0.95}Mo_{0.1}V_{0.9}O_4$.

3. The composite material of claim 1 wherein the scheelite material has the chemical formula $Bi_{1-2x-z}R_zM'_xV_{1-x}M''_xO_4$, R being a rare earth element La, Ce, Pr, Sm, Nd, Gd, Dy, Tb, Ho, Er, Tm, Yb, Lu, Y or Sc, M' being Li, Na, or K, and M" being Mo or W.

4. The composite material of claim 1 wherein the scheelite material has the chemical formula $(Na,Li)_{0.5x}Bi_{1-0.5x}(Mo,W)_xV_{1-x}O_4$, x being between 0 and 0.5.

5. The composite material of claim 1 wherein the scheelite material includes between 1 and 10 wt. % aluminum oxide.

6. The composite material of claim 5 wherein the scheelite material includes between 2 and 6 wt. % aluminum oxide.

7. The composite material of claim 1 wherein the scheelite material includes $BiVO_4$.

8. The composite material of claim 1 wherein the scheelite material includes $(Na_{0.35}Bi_{0.65})(Mo_{0.7}V_{0.3})O_4$.

9. The composite material of claim 1 wherein the scheelite material includes $(Na_{0.2}Bi_{0.8})(Mo_{0.4}V_{0.6})O_4$.

10. A method of forming a composite material for use as an isolator or circulator in a radiofrequency device, the method comprising:

providing a rod including a magnetic garnet material;

providing an outer ring having a scheelite crystalline structure, the outer ring having a firing temperature of 950 °C or below;

entering the rod within an aperture in the outer ring; and

co-firing the outer ring and the rod together at a temperature of 950 °C or below to shrink the outer ring around an outer surface of the magnetic garnet material rod without the use of adhesive or glue and form a composite material.

11. The method of claim 10 wherein the outer ring has the chemical formula $Li_{0.05}Bi_{0.95}Mo_{0.1}V_{0.9}O_4$.

12. The method of claim 10 wherein the scheelite material has the chemical formula $Bi_{1-2x-z}R_zM'_xV_{1-x}M''_xO_4$, R being a rare earth element La, Ce, Pr, Sm, Nd, Gd, Dy, Tb, Ho, Er, Tm, Yb, Lu, Y or Sc, M' being Li, Na, or K, and M" being Mo or W.

13. The method of claim 10 wherein the scheelite material has the chemical formula $(Na,Li)_{0.5x}Bi_{1-0.5x}(Mo,W)_xV_{1-x}O_4$, x being between 0 and 0.5.

14. The method of claim 10 wherein the scheelite material includes between 1 and 10 wt. % aluminum oxide.

15. The method of claim 14 wherein the scheelite material includes between 2 and 6 wt. % aluminum oxide.

16. The method of claim 10 wherein the magnetic garnet material rod includes Bi, Ca, Zr, Y, Fe, and O.

17. The method of claim 10 wherein the scheelite material includes $BiVO_4$.

18. The method of claim 10 further including slicing the composite material.

19. A radiofrequency isolator or circulator comprising:

a rod including a magnetic garnet material; and

a ring surrounding the rod, the ring being formed from a scheelite material having a firing temperature of 950 °C or below.

The radiofrequency of claim 19 wherein the ring reduces in diameter around the magnetic garnet material rod during firing so that no adhesive is used to connect the ring with the magnetic garnet material rod.

Claims:

1. A composite material for use as a radiofrequency component comprising: a rod including a magnetic garnet material; and a ring surrounding the rod, the ring being formed from a scheelite material having a firing temperature of 950 °C or below.

2. The composite material of claim 1 wherein the scheelite material has the chemical formula Li0.05Bio.95Meo.iVo.904.

3. The composite material of claim 1 or claim 2 wherein the scheelite material has the chemical formula Bii 2x-7R7M'xVi-xM"x04, R being a rare earth element La, Ce, Pr, Sm, Nd, Gd, Dy, Tb, Ho, Er, Tm, Yb, Lu, Y or Sc, M' being Li, Na, or K, and M" being Mo or W.

4. The composite material of any of claims I to 3 wherein the scheelite material has the chemical formula (Na,L1)0 53cB11-0 5x(MO,W)xV1-x04, x being between 0 and 0.5.

5. The composite material of any preceding claim wherein the scheelite material includes between 1 and 10 wt. % aluminum oxide.

6. The composite material of claim 5 wherein the scheelite material includes between 2 and 6 wt. % aluminum oxide.

7.The composite material of any preceding claim wherein the scheelite material includes BiVO4.

8.The composite material of any preceding claim wherein the scheelite material includes (Nao 35Bio 65)(Moo -/V0.3)04.

9.The composite material of any preceding claim wherein the scheelite material includes (Na0,2B10 8)(1\400 IVO 6)04.

10. A method of forming a composite material for use as an isolator or circulator in a rad °frequency device, the method comprising: providing a rod including a magnetic garnet material; providing an outer ring having a scheelite crystalline structure, the outer ring having a firing temperature of 950 °C or below; entering the rod within an aperture in the outer ring; and co-firing the outer ring and the rod together at a temperature of 950 °C or below to shrink the outer ring around an outer surface of the magnetic garnet material rod without the use of adhesive or glue and form a composite material.

11. The method of claim 10 wherein the outer ring has the chemical formula L10.05B10.95M00.1V0.9 04.

12. The method of claim 10 or claim 11 wherein the scheelite material has the chemical formula R being a rare earth element La, Ce, Pr, Sm, Nd, Gd, Dy, Tb, Ho, Er, Tm, Yb, Lu, Y or Sc, M' being Li, Na, or K, and M" being Mo or W.

13. The method of any of claims 10 to 12 wherein the scheelite material has the chemical formula (Na,L00 B 1-0.5 x(MO,W)xVI-x0 x being between 0 and 0.5.

14. The method of any of claims 10 to 13 wherein the scheelite material includes between 1 and 10 wt. % aluminum oxide.

15. The method of claim 14 wherein the scheelite material includes between 2 and 6 wt. % aluminum oxide.

16. The method of any of claims 10 to 15 wherein the magnetic garnet material rod includes Bi, Ca, Zr, Y, Fe, and 0.

17. The method of any of claims 10 to 16 wherein the scheelite material includes $BiVO_4$.

18. The method of any of claims 10 to 17 further including slicing the composite material.

19. A radiofrequency isolator or circulator comprising: a rod including a magnetic garnet material; and a ring surrounding the rod, the ring being formed from a scheelite material having a firing temperature of 950 °C or below.

20. The radiofrequency isolator or circulator of claim 19 wherein the ring reduces in diameter around the magnetic garnet material rod during firing so that no adhesive is used to connect the ring with the magnetic garnet material rod.