LOW FREQUENCY SHIELD SOLUTIONS WITH SPUTTERED/SPRAYED ABSORBER MATERIALS AND/OR ABSORBER MATERIALS MIXED IN MOLD COMPOUND

BACKGROUND

Technical Field

Embodiments of this disclosure relate to multi-component microelectronic devices and structures and methods of mitigating electromagnetic cross-talk in same.

Description of Related Technology

Modern electronic devices may include modules or packages housing multiple components, for example, power amplifiers, low noise amplifiers, voltage-controlled oscillators, switches, filters, and other components that operate utilizing alternating current. Market forces continue to demand electronic devices having increasingly smaller form factors and that are lighter and less expensive, but have greater functionality, for example, in electronic communication devices, the ability to support multiple frequency bands. As a result, the circuit density in many electronic devices continues to become greater with each new product iteration. Electromagnetic interference (EMI) or cross-talk between the components in a common electronic device module or between components in an electronic device module and external sources may degrade overall performance or cause failure of an electronic device.

SUMMARY

In ~~accordance with~~ one aspect, there is provided an electronic device. The electronic device comprises an electromagnetic interference shield including a layer of conductive material covering at least a portion of the electronic device and having a skin depth of less than 2 μm for electromagnetic signals having frequencies in a kilohertz range, the electronic device being covered in a molding material and the electromagnetic interference shield being disposed on the molding material.

In ~~some embodiments~~one example, the electronic device is covered in a molding material and the electromagnetic interference shield is disposed on the molding material. The molding material may include a filler material that retards propagation of electromagnetic signals. The filler material may have a skin depth of less than 2 μm for electromagnetic signals

having frequencies in the kilohertz range. The filler material may include a magnetic ceramic ferrite. The filler material may include an iron containing alloy. The filler material may be non-conductive. The filler material may include conductive particles surrounded by non-conductive material.

In ~~some embodiments~~another example, a component of the electronic device is configured to emit an electromagnetic signal at a frequency within one or more of a hertz range, a kilohertz range, or a megahertz range.

In ~~some embodiments~~another example, the layer of conductive material includes a magnetic ceramic ferrite.

In ~~some embodiments~~another example, the layer of conductive material includes an iron containing alloy.

In ~~some embodiments~~another example, the layer of conductive material has a thickness of less than 30 μm. The layer of conductive material may have a thickness of less than 20 μm.

In ~~some embodiments~~another example, the electronic device further comprises a radio frequency filter. The electronic device may be included in an electronics module.

In ~~accordance with~~ another aspect, there is provided and electronic device. The electronic device comprises a molding material covering at least a portion of the electronic device and including a filler material having a skin depth of less than 2 μm for electromagnetic signals having frequencies in a kilohertz range.

In ~~some embodiments~~another example, the filler material includes a magnetic ceramic ferrite.

In ~~some embodiments~~another example, the filler material includes an iron containing alloy.

In ~~some embodiments~~another example, the filler material is non-conductive.

In ~~some embodiments~~another example, the filler material includes conductive particles covered by non-conductive material.

In ~~some embodiments~~another example, a component of the electronic device is configured to emit an electromagnetic signal at a frequency within one or more of a hertz range, a kilohertz range, or a megahertz range.

In ~~some embodiments~~another aspect, the electronic device further comprises an electromagnetic interference shield including a layer of conductive material having a skin depth of less than 2 μm for electromagnetic signals having frequencies in a kilohertz range disposed on the molding material. The layer of conductive material may include a magnetic ceramic ferrite. The layer of conductive material may include an iron containing alloy. The layer

of conductive material may have a thickness of less than 30 μm. The layer of conductive material may have a thickness of less than 20 μm.

In ~~some embodiments~~ another example, the electronic device further comprises a radio frequency filter. The electronic device may be included in an electronics module.

In ~~accordance with~~ another aspect, there is provided a method of forming an electromagnetic interference shield on an electronic device. The method comprises depositing a molding material including a filler material having a skin depth of less than 2 μm for electromagnetic signals having frequencies in a kilohertz range on a surface of the electronic device.

In ~~some embodiments~~another example, the method further comprises depositing a layer of conductive material having a skin depth of less than 2 μm for electromagnetic signals having frequencies in the kilohertz range on the molding material.

In ~~accordance with~~ another aspect, there is provided a method of forming an electromagnetic interference shield on an electronic device. The method comprises depositing a molding material on a surface of the electronic device, the molding material covering at least a portion of the electronic device and including a filler material having a skin depth of less than 2 μm for electromagnetic signals having frequencies in a kilohertz range; and depositing a layer of conductive material having a skin depth of less than 2 μm for electromagnetic signals having frequencies in a kilohertz range on the molding material.

In another aspect, there is provided an electronic device. The electronic device comprises an electromagnetic interference shield including a layer of conductive material including a magnetic ceramic ferrite covering at least a portion of the electronic device and having a skin depth of less than 2 μm for electromagnetic signals having frequencies in a kilohertz range.

In another aspect, there is also provided an electronic device. The electronic device comprises an electromagnetic interference shield including a layer of conductive material covering at least a portion of the electronic device and having a skin depth of less than 2 μm for electromagnetic signals having frequencies in a kilohertz range, the electronic device further comprising a radio frequency filter.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of this disclosure will now be described, by way of non-limiting example, with reference to the accompanying drawings.

FIG. 1A is an illustration of suppression of electromagnetic interference (EMI) from a power amplifier module using a first type of shielding;

FIG. 1B is an illustration of suppression of EMI from a power amplifier module using a second type of shielding;

FIG. 2 illustrates an electronic device module including a first type of EMI shielding;

FIG. 3 illustrates an electronic device module including a second type of EMI shielding;

FIG. 4 illustrates an electronic device module including a combination of the first type of EMI shielding and the second type of EMI shielding;

CLAIMS

What is claimed is:

1. An electronic device comprising an electromagnetic interference shield including a layer of conductive material covering at least a portion of the electronic device and having a skin depth of less than 2 μm for electromagnetic signals having frequencies in a kilohertz range, the electronic device being covered in a molding material and the electromagnetic interference shield being disposed on the molding material.

2. The electronic device of claim ~~1~~32 wherein the electronic device is covered in a molding material and the electromagnetic interference shield is disposed on the molding material.

3. The electronic device of claim ~~2~~1 wherein the molding material includes a filler material that retards propagation of electromagnetic signals.

4. The electronic device of claim 3 wherein the filler material has a skin depth of less than 2 μm for electromagnetic signals having frequencies in the kilohertz range.

5. The electronic device of claim 3 wherein the filler material includes a magnetic ceramic ferrite.

6. The electronic device of claim 3 wherein the filler material includes an iron containing alloy.

7. The electronics device of claim 3 wherein the filler material is non-conductive.

8. The electronics device of claim 3 wherein the filler material includes conductive particles surrounded by non-conductive material.

9. The electronic device of claim 1 wherein a component of the electronic device is configured to emit an electromagnetic signal at a frequency within one or more of a hertz range, a kilohertz range, or a megahertz range.

10. The electronic device of claim 1 wherein the layer of conductive material includes a magnetic ceramic ferrite.

11. The electronic device of claim 1 wherein the layer of conductive material includes an iron containing alloy.

12. The electronic device of claim 1 wherein the layer of conductive material has a thickness of less than 30 μm.

13. The electronic device of claim 12 wherein the layer of conductive material has a thickness of less than 20 μm.

14. The electronic device of claim 1 further comprising a radio frequency filter.

15. An electronics module including the electronic device of claim 14.

16. An electronic device comprising a molding material covering at least a portion of the electronic device and including a filler material having a skin depth of less than 2 μm for electromagnetic signals having frequencies in a kilohertz range.

17. The electronic device of claim 16 wherein the filler material includes a magnetic ceramic ferrite.

18. The electronic device of claim 16 wherein the filler material includes an iron containing alloy.

19. The electronics device of claim 16 wherein the filler material is non-conductive.

20. The electronics device of claim 16 wherein the filler material includes conductive particles covered by non-conductive material.

21. The electronic device of claim 16 wherein a component of the electronic device is configured to emit an electromagnetic signal at a frequency within one or more of a hertz range, a kilohertz range, or a megahertz range.

22. The electronic device of claim 16 further comprising an electromagnetic interference shield including a layer of conductive material having a skin depth of less than 2 μm for electromagnetic signals having frequencies in a kilohertz range disposed on the molding material.

23. The electronic device of claim 22 wherein the layer of conductive material includes a magnetic ceramic ferrite.

24. The electronic device of claim 22 wherein the layer of conductive material includes an iron containing alloy.

25. The electronic device of claim 22 wherein the layer of conductive material has a thickness of less than 30 μm.

26. The electronic device of claim 25 wherein the layer of conductive material has a thickness of less than 20 μm.

27. The electronic device of claim 16 further comprising a radio frequency filter.

28. An electronics module including the electronic device of claim 27.

29. A method of forming an electromagnetic interference shield on an electronic device, the method comprising depositing a molding material including a filler material having a skin depth of less than 2 μm for electromagnetic signals having frequencies in a kilohertz range on a surface of the electronic device.

30. The method of claim 29 further comprising depositing a layer of conductive material having a skin depth of less than 2 μm for electromagnetic signals having frequencies in the kilohertz range on the molding material.

31. A method of forming an electromagnetic interference shield on an electronic device, the method comprising:

depositing a molding material on a surface of the electronic device, the molding material covering at least a portion of the electronic device and including a filler material having a skin depth of less than 2 μm for electromagnetic signals having frequencies in a kilohertz range; and

depositing a layer of conductive material having a skin depth of less than 2 μm for electromagnetic signals having frequencies in a kilohertz range on the molding material.

32. An electronic device comprising an electromagnetic interference shield including a layer of conductive material including a magnetic ceramic ferrite covering at least a portion of the electronic device and having a skin depth of less than 2 μm for electromagnetic signals having frequencies in a kilohertz range.

33. An electronic device comprising an electromagnetic interference shield including a layer of conductive material covering at least a portion of the electronic device and having a skin depth of less than 2 μm for electromagnetic signals having frequencies in a kilohertz range, the electronic device further comprising a radio frequency filter.