metal foil layer can be composite or clad structures with different layers of different metals and alloys. The reinforcing metal foil layer can be solid, perforated or in the form of mesh.

In one aspect, there is provided a silver film wherein the silver film is a multilayer structure comprising a reinforcing silver foil layer between two layers of sinterable particles wherein each layer of sinterable particles comprises a mixture of sinterable silver particles and graphite particles, wherein the multilayer structure does not exhibit degradation after 500 thermal shock cycles between −40° C. and 125° C., wherein the silver film is configured for die attachment by application of heat and pressure to sinter the silver film.

One or more other aspects may involve lamination processes using the disclosed films. Still further aspects may involve die attachment methods using the disclosed films.

In another aspect, the present disclosure provides a method of laminating a die for attachment using the silver film described herein, the method comprising applying the silver film to a back of a die.

In yet another aspect, there is provided a method of attaching a die to a substrate comprising applying the silver film described herein to a die; and placing the die on a substrate with applied heat and pressure to sinter the film and connect the die to the substrate.

Still other aspects, embodiments, and advantages of these exemplary aspects and embodiments are discussed in detail below. Embodiments disclosed herein may be combined with other embodiments in any manner consistent with at least one of the principles disclosed herein, and references to "an embodiment," "some embodiments," "an alternate embodiment," "various embodiments," "one embodiment" or the like are not necessarily mutually exclusive and are intended to indicate that a particular feature, structure, or characteristic described may be included in at least one embodiment. The appearances of such terms herein are not necessarily all referring to the same embodiment.

BRIEF DESCRIPTION OF THE DRAWINGS

Various aspects of at least one embodiment are discussed below with reference to the accompanying figures, which are not intended to be drawn to scale. The figures are included to provide illustration and a further understanding of the various aspects and embodiments, and are incorporated in and constitute a part of this specification, but are not intended as a definition of the limits of the invention. Where technical features in the figures, detailed description or any claim are followed by references signs, the reference signs have been included for the sole purpose of increasing the intelligibility of the figures and description. In the figures, each identical or nearly identical component that is illustrated in various figures is represented by a like numeral. For purposes of clarity, not every component may be labeled in every figure. In the figures:

FIG. 1 presents a schematic of a joint in accordance with one or more embodiments;

FIG. 2 presents a schematic of a composite silver film in accordance with one or more embodiments;

FIGS. 3 and 4 present schematics of composite silver films in accordance with one or more embodiments;

FIGS. 5A-5E present examples of metal foils in accordance with one or more embodiments;

CLAIMS

1. A silver film wherein the silver film is a multilayer structure comprising a ~~mixture of~~reinforcing silver foil layer between two layers of ~~and reinforcing (modifying)~~ sinterable particles wherein each layer of sinterable particles comprises a mixture of sinterable silver particles and graphite particles, wherein the multilayer structure does not exhibit degradation after 500 thermal shock cycles between –40° C. and 125° C., wherein the silver film is configured for die attachment by application of heat and pressure to sinter the silver film.

~~2. The silver film of claim 1, wherein the mixture comprises a sinterable silver particles layer, and reinforcing particles.~~

~~3.~~2. The silver film of claim ~~2~~1, ~~further comprising a support~~wherein the reinforcing silver foil layer is ~~film~~ configured to support the sinterable silver particles layer and the ~~reinforcing particles~~graphite particles.

~~4. The silver film of claim 1, wherein the reinforcing (modifying) particles can be metallic or non-metallic.~~

~~5.~~3. The silver film of claim 1, wherein the ~~reinforcing (modifying)~~graphite particles ~~can be of various shapes and sizes, including~~ comprise spheres, flakes, fibers, flowers ~~and,~~ nanowire and combinations thereof.

~~6.~~4. The silver film of claim ~~5~~3, wherein the size of the ~~reinforcing (modifying)~~graphite particles ~~can range from~~is between 2 nm ~~to~~ and 10 µm.

~~7.~~5. The silver film of claim ~~5~~3, wherein ~~the reinforcing (modifying) particles~~at least one layer of sinterable particles further comprises at least one of ~~used to modify the properties of sintered silver joint are~~ copper, aluminum, glass~~,~~ and carbon~~, graphite and others~~.

~~8.~~6. The silver film of claim ~~5~~3, wherein a concentration of the ~~reinforcing (modifying)~~ graphite particles ~~can range from~~ is between 0.1 wt% by weight to 50 wt % by weight.

7. The silver film of claim 1, wherein the reinforcing silver foil layer is a metalized polymer or a ceramic foil comprising silver cladding.

9.8. The silver film of claim 1, wherein the reinforcing silver ~~film~~ foil layer is ~~a multilayer structure composed~~ composite or a clad structure with different ~~of at least two~~ layers ~~but can be three layers, including a reinforcing foil layer~~of different metals and alloys.

~~10. The silver film of claim 9, wherein the reinforcing foil layer can be silver, copper, gold or any other metal or any alloy.~~

~~11. The silver film of claim 10, wherein the reinforcing layer is a metalized polymer or a ceramic foil.~~

~~12. The silver film of claim 9, wherein the reinforcing metal foil layer can be composite or a clad structure with different layers of different metals and alloys.~~

~~13.~~9. The silver film of claim ~~12~~8, wherein the reinforcing metal foil layer ~~can be~~is solid, perforated or in the form of mesh.

~~14.~~10. A method of laminating a die for attachment using the silver film of claim 1, the method comprising applying the silver film to a back of a die.

~~15.~~11. A method of attaching a die to a substrate comprising:
~~using~~ applying the silver film of claim 1 to a die; and
placing the die on a substrate with applied heat and pressure to sinter the film and connect the die to the substrate.

12. The silver film of claim 1 wherein the two layers of sinterable particles are in direct contact with the reinforcing silver foil layer.

13. The silver film of claim 1 wherein the silver film consists of the reinforcing silver foil layer and the two layers of sinterable particles.

14. The silver film of claim 13 wherein the reinforcing silver foil layer is sandwiched between and in direct contact with the two layers of sinterable particles.

15. The silver film of claim 1 wherein the silver film consists of the reinforcing silver foil layer, the two layers of sinterable particles, and a support layer.

16. The silver film of claim 15 wherein the reinforcing silver layer is sandwiched between and in direct contact with the two layers of sinterable particles and the support layer is attached to one of the layers of sinterable particles