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(54) **LAMINATED ENERGETIC DEVICE**

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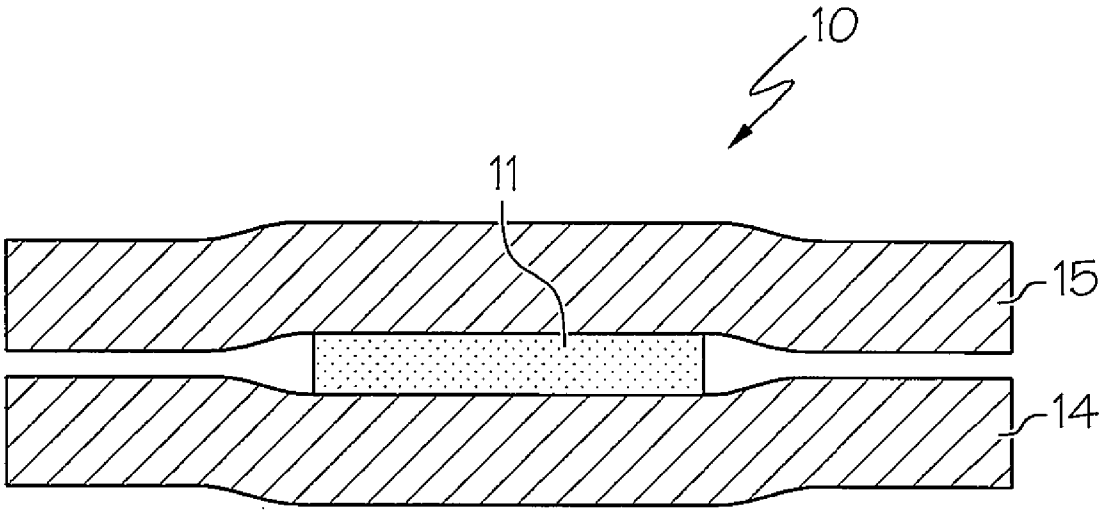
(57) **ABSTRACT**

A laminated energetic device is disclosed. The laminated energetic device includes a low-gas generating energetic mixture, a first film on which the low-gas generating energetic mixture is located, and a second film for sealing the low-gas generating energetic mixture between the first and second films.



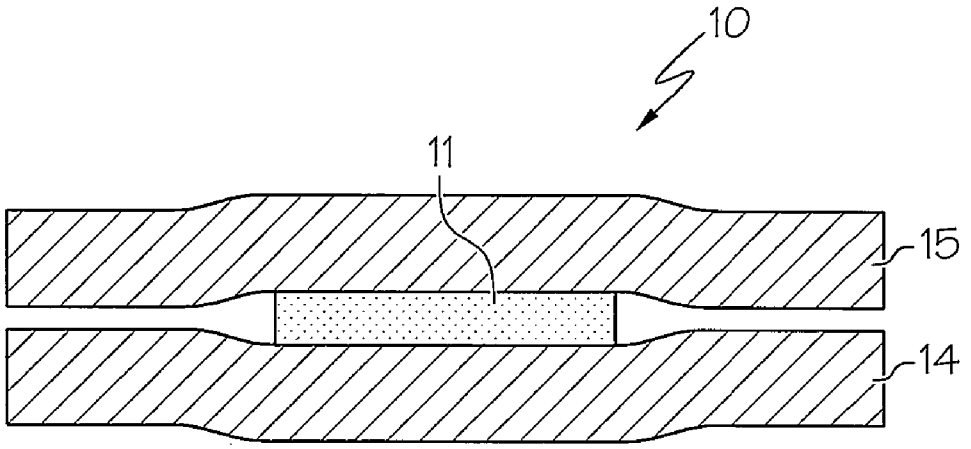


FIG. 1

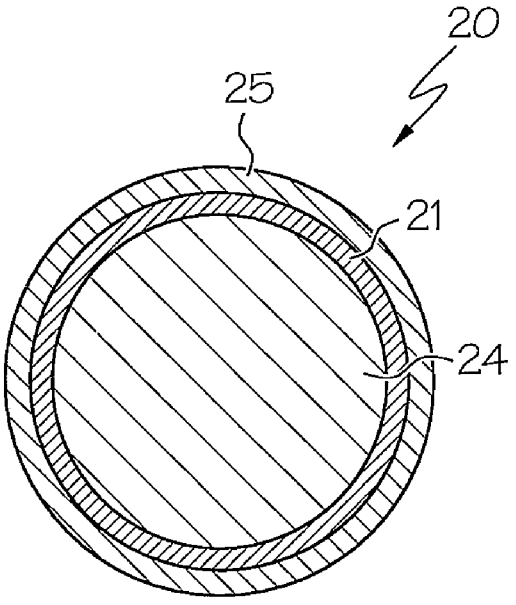


FIG. 2

LAMINATED ENERGETIC DEVICE

BACKGROUND OF THE INVENTION

[0001] 1. Technical Field

[0002] The present invention relates to energetic devices in general, and, in particular, to energetic devices for pyrotechnics. Still more particularly, the present invention relates to a laminated energetic device having a high propagation speed and low gas generation.

[0003] 2. Description of Related Art

[0004] Energetic devices for pyrotechnics are well-known in the art. An energetic device includes an energetic composition, and the energetic composition may be high-gas generating or low-gas generating. An example of a low-gas generating energetic composition is an intermetallic or a thermite. The most common thermite is a mixture of aluminum powder and iron powder. Once ignited, the thermite composition reacts exothermically, which raises the temperature of the mixture to approximately 3,000° C., resulting in molten iron and aluminum oxide while producing little or no permanent gas. The heat from the reaction can be used for many applications such as cutting and welding torches, plating of metals upon substrates, cutting or plugging oil well conduits, etc.

[0005] For many of the above-mentioned applications, it is desirable to maximize the transfer of heat from the thermite reaction to a target. However, for other applications, it may be desirable to use a low heat, fast-burning thermite composition.

SUMMARY OF THE INVENTION

[0006] In accordance with a preferred embodiment of the present invention, an energetic device includes a low-gas generating energetic mixture, a first film on which the low-gas generating energetic mixture is located, and a second film for sealing the low-gas generating energetic mixture between the first and second films.

[0007] All features and advantages of the present invention will become apparent in the following detailed written description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The invention itself, as well as a preferred mode of use, further objects, and advantages thereof, will best be understood by reference to the following detailed description of an illustrative embodiment when read in conjunction with the accompanying drawings, wherein:

[0009] FIG. **1** is a diagram of a laminated energetic device in a flat structure, in accordance with a preferred embodiment of the present invention; and

[0010] FIG. **2** is a diagram of a laminated energetic device in an annulus structure, in accordance with a preferred embodiment of the present invention.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

[0011] Referring now to the drawings and in particular to FIG. **1**, there is depicted a diagram of a laminated energetic device in a flat structure, in accordance with a preferred embodiment of present invention. As shown, a laminated energetic device **10** includes a low-gas generating energetic mixture **11** embedded between a first film **14** and a second film **15**. Low-gas generating energetic mixture **11** can be a thermite or an intermetallic. Examples of low-gas generating thermites include $2Al/Fe_2O_3$, $4Al/3SiO_2$, $4Al/3TiO_2$, $2Al/3CuO$, $2Mg/SiO_3$, $2Ti/2Fe_2O_3$. Examples of intermetallics include Al/Ni, 2Al/3S, 2B/Mo, 2Mg/Si, 3Si/5Ti. First and second films **14**, **15** can be made of, for example, polyethylene terephthalate (PET) films, plastic films, polymer films or metal foils. Low-gas generating energetic mixture **11** is hermetically sealed within first and second films **14**, **15**.

[0012] If a thermite is being used, low-gas generating energetic mixture **11** preferably includes a stoichiometric mixture of ferrous oxide (Fe_3O_4) and aluminum. Aluminum can be 80 nm aluminum power available commercially from Novacentrix Corporation. Iron oxide power can be 25 nm average diameter available commercially from Novacentrix Corporation. Low-gas generating energetic mixture **11** can be dispersed in isopropanol and sonicated.

[0013] Initially, a layer of dispersed low-gas generating energetic mixture **11** can be "painted" onto first film **14** as a trace having a width of approximately 2 cm and a thickness of approximately 0.01" or less. After the trace was allowed to dry, second film **15** is placed over first film **14** to form an air-tight and water-tight laminated structure for enclosing low-gas generating energetic mixture **11**.

[0014] Alternatively, the energetic mixture can be deposited in multiple alternating layers of metal comprising an intermetallic pair using magnettron sputtering.

[0015] Low-gas generating energetic mixture **11** can be ignited with an ordinary lighter at one of the two ends of laminated energetic device **10**. The propagation speed through low-gas generating energetic mixture **11** is approximately 4 m/s. Because the reaction propagation is very fast, first and second films **14**, **15** do not catch on fire from the reaction. In addition, low-gas generating energetic mixture **11** has a very low gas generation during combustion; thus, laminated energetic device **10** remains sealed during and after the combustion of low-gas generating energetic mixture **11**. Since the total amount of energy per unit length of laminated energetic device **10** is relatively low, the temperature of laminated energetic device **10** immediately after the combustion of low-gas generating energetic mixture **11** is low enough that it can be safely held in the hand.

[0016] First and second films **14**, **15** need not be transparent. However, if first and second films **14**, **15** are transparent, they can be initiated photonically, e.g., with an intense light source such as a xenon strobe or a laser, through the sealed films **14**, **15**, and the integrity of first and second films **14**, **15** need not to be breached in order to ignite low-gas generating energetic mixture **11**.

[0017] Instead of a flat structure, as shown in FIG. **1**, an annulus structure can also be used for containing a thermite mixture. With reference now to FIG. **2**, there is depicted a diagram of a laminated energetic device in an annulus structure, in accordance with a preferred embodiment of present invention. As shown, a laminated energetic device **20** includes a low-gas generating energetic mixture **21** embedded between a cylindrical core **24** and a protecting coating **25**. Low-gas generating energetic mixture **21** is hermetically sealed between cylindrical core **24** and protecting coating **25**.

[0018] Low-gas generating energetic mixture **21** is initially applied on the surface of cylindrical core **24** such as a tube or a solid rod. Protective coating **25** is then applied over low-gas generating energetic mixture **21** and cylindrical core **24**. This method can be more economical because both low-gas gen-

erating energetic mixture **21** and protective coating **25** can be serially applied with a continuous dip of a cylindrical core though different liquids.

[0019] The propagation speed of low-gas generating energetic mixture **21** on cylindrical core **24** is likely to be much faster than a thermite mixture on a flat structure (such as low-gas generating energetic mixture **11** on first film **14** in FIG. **1**) for the same film properties if cylindrical core **24** is optically transparent. This is because fully half of the radiation is directed inward to low-gas generating energetic mixture **21**. Furthermore, the annulus geometry enables radiation to be transmitted upstream of the flame front to preheat the unburned low-gas generating energetic mixture **21**, which reduces the activation energy and increases the burn rate.

[0020] As has been described, the present invention provides a laminated energetic device having a high propagation speed and a low gas generation.

[0021] While the invention has been particularly shown and described with reference to a preferred embodiment, it will be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. An energetic device comprising:

a low-gas generating energetic mixture;

a first film on which said low-gas generating energetic mixture is located; and

a second film for sealing said low-gas generating energetic mixture between said first and second films.

2. The energetic device of claim **1**, wherein said first and second films are hermetically sealed.

3. The energetic device of claim **1**, wherein said low-gas generating energetic mixture is a thermite.

4. The energetic device of claim **1**, wherein said low-gas generating energetic mixture is an intermetallic.

5. The energetic device of claim **1**, wherein said low-gas generating energetic mixture is approximately 0.01" thick or less.

6. The energetic device of claim **1**, wherein said first and second films are made of polyethylene terephthalate (PET) films.

7. The energetic device of claim **1**, wherein said first and second films are made of polymer films.

8. The energetic device of claim **1**, wherein said first and second films are made of plastic films.

9. The energetic device of claim **1**, wherein said first and second films are made of metal foils.

10. An energetic device comprising:

a low-gas generating energetic mixture;

a core on which said low-gas generating energetic mixture is located; and

a protective film for sealing said low-gas generating energetic mixture between said core and protective film.

11. The energetic device of claim **10**, wherein said core and protective film are hermetically sealed.

12. The energetic device of claim **10**, wherein said low-gas generating energetic mixture is a thermite.

13. The energetic device of claim **10**, wherein said low-gas generating energetic mixture is an intermetallic.

14. The energetic device of claim **10**, wherein said low-gas generating energetic mixture is approximately 0.01" thick or less.

15. The energetic device of claim **10**, wherein said core is cylindrical.

16. The energetic device of claim **10**, wherein said core is tubular.

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