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UNUSUAL STRUCTURAL MATERIAL

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ABSTRACT OF THE DISCLOSURE

This invention relates to a structural ablative material comprising an ablative material resistant to a nuclear detonation environment comprising a fibrous mat comprising about 45 to 55 weight percent asbestos fiber and about 5 to 10 weight percent polyolefin fiber, impregnated with a homogeneous mixture comprising about 30 to 40 weight percent nuclear radiation resistant thermosetting resin and about 13 to 18 weight percent magnesium oxide powder.

This invention relates to thermal and nuclear radiation resistant structural ablative materials and more specifically to materials that will withstand an extremely severe nuclear detonation environment and still be functional for high-frequency microwave applications.

The efficiency of prior art structural ablator materials varies with the thermal flux rate that the material is subjected to. For example, comparing weight losses of rigid structural ablators at various levels of thermal flux rates: silicone glass is more efficient than other rigid systems at 40 B.t.u./sec./sq. ft.; asbestos-phenolic is more efficient than other rigid systems at 430 B.t.u./sec./sq. ft.; nylon (hydrogenous)-phenolic is more efficient than other rigid systems in excess of 430 B.t.u./sec./sq. ft.; magnesium oxide, because of its reflectance approaching unity and its emittance approaching zero at extreme thermal flux rates is more efficient than other rigid systems at extreme thermal flux rates in excess of 800 B.t.u./sec./sq. ft. There is no known state of the art ablator that combines efficient stabilizing ingredients at all levels of thermal flux rates in one system.

The structural ablator materials of this invention can be used to protect offensive and defensive missiles. They are ablator materials that will increase a missile's radar transparency, withstand and dissipate high impact energy, function as efficient ablators at various thermal flux levels and retain functional electrical properties for high frequency microwave transmission even after being exposed to a simulated nuclear detonation.

The efficiency of dielectric insulators used in circuit breaker panels and various high frequency electrical condensers is limited by the amount of heat and by the frequency range that the insulator can withstand; beyond a certain point it becomes ineffective. For example, condenser difficulties have been encountered in "short wave" and "beam" transmission due to excessive energy losses in the dielectric portions which form the terminal insulators of the condenser. Paper has been used as the dielectric in many types of condensers because it is effective and economical; however, when paper condensers are subjected to high temperatures and/or high frequencies, the electrical losses encountered make their use impractical and more expensive devices such as valve oscillators with mica dielectric condensers immersed in oil must be used.

I have discovered that the compositions of this invention in addition to their desirable structural ablative properties, are also economical, highly efficient dielectric insulators. For example, paper based phenolic panels used

in present day circuit breaker panels cannot be used for electrical applications after exposure for 10 hours at 500° F. whereas the material of this invention would still be serviceable. Traditionally, asbestos fibers have been utilized because of their thermal insulative characteristics and strength, and not because of their dielectric characteristics. An important facet of this invention is based upon the fact that I have achieved a method of satisfactorily treating asbestos fibers so as to enable their effective use in instances where their dielectric characteristics are important.

Thus it is an object of this invention to produce an improved structural ablator material having the properties outlined above.

Another important object of this invention is to produce an improved dielectric material that has a low loss tangent, a low loss factor, excellent insulating properties, ability to perform high frequency applications after being exposed to high temperatures and relatively low cost.

Another important object of this invention is to produce a structural ablator material that is an efficient insulator in a wide thermal flux range.

Other objects and advantages will become apparent as the nature of the invention is more fully disclosed.

I have discovered that by impregnating a fibrous mat of asbestos and polyolefin fibers with a thermosetting nuclear radiation resistant resin mixture such as a phenolic, a silicone or an epoxy resin and magnesium oxide powder, a structurally strong ablative material is formed that maintains desirable structural, electrical, thermal insulating, ablative and radiation resistant properties within an extremely severe nuclear detonation environment which included thermal flux rates in the order of 10^3 B.t.u./ft.^{2}-sec., nuclear radiation flux rates in the order of 10^{19} neutrons per cm.^{2}-sec., and mechanical forces of 2,000 p.s.i.

I have also discovered that by driving off the atmospheric moisture contained in the pores of the asbestos fibers the dielectric constant and loss tangent of the resin impregnated asbestos were greatly reduced. Reduction in the loss tangent is a desirable property because asbestos was known to be a high loss material that dissipates electrical energy. Decreasing the loss tangent increased the ability of radar waves to see through and to pass through the material with a minimum amount of energy loss. Reduction of the dielectric constant of the dried asbestos-resin impregnated material is an added benefit since it also makes the material of this invention an excellent high temperature, low cost condenser dielectric material that can be used in high temperature and high frequency environments.

The structural ablative product of this invention is basically a fibrous mat composed of long asbestos fibers and polyolefin fibers that have been impregnated, or molded, with a homogeneous mixture of a nuclear resistant thermosetting resin and magnesium oxide powder. The structural material of this invention contains three ablative materials each of which is highly efficient at a different thermal flux level. That is the polyolefin, the nuclear resistant thermosetting resin, and the magnesium oxide are efficient ablative materials at different thermal flux rates, and all four ingredients are good insulators.

The asbestos gives the material of this invention its structural strength. Asbestos is a structurally strong insulator that has the unique characteristic of being able to withstand sudden thermal and mechanical shocks better than any known glass or mineral fiber. For example, glass fibers will spall and shatter in a high impulse energy environment. The asbestos fibers should be long since longer fibers produce a stronger product that is better suited for structural applications. The structural strength, insulating and electrical properties of the product are unusually good even without drying the asbestos

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fibers; however, drying the asbestos produced a superior product.

The asbestos fibers may be dried by using any known drying process; for example, it may be dried in an oven, heat lamp battery, etc., prior to impregnating the fiber with the homogeneous resin mixture. Removing the atmospheric moisture stabilized the electrical properties of the final product, and produced a better, closer bond between the asbestos and the thermosetting resin mixture. The drying step should be carefully controlled so that the molecular bound water in the asbestos molecule is not removed; only the atmospheric moisture should be removed from the pores of the asbestos fibers. Retention of the molecular bound water in the molecules of the fiber asbestos is desirable because this water takes part in the ablative cooling mechanism, functioning as a coolant and its removal weakens the strength of the fiber.

Polyolefin fibers are combined with the asbestos fibers because they are excellent heat ablators that increase the volume of the gas produced during ablation, increase the specific heat capacity of the system and improve the electrical properties of the system by minimizing electrical losses. The polyolefin aids in dissipating heat at the surface, and the gas barrier layer that it forms increases the system's insulating properties.

The preferred polyolefin fibers used in this invention are polyethylene or polypropylene, but any fiber having approximately the same carbon to hydrogen ratio and similar desirable electrical properties may be used. Copolymers and heteropolymer of the olefins may also be used.

When polyolefins derived from ethylene or propylene are subjected to radiation, the polymer chains cross-link to further stabilize the structural strength of the material. This is a desirable and unusual characteristic of this type of polyolefin.

Magnesium oxide powder is used in this invention mainly because of its high reflectance-low emittance properties during periods of extreme thermal flux rates. Magnesium oxide also performs an ablative stabilizing function since it helps to form a viscous liquid as the material melts during ablation; this aids in retaining the carbonaceous char and/or ablation products formed by the resin to the substrate, and it further enhances the electrical properties of the system by minimizing electrical losses.

The term nuclear radiation resistant thermosetting resin refers to a resin that will further cross-link in the presence of nuclear radiation. The resin used herein is phenyl-silane, but a great many thermosetting resins are known to have this property. For example, phenolic resins, silicone resins, epoxy resins, etc., may be used. The thermosetting resin is used as a binding matrix to increase the ablative content, to reduce the specific heat of the system and to uniformly disperse the magnesium oxide powder. The thermosetting resin ablates to form a protective carbonaceous char and a gas barrier layer during the ablative process.

The proportions of the ingredients used in the materials of this invention may be varied according to the conditions the material will encounter in actual use. The preferred proportions of the ingredients are:

	Weight percent
Asbestos fibers	45–55
Thermosetting resin	30–40
Magnesium oxide powder	13–18
Polyolefin fibers	5–10

The percentage of asbestos used will be determined by the strength level required for a specific function. Increasing the percentage of asbestos increases the strength of the material, but it also decreases the percentage of thermosetting ablative material. The proper balance between the amount of asbestos and the amount of thermosetting material will be determined by the

amount of ablative cooling the material of this invention will have to supply and the mechanical load it must withstand. The use of less than 30% thermosetting resin would produce an ablative starved material in a nuclear detonation area that would not adequately cool the material. The material must contain enough magnesium oxide to provide continuous surface reflection protection and as the surface layers ablate the newly exposed surfaces must also contain adequate amounts of magnesium oxide to provide continuous reflection protection; this amount of magnesium oxide would be the minimum amount used. When more than 18 weight percent of magnesium oxide powder is mixed into the system it begins to settle out, since a homogeneous balance between the thermosetting and the magnesium oxide is required to obtain uniform thermal flux properties throughout the material, the use of excess amounts of magnesium oxide is undesirable.

If the ablative material of this invention does not contain all four of the preferred ingredients the relative proportions that function best are:

(a)

	Weight percent
Asbestos fiber	45–60
Thermosetting resin	30–50
Polyolefin fiber	5–20

(b)

Asbestos fiber	45–60
Thermosetting resin	30–50
Magnesium oxide powder	10–23

If the material of this invention is to be used as a dielectric material in a non-ablative environment the proportions that function best are:

(a)

	Weight percent
Dried asbestos fiber	35–70
Thermosetting resin	30–65

(b)

Dried asbestos fiber	35–70
Thermosetting resin	30–65
Magnesium oxide powder	10–23

(c)

Dried asbestos fiber	35–70
Thermosetting resin	30–65
Magnesium oxide powder	10–23
Polyolefin fiber	5–20

The actual proportions of the various ingredients to be used in formulating the dielectric material would be determined by how much of an electrical loss can be tolerated in a given environment.

To produce the structural ablative material of this invention a fibrous mat is evolved by combing or carding uniformly mixed dried asbestos fibers and polyolefin fibers. A small amount of binder material may be used to hold the mat fibers in place. Alternatively the asbestos may be dried before it is combined with the polyolefin fiber or after the mat is formed. A liquid thermosetting resin (phenyl silane) and magnesium oxide powder are homogeneously mixed in an agitated tank and passed on to a dip tank. The mat is passed into the dip tank and uniformly impregnated with the homogeneous resin system. After the resin impregnated mat leaves the dip tank it is carried through a drying oven where it is partially cured to an intermediate unset stage. As the partially cured mat emerges from the oven it is wound around a windup roll and set aside. This rolled sheet material may be further processed at a later date if desired.

The partially cured sheet material can be used as a single ply or as a multi-ply material to make parts having various configurations and strengths by pressing the material to shape using heat and pressure. The rolled sheet material may have any desired thickness, for example 10 mils thick, but after being cut into uniform lengths it is

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handled in "bundles" by weight. From these bundles parts may be produced that have thicknesses of one ply to several dozen layers. The resin system when subjected to heat and pressure is further polymerized to form a rigid product.

Tests conducted on various resin systems show that the addition of the polyolefin fiber and magnesium oxide powder reduce the dielectric constant and the loss tangent of the system. For example the dielectric constant and loss tangent of an asbestos based phenyl silane measured at frequencies of 10^9 to 10^{10} cps. is 5.11 and 0.42 respectively. When polypropylene fiber and magnesium oxide powder was added to the system in the manner outlined above and the same quantities measured at the same cycle frequencies (without drying the asbestos), these measurements were reduced to 4.75 and 0.09 respectively. When the asbestos fibers in the first composition were dried before resin impregnation and then measured at the same cycle frequencies, these measurements were reduced to 3.92 and 0.049 respectively. It is evident that the loss tangent of phenyl silane-asbestos is approximately 500% higher than that of the phenyl silane-asbestos-polypropylene-magnesium oxide composition and almost 1000% higher than that of the phenyl silane-dried asbestos composition. Both steps individually produced significant and dramatic improvements and by combining both steps, that is by drying the asbestos and adding polypropylene and magnesium oxide an even more dramatic reduction in the dielectric constant and loss tangent is obtained.

Ablative tests comparing the ablative properties of phenyl silane-dried asbestos and phenyl silane-asbestos-polypropylene-magnesium oxide illustrate that the latter had a longer ablative life. For example, both materials were subjected to the same simulated nuclear detonation environment with the following result.

	Phenyl silane asbestos (in.)	Phenyl silane asbestos-polypropylene-MgO (in.)
Material destroyed	0.25	0.10
Char thickness	0.05	0.05

This indicates that the addition of polypropylene and magnesium oxide powder more than doubled the life of the ablator material. This is another significant improvement of this invention.

The structural strength of the polypropylene-magnesium oxide containing ablator material after being subjected to the simulated nuclear radiation environment was approximately 29,000 p.s.i. This material can be structurally used as an efficient insulator in many varying missile environments such as launching, reentry, general flight and nuclear detonation environments. The structural and electrical properties of this material are even better when the atmospheric moisture is removed from the asbestos before resin impregnation.

After reading the foregoing detailed description, it is apparent that many variations may be made in the illustrative details of this invention without departing from the spirit of the invention or the scope thereof as defined in the appended claims.

What I claim is:

1. An ablative material resistant to a nuclear detonation environment comprising a fibrous mat comprising about 45 to 55 weight percent asbestos fiber and about 5 to 10 weight percent polyolefin fiber, impregnated with a homogeneous mixture comprising about 30 to 40 weight percent nuclear radiation resistant thermosetting resin and about 13 to 18 weight percent magnesium oxide powder.

2. A method of providing improved protection against a nuclear detonation environment comprising providing a covering consisting of the ablative material of claim 1.

3. The ablative material of claim 1, wherein said asbestos fiber is an asbestos fiber that contains no atmospheric moisture.

4. The ablative material of claim 1, wherein said thermosetting resin is a phenyl silane resin.

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