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**REINFORCED METALLIC COMPOSITES**

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 No Drawing. Original application Oct. 21, 1960, Ser. No. 64,226, now Patent No. 3,138,837, dated June 30, 1964. Divided and this application Jan. 23, 1964, Ser. No. 339,821

1 Claim. (Cl. 29—198)

(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purpose without the payment of any royalties thereon or therefor.

This application is a division of copending application Serial No. 64,226, which was filed October 21, 1960, now Patent 3,138,837, issued June 30, 1964.

This invention concerns fiber reinforced metal composites.

Prior art in the field of metal reinforced metallic composites has been work in which titanium and its alloys are reinforced with molybdenum wire and a composite made using powder metallurgy technique and severe mechanical working. The major disadvantage of this is the necessity of mechanically working the composite in order to achieve the desired tensile strength, low degree of porosity, and fiber orientation. An additional disadvantage is the necessity for extensive machining in order to produce a finished shape.

A further disadvantage of this prior art is the necessity for using unusually large powder presses or rolls when large pieces of material are required.

Still another disadvantage of the prior art is that the final properties of the composite are determined by the amount of working given the composite and the temperature at which this is done. Thus, it is almost impossible to predict what the properties of the material will be until it has been tested.

A still further disadvantage of this prior art is that because of the mechanical working, the product is restricted to one which has fibers with a high degree of preferred orientation. Furthermore, the working processes tend to orient the fibers in one principal direction and as such the composite must be highly anisotropic.

An object of this invention is to provide a high strength and high strength-density ratio material for application at both normal room temperatures and at elevated temperatures.

Another object of this invention is to provide high strength and high strength-density ratio, high ductility, and low notch sensitivity materials for application at cryogenic temperatures.

A further object of the invention is to provide a material having a high modulus of elasticity and modulus-to-density ratio over a wide range of temperatures.

Still further object of the invention is to provide a fiber reinforced metallic composite wherein no working of the composite is necessary to utilize the strength or properties desired in the fiber.

Still another object of the invention is to provide a fiber reinforced metallic composite which maintains the original shape, size, and orientation of the fibers.

Still another object of the invention is to provide fiber reinforced metallic composites which may utilize brittle fibers since no working of the fiber is involved in the fabrication of the composite.

The present invention consists of composite material

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composed of many high strength fibers such as tungsten fibers at 11 to 87 percent by volume surrounded by and dispersed in a lower strength but more ductile matrix or binder such as copper. The fibers have a diameter of less than 0.010 inch and a length equal to the full length of the specimen. Within the composite, fibers are oriented parallel to each other and parallel to the long dimension of the specimen and extend the full length of the specimen or the length of the stressed portion of the product.

The composite material is prepared by packing the fibers in close proximity to each other so that their longitudinal axes are parallel to each other. The fibers are held in this position either by wrapping a helix of wire around the bundle or by forcing the bundle into a ceramic tube which holds them in position during subsequent operations. The specimens are then heated under a protective atmosphere. In the case of the specimens containing large volume percents of fiber, the end of the bundle is immersed in a molten pool of the material to be used as matrix. The fine spaces between the wires serve as capillary tubes through which the molten matrix material flows. The composites are then cooled and the helix unwrapped or the constraining tube removed. The important feature involved in this operation is that the composites are not produced, using conventional casting techniques, but rather by using infiltration. In cases where specimens contain low fiber content or in cases where one arbitrarily chooses to do so, infiltration between fibers may be accomplished by using top-feed infiltration techniques.

The invention will be better understood from the following detailed example:

Cut lengths of tungsten wire were cleaned with sodium peroxide and ammonium hydroxide and loaded into an aluminum tube. This tube was then placed in a closed end quartz tube having a slug of copper infiltrant in the bottom. The entire assembly was heated to 2200° F. and held for one hour at this temperature. During infiltration the spaces between the wires of the tightly-packed bundles serve as capillary tubes through which the molten copper could flow. The specimens were kept under a vacuum during infiltration to prevent oxidation of the tungsten and thereby provide a clean wire surface. This was essential since it is found that any surface film on the wire greatly reduces the chances of producing a successful infiltration. However, hydrogen or inert atmospheres could be used rather than a vacuum.

Some variation in the above procedure is found to be necessary when specimens of low fiber content are made. Because of the larger openings between wires, capillary rise cannot take place and it becomes necessary to top feed the specimens by placing the infiltrating material in the tube above the wires and allowing gravity flow to take place. The specimens so produced range from 40 mils to 1/8 inch in diameter and from 3 to 6 inches in length. The fibers used in the examples were of 3 mil, 5 mil, and 7 mil diameters. It is found that the strength of the composites increase with decreasing wire diameters. This is expected because the finer wires had a higher initial tensile strength. Within the range of the compositions tested it is determined that the strength of the composite is directly proportional to the amount of reinforcements present.

It is to be understood that tungsten fibers in a copper matrix have been shown only by way of specific example. This invention embraces the combination of any high strength fiber in a more ductile matrix to produce a composite having the desirable properties of each. Additionally, it is to be understood that the use of capillary rise or infiltration from the top to introduce the binder or matrix material between the filaments of a high strength

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fiber can be applied to various combinations of materials for both the high strength fiber and the ductile matrix.

Obviously, many modifications and variations of the present invention are possible in the light of the above teachings. It is, therefore, to be understood that within the scope of the appended claims the invention may be practiced other than as specifically described.

What is claimed is:

A reinforced metallic composite comprising a plurality of cleaned tungsten fibers in contiguous relationship and oriented with their longitudinal axes substantially parallel to the longitudinal axis of the composite, each of said fibers having a diameter less than 0.010 inch and a length equal to the full length of the composite, and a copper matrix for maintaining the orientation of the fibers, the

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fiber content of the composite being 11 to 87 percent by volume.

#### References Cited by the Examiner

##### UNITED STATES PATENTS

5	867,659	10/07	Hoopes	29—191.6
	967,145	8/10	Simpson	29—191.6 X
	1,125,161	1/15	Page	29—191.6 X
	2,305,555	12/42	Peters	29—191.6 X
10	2,605,201	7/52	Howe	29—191.6 X
	3,084,421	4/63	McDaniel et al.	29—194
	3,098,723	7/63	Micks	29—191.6 X

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