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COMPOSITE FILAMENT

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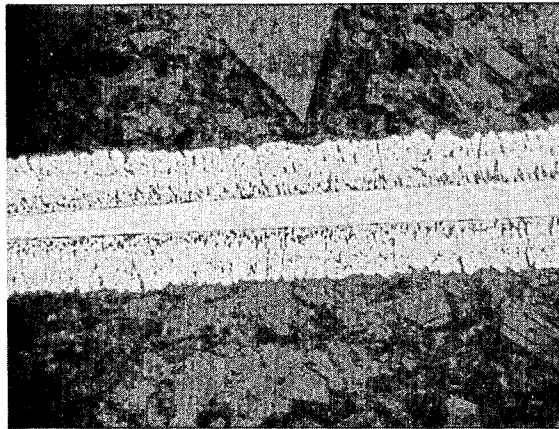


Fig. 1

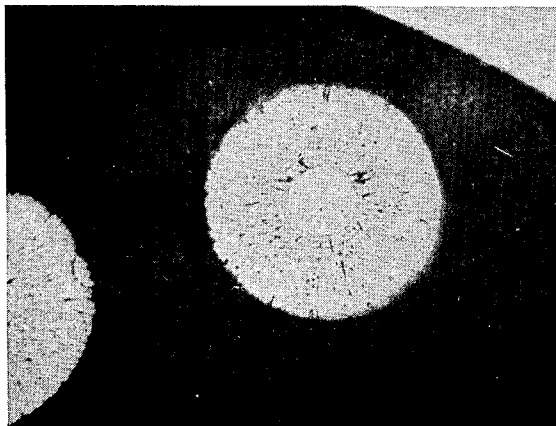


Fig. 2

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COMPOSITE FILAMENT

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1 Claim

ABSTRACT OF THE DISCLOSURE

A process for the continuous formation of composite filaments utilizing a continuous filament substrate and a metal capable of being deposited from the vapor state, wherein said filament is passed through a confined source of metal vapor, the deposit being built up in layers through succeeding passes, whereby composite filaments are produced, the process being carried out under vacuum.

SUMMARY OF THE INVENTION

This invention relates to a composite filament consisting of a core and outer layer(s).

More particularly, the invention relates to a composite filament or article in the form of a core of metal or other substrate and an outer coating of a second metal.

It is, therefore, an object of this invention to provide a composite filament.

Other objects and advantages will become apparent from the following detailed description of a preferred embodiment of the invention which is intended only to illustrate and disclose, but in no way to limit, the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Accordingly, the invention provides a process for producing composite filaments consisting of a filament substrate and a metal capable of being deposited from the vapor state, comprising alternately passing said filament substrate through a confined source of metal vapor at a temperature and speed predetermined to deposit said metal from the vapor state onto said substrate and through a cooling zone, whereby said deposit is formed in layers through succeeding alternate passes, the entire process being carried out under vacuum.

Preferably, the filament substrate is selected from the group consisting of tungsten, stainless steel, or a nickel-base alloy; however, other substrate filaments such as metals, ceramics, various glasses, and carbon may be used provided they will not deteriorate or melt under the conditions of metal vapor deposition and are capable of retaining a deposit of metal vapor on their peripheral surfaces.

The outer coating may be any desired metallic substance which has sufficient vapor pressure at some point below its melting point to provide a reasonable rate of deposition, but beryllium is preferred. A vapor pressure on the order of 0.01 mm. is generally regarded as adequate for most deposition procedures.

It is essential that the process be conducted under a high vacuum to prevent formation of metal oxides by reaction of the vapor source metal with oxygen and to facilitate migration of the metal vapor ions to the filament substrate. The vacuum is, therefore, preferably maintained at about 2×10^{-8} mm. Hg.

The temperature of the vapor source metal may be varied within wide limits depending upon the vapor pres-

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sure and melting point of said metal. The minimum temperature would be that at which the vapor pressure of the source metal is about 0.001 mm., while the maximum would be just below its melting point. Other factors, such as rate of travel of the filament substrate and rate of deposition desired, must be taken into account. When beryllium is the vapor source metal, the temperature may range from about 1140° C. to about 1230° C. and preferably is maintained at about 1230° C.

The speed of travel of the substrate filament must be maintained within a range which prevents heating thereof by radiation from the surrounding atmosphere sufficient to cause melting, deterioration, or other undesirable effects of the substrate, and slow enough so that the desired deposition takes place during the travel through the vapor source chamber. The rate of travel of the substrate, when beryllium is the vapor source, may vary from about 50 feet to about 300 feet per minute, depending on the other variables.

This process provides an improved article of manufacture which comprises a composite filament of from about 0.0005" to about 0.010" in diameter. Preferably, the composite filament consists of a substrate core of one material selected from the group consisting of tungsten, stainless steel and a nickel-base alloy (Chromel A), and which is completely covered by an outer coating of beryllium; although, as above mentioned, other substrate filaments and metal outer coatings may be employed.

The preferred process of producing a composite beryllium filament comprises alternately passing a rapidly moving filament substrate through a hollow beryllium cylinder heated to a temperature just below 1285° C. and then through a cooling zone. The process is performed in a vacuum of approximately 2×10^{-5} mm. Hg with the filament being driven into the hot metal vapor source and then through a cooling zone by means of a variable-speed drive pulley or any other suitable means.

The substrate is passed through the beryllium cylinder at such a rate that the filament is not heated appreciably through radiation and at a rate which allows reasonable deposition of beryllium onto the substrate. The larger the filament the slower can be the rate of travel, or, conversely, the longer can be the hot zone of the beryllium vapor source. Varying the length of the hot zone as the deposit builds up, rather than the rate of travel, enables one to use a continuous pass through multiple zones to produce a final filament of desired proportions. Rates of travel are preferably maintained between about 50 to about 180 ft./min.

Referring to the drawing:

FIGS. 1 and 2 show photomicrographs of polished cross sections of typical composite filaments produced by this technique prior to any further heat treatment.

Reference to the following Table I shows the results of employing various lengths and various inside diameters of the beryllium cylinder, at varying temperatures and times. As shown in Table I, cylinders consisting of both hot pressed (H.P.) and cast beryllium susceptors (heating units) may be used as the heating unit. At a particular temperature, the deposition rate is roughly proportional to the evaporating surface area of the beryllium cylinder for a given filament diameter and increases with increasing filament diameter, but not nearly in proportion to the increased filament surface area. The rate limiting factor is primarily the availability of beryllium vapor. Comparison of Examples 9 and 11 shows the final filament diameters to be roughly the same regardless of the use of cast beryllium or hot-pressed beryllium.

TABLE I.—SUMMARY OF VAPOR DEPOSITION RUNS

Ex.	Be source (I.D. × L in inches)	Run conditions		Substrate (diameter in inches)	Be de- posited μg/in. of filament length	Final filament diameter (inches)
		(Min.)	(Temp. ° C.)			
1.....	H.P., 3/4 × 1.....	30	1,200	(0.0005) W.....	2.6	0.0006
2.....	H.P., 3/4 × 1.....	75	1,200	(0.0005) W.....	17.9	0.0010
3.....	H.P., 3/4 × 1 1/4.....	10	1,200	(0.0005) W.....	5.7	0.0007
4.....	H.P., 3/4 × 1 1/4.....	15	1,200	(0.0005) W.....	9.3	0.0008
5.....	H.P., 3/4 × 1 1/4.....	20	1,200	(0.0005) W.....	17.9	0.0010
6.....	H.P., 3/4 × 2 1/4.....	10	1,200	(0.0005) W.....	22.9	0.0011
7.....	H.P., 3/4 × 2 1/4.....	50	1,200	(0.0005) W.....	89.2	0.0020
8.....	H.P., 3/4 × 2 1/4.....	20	1,230	(0.0005) W.....	71.1	0.0018
9.....	H.P., 3/4 × 2 1/2.....	10	1,200	(0.0005) W.....	285.6	0.0035
10.....	Cast, 3/4 × 2 1/2.....	61	1,230	(0.0005) W.....	89.2	0.0020
		10	1,195			
		15	1,230			
11.....	Cast, 3/4 × 2 1/2.....	20	1,140	(0.0005) W.....	223.0	0.0031
		10	1,170			
		29	1,230			
12.....	Cast, 3/4 × 2 1/2.....	10	1,170	(0.0005) W.....	89.2	0.0020
		18	1,200			
		10	1,190			
13.....	H.P., 1 1/4 × 1 1/2.....	6	1,190-1,230	(0.0005) W.....	109.0	0.0022
		30	1,230			
		10	1,170			
14.....	H.P., 1 1/4 × 1 1/2.....	8	1,200	(0.0005) Chro- mel A.	13.3	0.0009
		16	1,200			
		13	1,230			
15.....	H.P., 1 1/4 × 2 1/2.....	46	1,210	(0.0005) W.....	208.0	0.0030
16.....	H.P., 1 1/4 × 2 1/2.....	20	1,200	(0.001) Stainless.....	53.2	0.0018
17.....	H.P., 1 1/4 × 1 1/2.....	98	1,200	do.....	284.7	0.0036

NOTE.—The designation H.P. in the beryllium source column above denotes "hot-pressed."

Examples 7 and 8 show the effect of temperature. The rate of deposition is shown as not being in direct proportion to the susceptor length by comparing Examples 2, 5, 6 and 7. This variation results from some loss of radiating surface at the top due to the inside fit of the beryllium oxide cover and a sizeable loss at the bottom of the susceptor due to the heat sink effect of the BeO support. Increasing the inside diameter of the beryllium vapor source by 50% resulted in approximately the same deposition rate in Example 16 at 1210° C. as was obtained in Example 9 at 1230° C.

The results of mechanical tests made on some of the composite filaments produced are shown in Table II. By varying deposition rates or through various subsequent heat treatments which could change the structure of the deposited metal, strengths greater than those shown could be obtained.

It will thus be seen from the above description and tables that composite filaments of from about 0.0005" to 0.010" in diameter may be economically produced by this method.

TABLE II.—SUMMARY OF FILAMENT MECHANICAL TESTS—BERYLLIUM ON VARIOUS SUBSTRATES

Example	Filament substrate	Composite filament (diameter, inches)	Tensile strength (p.s.i.)
1.....	(0.0005) Tungsten.....	0.0006	319,000
2.....	do.....	0.0007	258,000
3.....	do.....	0.0010	123,500
4.....	do.....	0.0018	38,100
5.....	do.....	0.0020	31,500
6.....	do.....	0.0030	13,900
7.....	do.....	0.0035	15,300
8.....	(0.001) Stainless.....	0.0036	12,700
9.....	do.....	0.0038	11,700
10.....	(0.0005) Chromel A.....	0.0009	16,800

An advantage of this process over conventional vapor plating techniques is that deposition rates several orders of magnitude higher may be obtained.

The composite filaments of the invention are useful in many applications where materials of light weight, high tensile strength and high modulus of elasticity are required. Such filaments, consisting of a filament substrate selected from the group consisting of tungsten, stainless steel, Chromel A, glass, quartz and graphite, and having an outer coating of beryllium, are especially useful in component parts of vehicles designed for travel in outer space.

Having thus described my invention, I claim:

1. An article of manufacture comprising a composite metal filament of from .0005" to .010" in diameter and consisting essentially of a substrate core of at least one metal selected from the group consisting of stainless steel and a nickel base alloy consisting of 20% chromium, balance nickel, completely covered by an outer coating of beryllium.

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