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High Voltage Electrical Insulation Coating for Refractory Materials

A formula and process have been developed for coating refractory metal surfaces with a high voltage electrical insulation for use at temperatures to 600°C. Coatings previously available are of two types: glass, and flame-sprayed polycrystalline ceramic. Glass coatings are better for use at low temperatures, since they are limited by softening point and viscosity. Flame-sprayed ceramic coatings withstand higher temperatures but have low dielectric strength, poor adherence and porosity. The new coatings give excellent high voltage protection, because impervious coatings can be applied up to 0.102 cm in thickness, which is not generally attainable with other processes. Adherence to the metals is comparable to that for glass coatings. The temperatures at which new coatings may be used are equivalent to those of the flame-sprayed type. The new coatings will not break down in vacuum at less than 3000 V compared to less than 1000 V for the conventional thinner glass coatings.

The new coatings were specifically developed as a high voltage insulation for the surface of a perforated, molybdenum, ion-accelerator grid, but are not limited to this application. Advantages of the new coatings are: (1) it is possible to apply thick, adherent and impervious coatings, (2) electrical insulation in vacuum can be achieved up to 3 kV or higher, (3) the coatings will protect the surface and remain intact at temperatures up to 600°C in air, inert atmosphere or vacuum, (4) good coverage of a perforated surface is achieved, especially around sharp corners and down into holes, (5) a voltage puncture is repairable with filler and sealer glasses, (6) distortion of a thin molybdenum sheet by the thick coating can be held to a minimum with proper firing jigs, and (7) other low expansion refractory metals such as tungsten and tantalum may also be protected by these coatings.

The coating system consists of three components: (1) refractory dielectric subcoat, (2) low viscosity glass filler, and (3) high resistivity glass sealer coat.

A generalized formula for a refractory dielectric subcoat is as follows:

	Percent
100-200 mesh pre-fired refractory dielectric powder, thermal expansion coefficient, 2 to 4.5 x 10^{-6}/°C	70 to 95
High resistivity glass (fusion temperature 850 to 1050°C, thermal expansion similar to the substrate metal)	30 to 5

An example of a specific formula for basic high resistivity glass frit is as follows:

	Percent
Magnesium	9.7
Calcite	4.8
Alumina	10.6
Boric Acid	41.0
Silica	33.9

All materials are prepared to less than 200-mesh, dry blended and melted at 1400°C for 4 hours, then poured into water to quench and shatter. The shattered glass is crushed to pass an 8-mesh screen. The crushed glass is used in the following formula.

	Percent
200-mesh mullite powder	80
8-mesh basic glass frit	16
Enamel clay	4
	100
Water	95
Sodium nitrite	0.05

(continued overleaf)

This mixture is ball milled for four hours in a porcelain mill with Alundum stones and the milled slip passed through a 100-mesh screen.

The metal surface is prepared by any of the following methods: degreasing, sandblasting, liquid honing, electropolishing or oxidation. The wet coating is applied with a spray gun, 0.102 to 0.203 mm thick per coat. A thickness of at least 0.38 mm is built up by drying and fusing between coats. If thicker subcoats are required, each application is thoroughly dried and fused. Fusion is accomplished at 1100°C for 30 minutes in argon at a pressure of at least one inch of water above atmospheric pressure. Argon flow should be sufficient to carry away volatile products during heating. Heat required for bonding coating to metal is supplied by an inductively heated graphite susceptor.

Next, the low viscosity glass filler coat is applied. Required properties of filler glasses are low viscosity at melt temperature, thermal expansion close to mullite and high electrical resistivity. The formula for this coat consists of the following:

silica (20 g)
magnesia (13 g)
alumina (10 g)
boric acid (80 g)
calcite (15 g)

The formula is dry blended, melted at 1350°C quenched in water and dried. The resulting frit is ground with 3 to 6 percent enamel clay and sufficient water to produce a sprayable slip. A 0.051 to 0.152 mm thick coating of this slip is applied over the previously fired refractory subcoat. The refractory subcoat is saturated with the filler coat(s) by heating to 1000 to 1050°C in argon atmosphere.

Next, the glass sealer coat is applied. The glass sealer coat is composed of either of the following: (1) the previously described filler coat fired at least 100°C lower than when used for a filler, or (2) basic high resistivity glass frit (96 percent), enamel clay (4 percent) and water to produce a sprayable slip. This mixture is ball milled four hours and sprayed over the subcoat and filler. This coating is fired to 900 to 950°C for 30 minutes in argon.

Notes:

1. The following documentation may be obtained from:
   National Technical Information Service
   Springfield, Virginia 22151
   Single document price $3.00
   (or microfiche $0.95)

   Reference: NASA CR-72677 (N70-28290), Low Specific Impulse Ion Engine
2. Technical questions may be directed to:
   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B72-10290

Patent status:

No patent action is contemplated by NASA.

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