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WORKABLE DUPLEX STRUCTURED RUTHENIUM ALLOYS

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ABSTRACT OF THE DISCLOSURE

A cold-workable ruthenium alloy capable of being cold drawn to wire containing, by weight, about 60% to about 90% ruthenium, about 5% to about 40% copper, up to about 35% palladium and up to about 10% nickel is produced by liquid-phase sintering, preferably by infiltration of copper or copper alloy into a ruthenium compact, at temperatures between 1083° C. and 1500° C.

In U.S. Patent No. 3,278,280, alloys composed of grains of ruthenium dispersed in a gold-palladium matrix and containing by weight from 5% to 35% gold and 5% to 35% palladium, the balance except for impurities being ruthenium and amounting to at least 60%, are described.

Such an alloy has the essential advantageous properties of pure ruthenium but can be worked. At the surface of the alloy, the more wear-resistant ruthenium grains stand out presenting, in effect, a substantially pure ruthenium surface. Deeper within the mass of the alloy the ruthenium grains are surrounded by and metallurgically bonded to the matrix metal. By virtue of composition, the matrix metal and the ruthenium co-operate to produce a workable alloy of substantial hardness and strength and appreciable ductility. Although these previous alloys are workable, they cannot readily be drawn into wire.

We have now found that if the matrix of palladium and gold is replaced by a matrix of copper or an alloy of copper with nickel or palladium or both, the workability is improved such that the alloy can be readily drawn to wire.

Thus, according to the invention an alloy composed of grains of ruthenium dispersed in a matrix contains by weight from 5% to 40% copper, from 0 to 35% palladium and 0 to 10% nickel, the balance except for impurities being ruthenium and amounting to at least 60%. The impurities normally will not exceed 0.5%.

The alloys according to the invention are made by powder-metallurgical methods which involve heating a powder compact to a sintering temperature at which the matrix melts but the ruthenium does not. This compact may initially consist of all the elements, or only of the ruthenium, the compact then being infiltrated with molten matrix at the sintering temperature, which may be from 1083° C. (the melting point of copper) to 1500° C. It is advantageous to subject a ruthenium compact to light sintering under vacuum before the infiltration.

During the sintering, ruthenium enters the matrix, which indeed is believed to become substantially saturated in ruthenium, and the ruthenium grains, which are advantageously from 0.002 inch to 0.0002 inch in diameter, become metallurgically bonded to the matrix. It is found that in the process the grains of ruthenium tend to grow, and also to become rounded. Workability of the alloy depends to some extent upon this phenomenon, increasing as the spheroidicity of the ruthenium particles increases. Sagging or distortion occurs during sintering if the ruthenium content is below 60% and the ductility of the alloy is low if the ruthenium is above 90%, the ruthenium content preferably not exceeding 80%. If the matrix amounts to less than 5% of the alloy, workability is lost.

In the preferred alloys, the matrix is binary, the alloy containing from 20% to 25% copper and either 1% to 5% nickel or 9% to 13% palladium.

The composition of some alloys within the invention will now be given, the balance in each case being ruthenium. All the alloys were made by infiltration of a molten matrix into a ruthenium compact for two hours. The ruthenium powder had a particle size of about 4μ (microns). The temperature of infiltration is given in each case, together with the extent to which the alloy could be reduced by cold forging without intermediate anneals before edge cracks developed and the hardnesses of the primary phase (the ruthenium) and the secondary phase (the matrix).

TABLE I

Composition, percent			Temperature of infiltration, ° C.	Reduction after cold-forging, percent	Micro-hardness primary phase, mHV_{50}	Micro-hardness secondary phase, mHV_{20}
Cu	Ni	Pd				
20	5	------	1,250	43	452	229
25	------	------	1,283	34	318	125
24	1	------	1,150	40	313	113
16	------	9	1,220	38	487	267
12.5	------	12.5	1,250	48	650	414
9	------	16	1,300	40	505	241

Alloys as described in the table are capable of being drawn to wire, with cold reductions in area of about 5% to 10% per pass being employed and with total cold reductions in area of 30% being realized without intermediate anneals. Wire having a diameter as small as 0.06 inch can be produced from these alloys.

An element of considerable surprise is that with high hardness in the primary phase, that is to say above 550 mHV_{50} (as determined by means of the Vickers microhardness tester having a diamond indenter and using a 50 gram load), it is still possible to work the alloys satisfactorily.

Because of their workability, the alloys according to the invention are eminently suitable for electrical contacts since the alloys can be made into wire and upset or cold-headed to produce contact surfaces.

The invention affords two additional advantages. One arises from the fact that the sintering of alloys of the kind in question is effected in practice in a non-oxidizing atmosphere. The prior alloys containing palladium in the matrix are sintered in argon with or without partial vacuum because of the ease with which palladium picks up hydrogen. The present alloys that have a matrix of copper or copper and nickel can be sintered at substantially atmospheric pressure in hydrogen or a mixture of hydrogen and nitrogen, both of which are cheaper and more readily available than argon. The second additional advantage is that copper and nickel are less expensive than palladium and gold.

Although the present invention has been described in conjunction with preferred embodiments, it is to be understood that modifications and variations may be resorted to without departing from the spirit and scope of the invention as those skilled in the art will readily understand. Such modifications and variations are considered to be within the purview and scope of the invention and appended claims.

I claim:

1. A liquid-phase sintered alloy containing, by weight, about 5% to about 40% copper, up to about 35% palladium, up to about 10% nickel and the balance essentially ruthenium, with the ruthenium content being at

least about 60% but not more than about 90%, said alloy having a duplex microstructure consisting of rounded ruthenium grains in a matrix from the group consisting of copper and of copper alloyed with at least one metal from the group consisting of nickel and palladium and saturated with ruthenium.

2. An alloy according to claim 1 containing not more than 80% palladium.

3. An alloy according to claim 1 containing about 20% to about 25% copper and one metal from the group consisting of about 1% to about 5% nickel and 9% to about 13% palladium.

4. An electrical contact made of the alloy of claim 1 and having a contact surface produced thereon by cold work.

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