# Ruthenium-Copper as an Electrical Contact Material

## MECHANICAL ALLOYING OF MUTUALLY INSOLUBLE METALS

Despite the enormous advances in electronic engineering a demand for the older types of electrical contacts persists and will undoubtedly continue for many years to come. Numerous alloys of the platinum metals have for long been relied upon where contact resistance must be kept to a minimum over considerable periods of time; the harder alloys such as iridium-platinum, ruthenium-platinum, copper-palladium and silver-palladium being preferred where resistance to wear is also an important factor.

A quite new approach to the provision of this combination of properties has now, however, been introduced by engineers at Bell Laboratories (1). This makes use of the technique of mechanical alloying rather than the normal process of melting, casting and working. This novel approach was necessary to take advantage of the excellent contact properties of ruthenium, the least expensive of the platinum group, but one which is essentially brittle and which does not alloy with many other metals, particularly copper, silver and gold. It is nevertheless an excellent conductor as well as being resistant to corrosion.

In the first phase of their research the authors chose a composite of 15 volume per cent ruthenium 85 per cent copper for study, these proportions being considered to combine the electrical and refractory properties of the former with the ductility and economy of the latter. The copper powder was atomised and screened to −100 mesh, the ruthenium powder, prepared chemically, being screened to −200 mesh. They were first mixed by hand and then milled and mechanically alloyed between hardened steel balls. In this last stage the copper particles deformed into discs while the ruthenium particles broke down into still smaller particles and became embedded in the copper discs, becoming evenly distributed.

To facilitate compaction the powder composites were annealed, the copper network sintering and exposing ruthenium on the surface of the particles. Warm rolling then yielded the composite in the form of strip. A tendency for edge cracking to occur on rolling was reduced once the strip was below 0.050 inch in thickness; at 0.010 inch the strip had a density which was 99.6 per cent of theoretical.

Etching in nitric acid then caused the ruthenium particles to protrude from the surface, giving what the authors refer to as a "sandpaper" structure in which the hard conductive ruthenium particles act as electrical contacts, the copper matrix serving as a support and providing electrical continuity. The contact resistance behaviour of the composite was found to be very similar to that of pure ruthenium at both room temperature and 100°C with exposure times up to 1300 hours.

After longer times at 100°C contact resistance values increased, probably due to the formation of RuO, a non-conducting oxide of ruthenium. It is suggested that this problem may be overcome by preparing copper-$Ru_2O$ composites.

Wear testing on the new contact material has not yet been carried out, and the authors consider that in fact resistance to wear might well be poor when mated either with itself or with softer materials. It is felt nonetheless that it might find applications in zero-insertion-force connectors where, once inserted, the contacts are locked together under a greater force.

The authors also emphasise that this novel procedure for producing a ruthenium-base metal composite with good electrical contact properties could be applied to an unlimited number of alloy systems.

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### Reference

1 M. L. Green, E. Coleman, F. E. Bader and E. S. Sproles, *Mater. Sci. Eng.*, 1984, **62**, (2), 231–239