Palladium Alloys for Electrical Contacts

PAPERS PRESENTED AT THE ANNUAL HOLM SEMINAR

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The tarnishing characteristics of the palladium-silver alloys have been a topic of considerable interest for many years. Recent developments in surface analysis techniques have given investigators new tools for studying these alloys and providing solid answers to questions that were more speculative in previous years, and the 1975 Holm Seminar on Electrical Contacts, held in Chicago, provided four papers dealing with palladium and palladium alloys for use as electrical contacts.

Contact Surfaces in Tarnishing Atmospheres

T. R. Long and K. F. Bradford, of Bell Laboratories, Columbus, Ohio, presented a paper on the "Contact Resistance Behaviour of the 60Pd–40Ag Alloy in Tarnishing Environments". This report was part of a larger study carried out by the Columbus group studying all aspects of the contact performance of the 60Pd–40Ag alloy compared to pure palladium in telephone applications. As a result of this work, the manufacturing arm of the Bell System, Western Electric, was authorised in April 1974, to convert their general purpose wire spring relay production over to the use of 60Pd–40Ag where pure palladium had previously been used. This one application had been the major use of palladium by the Bell System.

Samples of the 60Pd–40Ag alloy were prepared as flat coupons and also as factory assembled contacts on test relays. They were then exposed to tarnishing environments of mixtures of 0.2 p.p.m. H_2S, SO_2 and NO_2 at 60°C and both 75 and 90 per cent relative humidity for times up to 280 days. In addition, relays which had been made with contacts of these materials in 1943 and put into service in a telephone office in New York City for thirty years were recovered and extensively examined.

Results showed that values of contact resistance tend to be 10 to 30 milliohms higher on the 60Pd–40Ag alloy than on pure palladium, but the changes with exposure are indistinguishable. Film thicknesses are slightly less on the alloy for equivalent exposures and the sulphide film is not a simple silver sulphide but is probably Pd_3Ag_2S. Statistical analysis of the multitude of test results indicate that no significant changes in contact performance would be expected as a result of the conversion to the alloy.

J. Potinecke, of Standard Electrik Lorenz AG (ITT), Stuttgart, reported on the "Behaviour of Contact Surfaces Consisting of Ag and Pd Alloys in H_2S-NO_2-SO_2 Atmospheres". This is an interim report from a large study of accelerated testing for ten European companies. They, like others, are trying to reproduce the effects of natural environments at an accelerated rate. Uniquely, however, they are separating out the effects of the constituent gases by careful design of the experimental conditions.

Four materials were reported on: Ag, 70Ag–30Pd, 50Ag–50Pd and 85Pd–15Cu. For pure silver a regression equation was generated to predict the contact resistance as a function of constituent gas concentrations and exposure time. The effects of SO_2 on pure silver were surprising in that a higher concentration of SO_2 causes a smaller resistance increase with exposure than does a lower concentration. Film thickness measurements also established that 4 p.p.m. SO_2 exposure led to a much thinner film than a 1 p.p.m. exposure. H_2S and NO_2 cause contact resistance to increase while SO_2 reduces the rate of increase.

For the palladium alloys, the regression relations just include the gas effects for an exposure of 144 hours. For the palladium-silver alloys, this analysis shows that H_2S reduces the resistance while NO_2 causes an increase. SO_2 leads to a resistance increase with 70Ag–30Pd and 85Pd–15Cu while this influence is not significant on the 50Ag–50Pd alloy.

These results have not yet been correlated with similar tests on actual component structures where component-specific conditions such as friction, wipe distance and contact pressure will be important, but such investigations are planned.

Metal Transfer

C. A. Haque, of Bell Laboratories, Columbus, presented a paper on "Metal Transfer Characteristics in Arcing Pd-Ag 40 wt. per cent versus Au Capped Pd-Ag 40 wt. per cent Metal Alloy Contacts". By using Auger electron spectroscopy to measure the average composition of the top few Ångstroms of the surface he was able to show that the arcing process preferentially transfers silver out of the Pd-Ag alloys on to the cathode and deposits it on to the anode. This produces regions on the anode which are enriched in silver relative to the 14 wt. per cent silver already available in the 22 carat gold cap. The question of tarnish susceptibility of this altered surface composition was naturally posed and tested. No significant detrimental effects were observed on contact resistance performance of relays; it is however, important to be aware of this segregation process in dealing with alloy contact materials under arcing conditions.

Inlay Materials for Connector Springs

Franklin F. M. Lee, of International Business Machines, Endicott, New York, presented a comprehensive report on "Clad Metal Inlays for Connector Springs". Several commercially available binary, ternary and even quaternary alloys of gold, silver, palladium, platinum, nickel, copper, cobalt, indium and cadmium, were prepared in inlay form on base metal substrates. They were evaluated in terms of their porosity, wear resistance, formability and resistance stability. Pure gold and palladium in both wrought inlay and electroplated form and some electroplated alloys were also included in the test matrix for comparison purposes. They were evaluated in both strip form and in spring shape. In all, fifteen different inlay materials were studied including five different palladium-silver alloys.

This paper, like Potinecke's, is the first part of a longer project which will be completed in a few years time. Results in this paper were obtained from accelerated environmental chamber tests, but they plan to report on long term exposures at various field sites in subsequent papers.

The porosity of inlay materials is quite different from that in electroplated materials both in appearance and in cause of formation. Inlay materials tend to be lower in porosity than electroplated materials of the same thickness, but, depending on manufacturing technique, they can range from very good to very poor.

Overall, inlays can perform as well as their electroplated counterparts of the same composition and thickness. The alloy having the composition 69Au–25Ag–6Pt was found to be the most reliable of those studied. However other good candidates were the alloys 70Pd–30Ag, 75Au–25Ag, and 55Au–39Ag–3Cd–3In; and palladium.