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Third-body formation by selective transfer in a NiCr / AgPd electrical contact. Consequences on surface reliability and remediation by a barrel tumble finishing process

Manon Isard[1-2)], Imène Lahouij[1)*], Jean-Michel Lanot[2)] and Pierre Montmitonnet[1)]

[1)] MINES ParisTech, PSL Research University –
CEMEF, Centre de Mise en Forme des Matériaux, CNRS UMR7635, Sophia Antipolis, France
[2)] Vishay S.A, Nice, France.
*Corresponding author: imene.lahouij@mines-paristech.fr

In electrical components, wear and 3rd body formation have a significant impact on the lifetime of the surface contact as well as on the electrical signal quality. This work addresses a particular case of interaction between adhesive and abrasive wear in the electrical contact of position sensors, characterized by a selective adhesive transfer layer. Severe abrasive wear is found to be at the origin of a deterioration of the electrical response of sensors. The transition from mild to severe abrasion is due to the formation of a chemically selective adhesive transfer. An alumina-assisted tumble finishing process has been identified as an efficient solution to preserve surfaces from wear and therefore improve the electrical lifetime of the sensors.

Keywords: third body, electrical contact, wear, alumina

The aim of this work is to investigate the physical and chemical mechanisms involved in the formation process of a third body in an electrical contact. The device studied is an electric rheostat position sensor consisting of a low pressure sliding contact between a resistive track (5 µm-thin NiCr layer) and a contactor (AgPd alloy). The contact is lubricated with a silicone oil / PTFE grease operating under boundary lubrication condition to ensure low electrical contact resistance. The angular position / electrical circuit resistance relationship is found to be disturbed by severe wear of the NiCr track surface [3].

In-depth cross-section analyses combining focused ion beam (FIB) with analytical transmission electron microscopy (TEM) techniques are used to identify the structural and chemical changes undergone by the interfacial contact involving NiCr and AgPd surfaces. The results reveal the formation of a third body on the AgPd cursor with a nano-grain microstructure and a selectivity in Ni (fig.1), which changes the nature of the initial contact from AgPd-NiCr to nano-Ni-NiCr. This third body is found to have an abrasive action on the NiCr track surface due to its high hardness which induces severe wear and significant loss of track thickness (initially 5 µm). This explains the deterioration of the electrical response of sensors [4]. Based on the literature, possible explanations of the "evaporation" of Cr from the third body are temperature or electric current effects, or catalysis by elements of the cursor : Pd, Ag and Cu.

Coming to remedies, an alumina-assisted tumble finishing process added as the last step of NiCr track manufacturing was revealed efficient in inhibiting the detrimental nano-Ni-selective transfer formation. It results in a very significant decrease of the severe abrasive wear of NiCr tracks, improving the electrical behaviour of the position sensor. The role of alumina in preventing the contact from wear could be either a solid lubricant effect preventing adhesion and transfer or a "cleaning" effect by abrasive alumina. Scenarios of the evolution of the interfacial contact under operating conditions can thus be proposed.

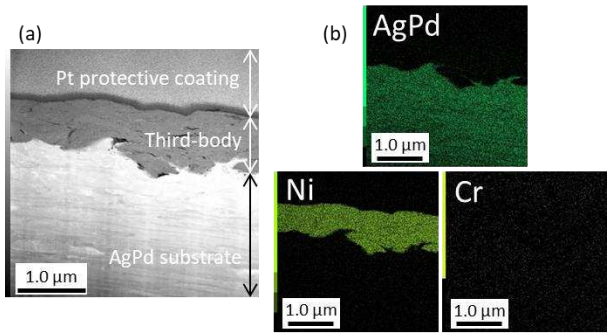

Figure 1: (a) STEM micrograph of the AgPd cross section showing the presence of a third body, (b) the corresponding EDS mapping showing that the third body is composed of Ni only

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