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Corrosion failure analysis of hearing aid battery-spring contacts

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ABSTRACT

Reliability of low power electrical contacts such as those in hearing aid battery-spring systems is a very critical aspect for the overall performance of the device. These systems are exposed to certain harsh environments like high humidity and elevated temperatures, and often in combination with high levels of salt from human perspiration and environmental pollutants. In addition, the design aspects of such systems often call for multi-material combinations of substrate and coatings for catering to various requirements such as electrical conductivity and wear resistance, which in turn enhance the susceptibility of these systems to galvanic corrosion. In this study, traditional behind-the-ear (BTE) hearing aid systems, which failed during service were analysed. Failure analysis was performed on the dome type battery-spring contact systems. The morphology of the contact areas was observed using scanning electron microscopy, and the compositional analysis of the corrosion products and contaminants was performed using energy dispersive X-ray spectroscopy. Wear track morphology was observed on the contact points, and the top coating on the dome was worn out exposing the substrate spring material. The obtained results were correlated to the underlying corrosion mechanism and the failure mode is presented.

1. Introduction

Modern day hearing aids are generally very reliable and durable in their performance. However, certain harsh environments, such as places with high humidity and elevated temperatures, often combined with increased levels of perspiration from the user and earwax can impair the functionality of the devices [1–6]. Electrical contacts (low power) in these devices are critical components, which limit the hearing aid performance in such situations, leading to reduced battery life, power dropouts and increased acoustic feedback (whistling) in the device output [7]. Currently, majority of the electrical contacts systems are based on traditional electro/electroless plated Ni/Au-systems (see Fig. 1); however, this system is very sensitive to wear of the Au-top layer, corrosion of the underlying Ni layer and of the substrate material [8,9]. Increasing the thickness of the top Au layer is not usually recommended due to the steep increase in cost of the contact system. On the contrary, the current trend is to reduce the thickness of the top Au layer in order to reduce product cost, but the increase in porosity due to pinholes in the Au plating sets a limit on the down gauging of the Au layer thickness [10]. Reduced Au layer thickness also exposes both the Ni interlayer and the substrate underneath. This study analyses the in-service corrosion failure of such low power battery spring contacts used in behind-the-ear hearing aid devices. The spring surfaces have been characterized using scanning electron microscopy combined with elemental analysis by EDS and the underlying failure mechanisms are presented and discussed. Failure analysis of five spring contacts is presented in this paper.

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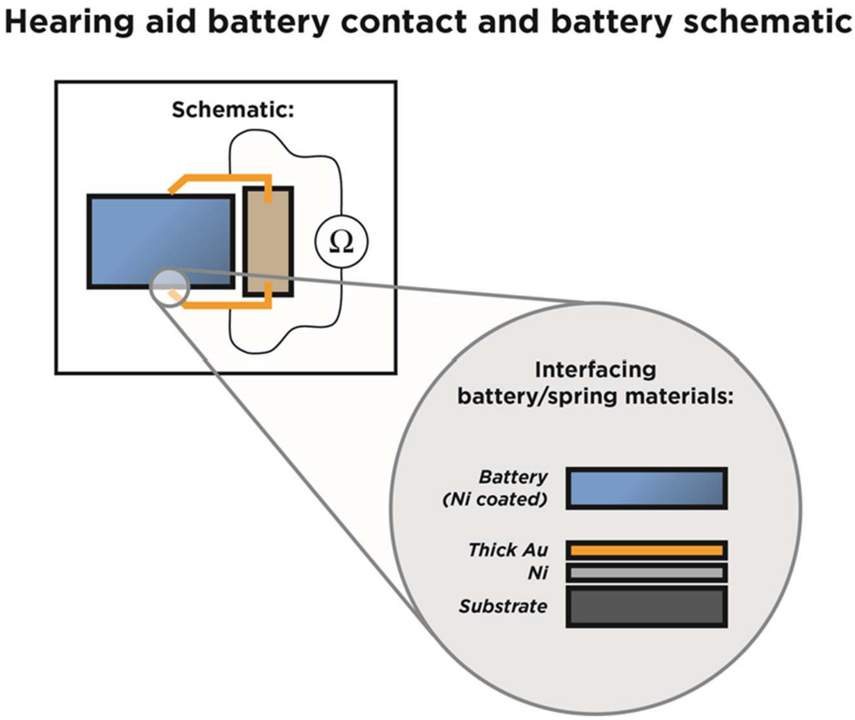

Fig. 1. Illustration of currently used battery spring system and typical multi-layer coating used.

2. Materials and methods

Behind the ear hearing aid devices installed with Au plated battery spring contacts were obtained from the field after being in service for different periods. The metal spring contacts were then carefully separated from the rest of the device and were prepared for analysis of the contact surface (see Fig. 2). The springs are numbered sequentially as *Contact-1*, *Conatct-2*, *Contact-3*, *Contact-4*, and *Contact-5*. The separated springs were then mounted for electron microscopy observations onto an Aluminium stub, and painted with conductive Ag paint around the edges to prevent charging. Scanning electron microscopy was performed on the contact surfaces using a SEM Quanta 200 ESEM with Oxford X-max EDS capability. In addition, selected areas were subjected to focused ion beam milling for in-situ observation of the cross sections using a Helios Nanolab dual beam FEG SEM.

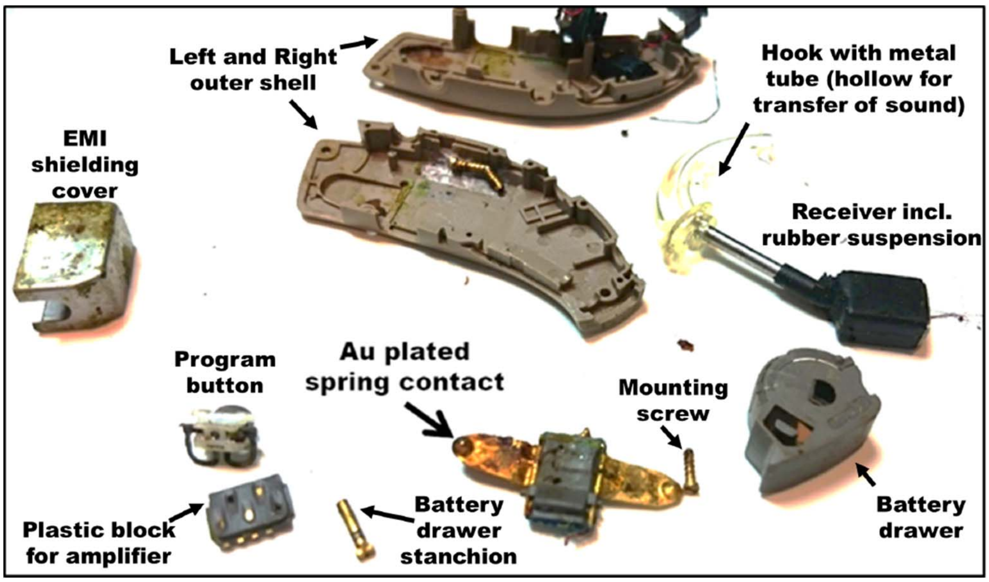

Fig. 2. Photograph showing a representative Au plated spring contact separated from the rest of the hearing aid device.