Particle contamination, the disruption of electronic connectors in the signal transmission system*

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Received Dec. 19, 2006; revision accepted Jan. 5, 2007

Abstract: Particle pollution in air, also sometimes known as fine dust contamination, may cause electric contact failure. Recent research further proved that the fine particle is becoming a major disruption of the electronic connectors in signal transmission system. This paper specifies the connector contact in mobile phone application. To study the contact failure of mobile phone, a series of inspections and analytical research methods are introduced. Special features that cause the contact failure are summarized. Particle accumulation is the main problem; organic material such as lactates from sweat of the human body may act as adhesives to stick the separate particles together and make them adhere on the contact surface; chemical properties of dust cause serious local corrosion. The corrosion products may trap the particles and firmly attach on the contact surface; micro motion frequently occurs at the contact interface. Hard particle can be embedded into the surface, and soft particle could be squeezed and inserted into the contact; silicon compounds in dust play the most important role in forming high resistance regions that lead to failure; deposition of particles depends on the amount of materials, static electricity attracting force and gravity force applied on the particles. Current dust test can hardly reflect the serious contact failure. It is difficult to simulate the complexity of contact failure caused by particle contamination. Thus alternative ways of simulation experiment and improvement of contact reliability are proposed.

Key words: Dust, Particle contamination, Micro motion, Corrosion
doi:10.1631/jzus.2007.A0361 Document code: A CLC number: TB114.3; O224; O211.6

INTRODUCTION

Electrical and electronic products in China have been developed rapidly. Taking telecommunication products as examples, by the end of 2005, the number of mobile phone users has reached 400 million, and optical telecommunication customers have exceeded 300 million. These are important sources that support the rapid economic growth of this country. However, numerous unpleasant complaints related to the unreliable mobile phones have been reported to the Consumer Association. They are listed as the top complaints beyond all others over the past consecutive years. At the same time, the returning of the failed mobile phones to the companies for repair has been increased unexpectedly. The error code rates of optical telecommunications have seriously affected the quality of message exchange. Even though great effort has been made to replace the suspected connectors, and clean up the contacts, the error code rates would turn up again eventually. Thorough studies and research on the failure revealed that a large number of failures are caused by unreliable electrical contacts. As it is known, electronic connectors are widely used in telecommunication and electric control systems; their function is to link the electronic signal through various transmission lines. Unreliable connection directly affects the reliability of the system. Since the connector contact is the unique electronic component that is exposed in air, the contact will be undoubtedly greatly affected by the ambient environment. Result of tests on the failed connector contacts used in mobile phones collected from various cities in China
revealed that the contacts were contaminated by various materials of different sizes accumulated in them. Fig.1 illustrates a typical failed contact of a mobile phone whose life is only 3 months. At the testing points 1, 2, 3, certain amount of Si which is one of the main elements in dust, was found in the contaminant of the contact.

Fig.1 Accumulated particles on failed contact surface (covered with thin Au)

Another example is the surface of failed coaxial connector contacts used in optical telecommunication system is covered with elements of gypsum, sulfates of copper and nickel. Gypsum is one of the major components in dust and is soft and easy to be squeezed into the contact interface. The water solution of gypsum containing certain concentration of $\text{SO}_4^{2-}$, in a humid environment, may cause corrosion on contact surface.

China has a huge market for electrical and telecommunication products, and is becoming the base of global manufacturers. Therefore contact failure is not only a domestic problem but also a global one that has to be solved.

A series research was carried out in western countries and great efforts have been made to reduce electrical contact failure since the 1960’s (Reagor and Russel, 1985; Williamson et al., 1956; Mano, 1981; Robbins, 1973). At present, contact problem is not as serious in western countries. The main target in the west is to reduce the effect of corrosive gases in the air such as $\text{SO}_2$, $\text{H}_2\text{S}$, $\text{Cl}_2$, $\text{NO}_2$, etc. Purification of work area air is also an important strategy to reduce dust contamination. Unfortunately this is not the case in China where air pollution has become very serious. High concentration of $\text{SO}_2$ gas remains in the air, and a great amount of fine particles is floating all over. Dust storm hits the northern part of China almost every year. Fig.2a illustrates dust storm in Beijing. Fig.2b shows the same area after rain shower. Fig.2c shows the same area under normal condition with low visibility. Even in southern coastal cities such as Shanghai, high amount of fine particles in the air have also been found.

Fig.2 (a) Dust storm in Beijing; (b) Photo taken after rain shower; (c) The usual air pollution in Beijing

For further studying the air pollution effect on gold plated samples, a series of sheets were placed indoor in Shanghai for monitoring the changes on the surface.

Fig.3a shows the corrosion stain on gold plated sample after 22 months of exposure indoor in Shanghai (taken by optical microscope). Fig.3b shows the morphology of a corrosion stain (taken by scanning electron microscope (SEM)). In the stain, where a core is located at the center, surrounding by several rings. Fig.3c shows the ring formed by numerous islands (Zhang et al., 2000).

X-ray energy spectroscopy (XES) reveals the composition of these islands consisted mainly of ele-