Materials Engineering Branch

TIP*

No. 054 Galvanic Corrosion

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Galvanic corrosion is corrosion that occurs between two electrically connected metals, alloys, or non-metallic conductors (e.g., graphite) that are at different electro-potentials and also are connected via an electrolyte. The greater the potential difference, the more active is the couple with the material having the more negative potential being the one suffering the greater corrosion.

Dissimilar metals under the same or no applied potential form a galvanic couple, as do similar metals under a potential gradient. Although spacecraft hardware is normally carefully handled and protected against harsh corrosive environments, galvanic corrosion is still a problem. The use of stainless steel fasteners in contact with magnesium or aluminum alloys is a common spacecraft configuration. However, the more reactive (less noble) magnesium and aluminum alloys generally are protected somewhat by anodizing, chromating, plating, painting or other films that electrically insulate or reduce the galvanic potential.

Metals are normally considered compatible if the difference in potential between them is equal to or less than 0.25 volts. Mil-Std-889B lists most common metals and alloys according to compatibility. For most spacecraft applications, galvanic corrosion is a superficial phenomenon that causes no structural harm. However, in the case of small metallic components, such as electronic leads, galvanic corrosion has been a problem.

For instance, Kovar leads on flat-pack devices had been plated with electroless nickel and then over plated with gold. Subsequent bending of the leads resulted in cracking of the brittle electroless nickel and the thinner gold over plate. This condition presented a galvanic triad, with Kovar being the least noble of the group and, therefore, suffering the most galvanic corrosion. As a result, many of the leads failed via a galvanic corrosion mechanism.

Another example of this is electro-migration. In this case, conductive paths are formed on printed circuit boards between close metallic conductors of the same metal or alloy that are at a potential difference when bridged by condensed moisture (the electrolyte). Because the potential difference is usually quite large (approx. 20-30 volts) the resulting galvanic action is normally so active that metallic particles are carried from one conductor to the other through the electrolyte film until direct contact is made and shorting occurs. To prevent this failure, the printed circuit boards must be thoroughly dried and conformally coated with a polymeric film that will exclude the moisture.

Light weight, specular thermal control surfaces have been made by vapor depositing aluminum (VDA) on to smooth as-molded graphite/resin face sheets. The specular surfaces are routinely covered with a strippable protective coating. The coating consists of a water emulsion of elastomeric particles that is sprayed on. When this coating was used with composite substrates, blisters formed under the VDA due to galvanic corrosion between the graphite fibers and the aluminum film. This resulted in a severely spotted surface with a concomitant loss of specularity.