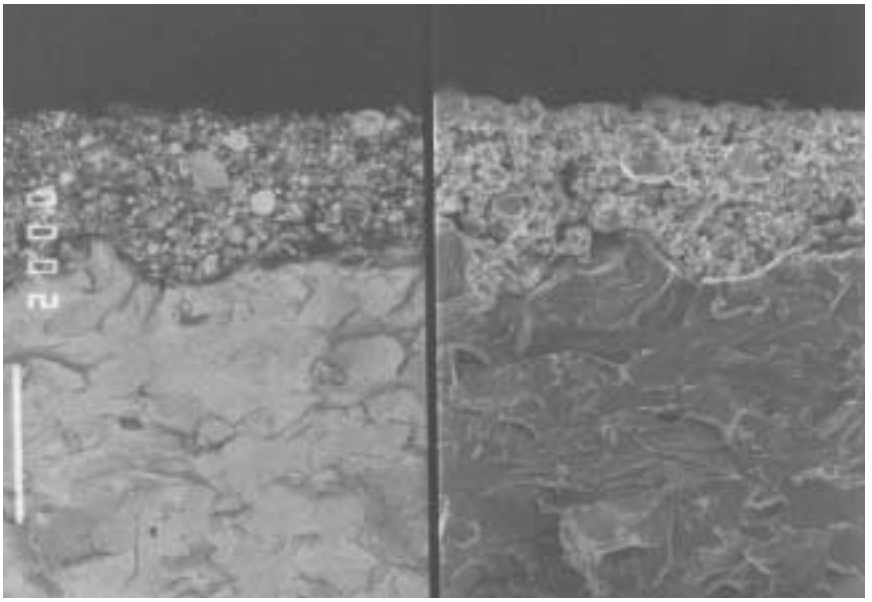
# New Coating Technology for Corrosion Prevention

by Karen J. Thornton

According to the Battelle Memorial Institute and the Specialty Steel Industry of North America, the cost of corrosion for industry in the United States has tripled in the last 20 years, an estimated $100 billion of which is preventable. Corrosion costs $1.17 trillion on a worldwide scale, which figures to about $193.65 for every man, woman and child (the computation was adjusted for the estimated world population as of the date of calculation, 12 February 2000.)

Applied Semiconductor, Inc. of New York City has devised a method that may reduce the cost of corrosion. Zeta$^n$, a semiconductor technology developed by Applied Semiconductor and Marine Environmental Research, Inc., has been laboratory and field-tested for more than 10 years and is patented in the United States and other major world markets. Zeta$^n$ is the first direct industrial application of semiconductor technology with uses including corrosion prevention and marine anti-fouling. Unlike other methods of addressing corrosion, which either cover the substrate with a material that corrodes at a slower rate than that of the material it is trying to protect (for example, any barrier coating such as paints, enamel, epoxy, or lacquer) or provide an element that protects by sacrificing itself (either galvanizing or individual sacrificial anodes), Zeta$^n$ prevents corrosion by inhibiting the flow of electrons required for corrosion.



*Two magnified views showing the tight bond of the Zeta$^n$ coating (top, thinner band) with a steel plate (bottom, thicker band).*

The system's technology consists of a semiconductor coating, applied in a single coat, and an electronic control unit (ECU). The coating thickness varies depending on the application. For example, applications such as automobiles require 0.5 to 1 mil, while industrial to marine applications might require 3 to 6 mils. In structural applications, a coating of 3 to 6 mils would be required: 3 mils in areas where there is less "wear and tear" and 6 mils in areas subject to frequent abrasion. With a power requirement of <1mA, Zeta$^n$ uses the "P" and "N" semiconductors in the coating to stabilize the potential charge in the protected substrate and inhibit the flow of electrons necessary for corrosion by a factor of 103.

The original coating formula, the basis of the Zeta$^n$ coating, was developed by NASA and used 30 years ago on the lunar rover to prevent warping of its parabolic antenna from the extreme temperature changes as it went from the dark to the light side of the moon. The Zeta$^n$ coating, optimized for electronic properties, retains the flexibility characteristics of this "lunar" coating, and like the

NASA formulation, bonds by chemical reaction rather than mechanical adhesion to the substrate upon which it is applied.

The Zeta$^n$ coating, when used in system with the electronic control unit:

- Will withstand 2,000°F (1,093°C) momentarily, 1,400°F (760°C) for an extended period (typically, 10 minutes, but the length of time will depend in part on the thickness of the treated substrate), and 800°F (427°C) without limit. Zeta$^n$ can withstand any cold temperature levels. (See microscopy pictures of Zeta$^n$ on a steel substrate that was frozen with liquid nitrogen in order to break the plate for the study. The Zeta$^n$ coating remains intact.);
- Is approximately 1,000 times harder than epoxy;
- Is non-carcinogenic;
- Is non-polluting in both application and use and is EPA approved for use inside potable water containers;
- Is a single coat;
- Requires no special equipment or surface preparation for application; and
- Has a laboratory projected life of 3,000 to 5,000 years. Practically, it will last for the design life of whatever has been coated.

Regarding saline environments, Ben Royal, a test vessel, has been in salt water for over ten years. The extreme ends of the pH scale will cause problems. NASA has run extended tests at a 10% acid solution without damage (without electronics). Applied Semiconductor is currently testing the pH limits of Zeta$^n$ using the ECU.

The installed cost of Zeta$^n$, inclusive of electronics, is approximately the same as a standard three coat epoxy finish. The Zeta$^n$ system, coating (sufficient for six mils to eight mils) and ECU, is about $2.00 per square foot. Standard air or airless

**Field test structure:** fuel storage tank

**Field test location:** University of North Carolina Marine Lab (located on a barrier island)

Before coating
September 1, 1993

After coating
September 14, 1993

7 years after coating
May 7, 2000

spray equipment is used for application with a good quality dust mask to protect the applier. Zeta$^n$ has no known code or environmental issues. Zeta$^n$ is 0 VOC and is EPA approved for use in potable water containers.

To date, Zeta$^n$ has not been commercially available. However, field tests of commercial size have been conducted, as shown in the pictures of a fuel storage tank at the University of North Carolina Marine Lab located on one of the barrier islands off of North Carolina. Applied Semiconductor, Inc. is now entering into the commercialization of Zeta$^n$, and it will be available in early 2001.

*Applied Semiconductor is located in New York City. David B. Dowling, President & CEO, can be reached at 212/509-0602 and ddowling@appliedsemi.com.*