Technology Readiness Level: 4
Component and/or Breadboard Validation in Laboratory Environment

Eltron Research & Development

Tech Brief

Heat Tolerant, Corrosion Resistant Coating Lowers Costs for Corrosion Prevention

Ceramic coating for ferrous materials, corrosive applications

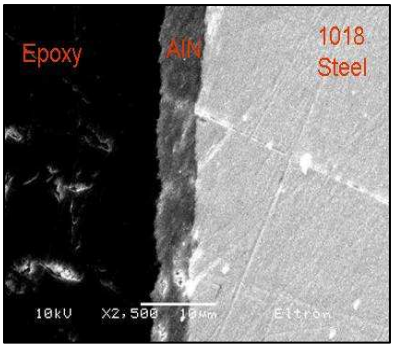
Features & Benefits

- Operating temperature: 600°C – 950°C
- Deposition demonstrated on steel, AlN, and molybdenum substrates
- Deposition rates between 0.1 and 1 microns per minute
- One patent issued and another pending
- Cost competitive

A variety of corrosion prevention methods are available for protecting steel surfaces. Using expensive alloys, coating with epoxies or paints, anodization, pack cementation, electroplating and galvanizing are all options. But, these corrosion prevention methods are effective mostly for ferrous materials used in low-temperature applications.

Protection in high-temperature, corrosive environments is more difficult. Epoxies and paints thermally decompose at high temperatures, and metal coatings are often not stable to harsh conditions. For these environments, either very expensive materials such as stainless steel or superalloys must be used, or very expensive methods such as physical vapor deposition must be employed to coat less expensive mild steel.

Ceramic coatings can withstand the combination of high temperature and corrosive environments. However, adhering ceramic coatings to a metal surface is difficult due to the difference in thermal expansion of the materials.



2500x SEM image of the cross section of an AlN coating applied to 1018 carbon steel during testing at Eltron. The AlN is well-adhered to the steel and is 5 microns thick.

The Solution

Eltron Research & Development, Inc. has developed and tested a proprietary process for depositing and adhering a corrosion-resistant ceramic coating on the surface of ferrous materials and, specifically, mild steel.

In Eltron's process, coating precursors are produced using environmentally friendly, room temperature molten salt technology. Volatile aluminum/nitrogen containing species are then synthesized that can be introduced into the pipe to be coated, which acts as an *in situ* chemical vapor deposi-

tion (CVD) chamber. Volatile species react thermally to form aluminum nitride coatings on ferrous substrates. Aluminum nitride is then further reacted with oxygen to produce a functionally graded aluminum nitride/aluminum oxide coating.

The Technology

To demonstrate corrosion resistance of Eltron's AlN coated steel, two samples were exposed to humidified air at 200℃ for 34 days. The first sample was an uncoated piece of 1018 carbon steel. Figure 1 shows the X-ray diffraction (XRD) patterns of the steel surface before and after testing.

XRD data shows that before corrosion testing the surface of the 1018 carbon steel was iron. After corrosion testing, very little iron remained and the surface contained mostly amorphous iron oxide. The second sample was a piece of 1018 carbon steel coated with AlN. Figure 2 shows the X-ray diffraction (XRD) patterns of the steel surface before and after testing.

The data in Figure 2 shows that, before and after testing, only AlN and Fe were present on the sample surface. No iron oxide corrosion products were found after testing. This indicates that the AlN coating successfully prevented corrosion of the steel.

In addition to corrosion testing samples of AlN coated steel were thermally cycled to demonstrate that the AlN coating was well adhered to the steel surface. Coated samples were thermally cycled-up to 500℃. XRD results confirmed that the composition of the AlN surface did not change during thermal cycling. In addition, weight measurements showed the samples did not lose any mass during thermal cycling and optical microscopy confirmed that the AlN did not flake off or delaminate from the steel surface.

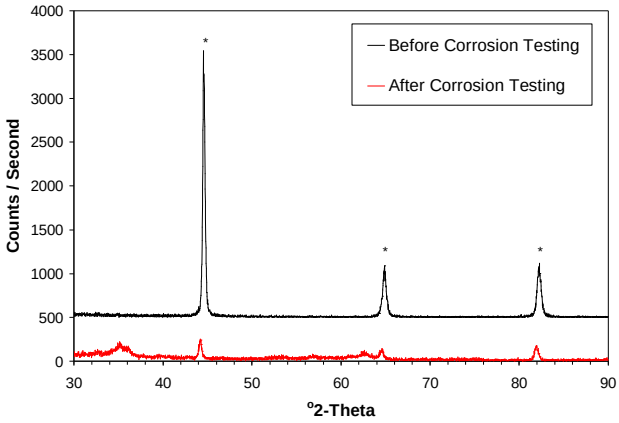


***Figure 1**. X-ray diffraction patterns for 1018 carbon steel before (top) and after (bottom) corrosion testing. An asterisk indicates diffraction peaks corresponding to iron.*

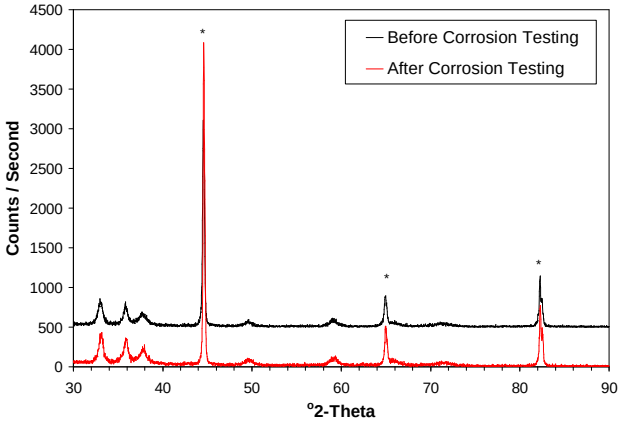


***Figure 2.** X-ray diffraction patterns for AlN coated 1018 carbon steel before (top) and after (bottom) corrosion testing. An asterisk indicates diffraction peaks corresponding to iron; unlabelled peaks correspond to AlN.*

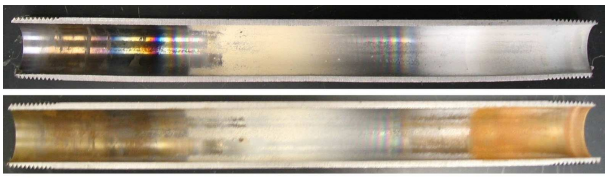
The Benefits

Eltron's process results in superior adhesion properties. Other advantages include rapid deposition rate and inexpensive capital equipment requirements.

Eltron has had consistent success depositing AlN onto steel coupons as well as the interior surface of carbon steel pipe. In addition to excellent adherence, the coated area of the pipe was corrosion-free after 600 hours of exposure to heat and steam.

During the course of research, Eltron identified the compatibility of this application method for substrates commonly used in other industries. The process can also be used in semiconductor fabrication and in the linings of reactor vessels for chemical and pharmaceutical manufacturing.

During the course of research, Eltron identified additional applications for its proprietary process including semiconductor manufacturing and large-scale reactor vessel linings.



Cutaway of mild steel pipe following AlN deposition. The top image shows the pipe immediately after deposition. The bottom image shows the effects after six months of testing. Note that the center of the pipe, where the coating was applied, is free of any corrosion.

Stage of Development

This technology has a provisional patent application, filed with the USPTO, number 61/057,288.

The technologies described, and all related inventions are owned by Eltron Research & Development Inc, and protected by copyrights, trademarks, issued and pending patents, trade secrets, or other applicable intellectual property rights.

Contact Us

To discuss the possibility of entering into a business relationship with Eltron, contact the Business Development Group at business@eltronresearch.com.

To learn more about Eltron Research & Development's coating processes and the many other technologies that the company is commercializing, visit www.eltronresearch.com.

Eltron Research & Development

Eltron Research & Development Inc.

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