Interconnect Cost Reduction

For Thick Gold Datacomm Backplane Connectors

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Introduction

Cost is a critical component of the decision-making equation when designing new products or managing legacy products. There are typically a handful of levers that can be pulled for cost reduction, including the reduction of precious metal, which can account for up to 25% of product costs for some designs. The reduction of precious metal can lower performance, however, leading to reduced sales or increased returns. Striking the right balance can require the adoption of new materials that displace a current Industry Standard or Process of Record (PoR). In this paper, we explore reducing the cost to manufacture datacomm backplane connectors by replacing nickel (NiS or nickel sulfamate) with XTRONIC®, XTALIC's stable nanostructured nickel alloy, to minimize the precious metal required on the contact interface.

The Industry Standard

The PoR finish for high-speed backplane connectors has historically been 30µ" Au (gold) over nickel plated onto a high-performance copper alloy substrate (eg. C511 or C7025 alloys). The gold layer provides low contact resistance and corrosion protection at the contact interface. The nickel provides a barrier layer, protecting the gold surface from interdiffusing with the copper substrate, and preventing degradation across electrical performance and corrosion resistance. In addition the nickel barrier layer also helps to prevent copper substrate corrosion due to exposure to corrosive environments and improves the durability of the connector.

The PoR finish evolved through extensive testing for connector reliability targeting a 20-year life for the connector in its typical operating environment. The qualification test sequences and performance targets that govern this application are detailed in the Telcordia GR-1217-Core and the test protocols are described in the EIA-364 testing suite. The primary acceleration test established to simulate the use environment is the 20-day Mixed Flowing Gas (MFG) test with class IIA conditions. This test combines many of the critical elements of connector performance for this application: electrical performance as a function of thermal conditioning, durability, and environmental exposure to corrosive gases.

To maintain a low contact resistance, only a very thin layer of Au is actually necessary. However, typical nickel barrier layers may have significant porosity in the coating providing pathways for environmental corrosion of the copper substrates. Additional gold thickness is required to address the porosity and maintain the proper corrosion resistance. Using a less porous and more corrosion resistant barrier layer material enables the reduction of the gold required to achieve the necessary environmental performance.

Traditional Alternatives

Palladium nickel (PdNi) is both more corrosion resistant and more durable than NiS. A common PdNi PoR replacement stack commercialized across the industry uses ~3µ" Au as the final finish over ~27µ" PdNi. The PdNi alloy is typically 80/20 and can provide a price reduction compared to the Industry Standard 30µ"Au finish. However, the prices of Pd and Au can vary widely making it difficult to maintain product margins or provide cost savings.

Nickel phosphorous (NiP) is another potential barrier layer material. NiP is also more corrosion resistant and more durable than NiS and does not have the price volatility of PdNi. The slow plating rate for NiP limits the suitability for the mass production reel-to-reel plating of datacomm backplane connector contacts. It also minimizes the potential improvements in corrosion resistance by limiting the achievable thickness. Also, NiP is more brittle than either PdNi or NiS creating the potential to generate debris in the mating interface which can accelerate durability failure.

Our Approach

XTRONIC® is more corrosion resistant, less porous and more durable than Nickel sulfamate. It is similar in durability and corrosion resistance to PdNi without the price volatility. It is both more durable and more ductile than NiP and can be plated at a sufficient rate to support reel-to-reel mass production. The XTRONIC® material was used to develop a plated stack optimized to produce equivalent environmental performance — reducing the gold thickness by 2/3, from 30µ" on the PoR to 10µ"over XTRONIC®. Throughout this section we compare the performance of XTRONIC® and NiS as discrete materials, with gold plating for development tests on coupons, production-line plated connector contacts, and then finally fully assembled connector qualification.

The development tests used to optimize corrosion performance compare XTRONIC® to the PoR NiS. The EIA-364-TP53 Nitric Acid Vapor (NAV) test provides a key indicator for corrosion performance. The NAV test is the production quality control (QC) test used to evaluate porosity for the plating stack and gate product quality after plating before down-stream connector processing such as overmolding and forming. In practice, a specification is set for the acceptable number of corrosion sites (blooms) per 100 contacts. The samples for NAV testing shown (Fig. 1) are C511 coupons plated with either 10μ" Au/XTRONIC® or 30μ"Au/NiS (PoR). Here, we counted the number of blooms on the samples after NAV exposure for comparison. The XTRONIC® samples at 1/3 the Au thickness of the PoR produced no corrosion blooms, while the PoR had 5 blooms.

75-Minute Nitric Acid Vapor Test (EIA-364-TP53)

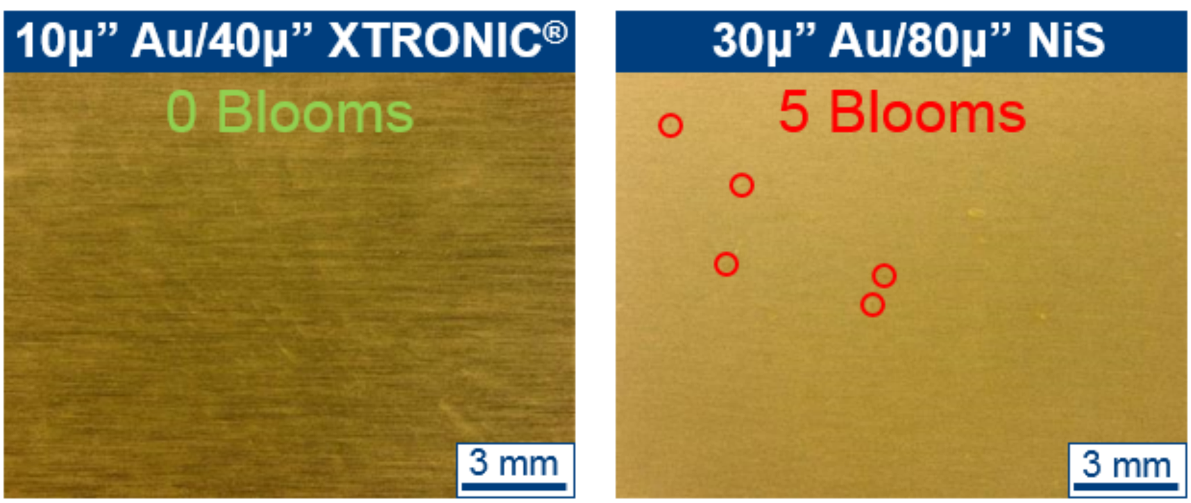


Figure 1

The product level qualification test for datacomm backplane connectors is the 20-day MFG test. The test is typically done on fully assembled connectors with 10 days mated and 10 days umated. In the unmated condition, the plated contact surfaces can be shielded from the environmental gases by plastic overmolding and the connector housing. Shielding can restrict corrosive gas flow to the contacts, making the corrosion environment less aggressive. As a development tool for coupon level testing, we used a 5-day MFG exposure of coupon samples, where the coupons were suspended fully exposed in the test chamber with no shielding. This produces a consistent test environment. After exposure, the samples were then inspected by SEM for corrosion blooms. Samples for this test were C511 coupons plated with 10μ” Au/XTRONIC®, 30μ”Au/NiS (PoR), or 10μ”Au/NiS. As can be seen in Fig. 2, the performance of the 10μ”Au/XTRONIC® is equivalent to the 30μ” Au/NiS (PoR) and significantly better than 10μ”Au/NiS.

5 Day MFG Class IIA (EIA-364-TP65)

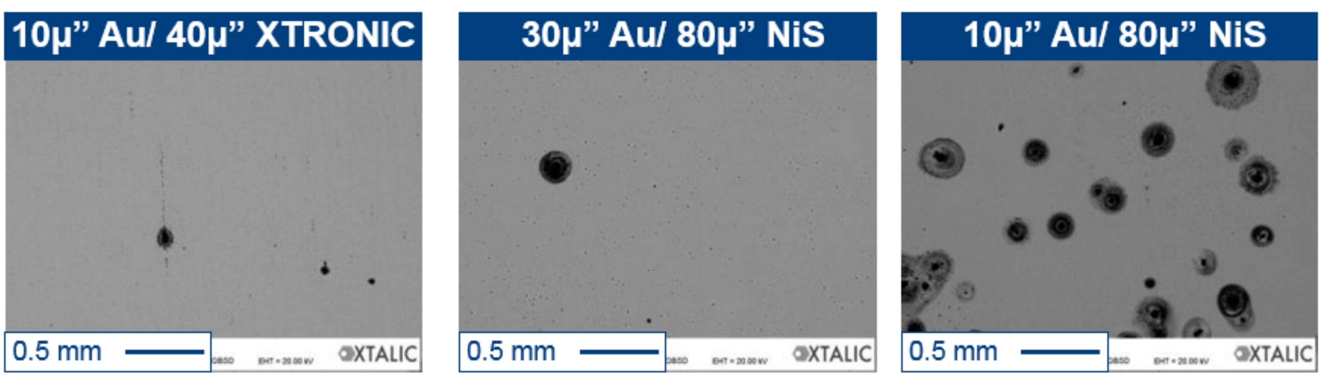


Figure 2

The 10µ"Au over XTRONIC® and PoR stacks were retested in NAV using contacts plated on a production reel to reel line using selective Au plating. Fig. 3 demonstrates that there is equivalent performance in the selective gold region for both the XTRONIC® and PoR stacks. Outside of the Au area where the XTRONIC® and NiS are exposed, the difference in porosity and corrosion resistance of the two barrier layers is clearly visible. The XTRONIC® sample has minimal corrosion product present, while the PoR sample shows significant Ni corrosion and Cu substrate corrosion products.

Barrier Layer Porosity and Corrosion Test (NAV)

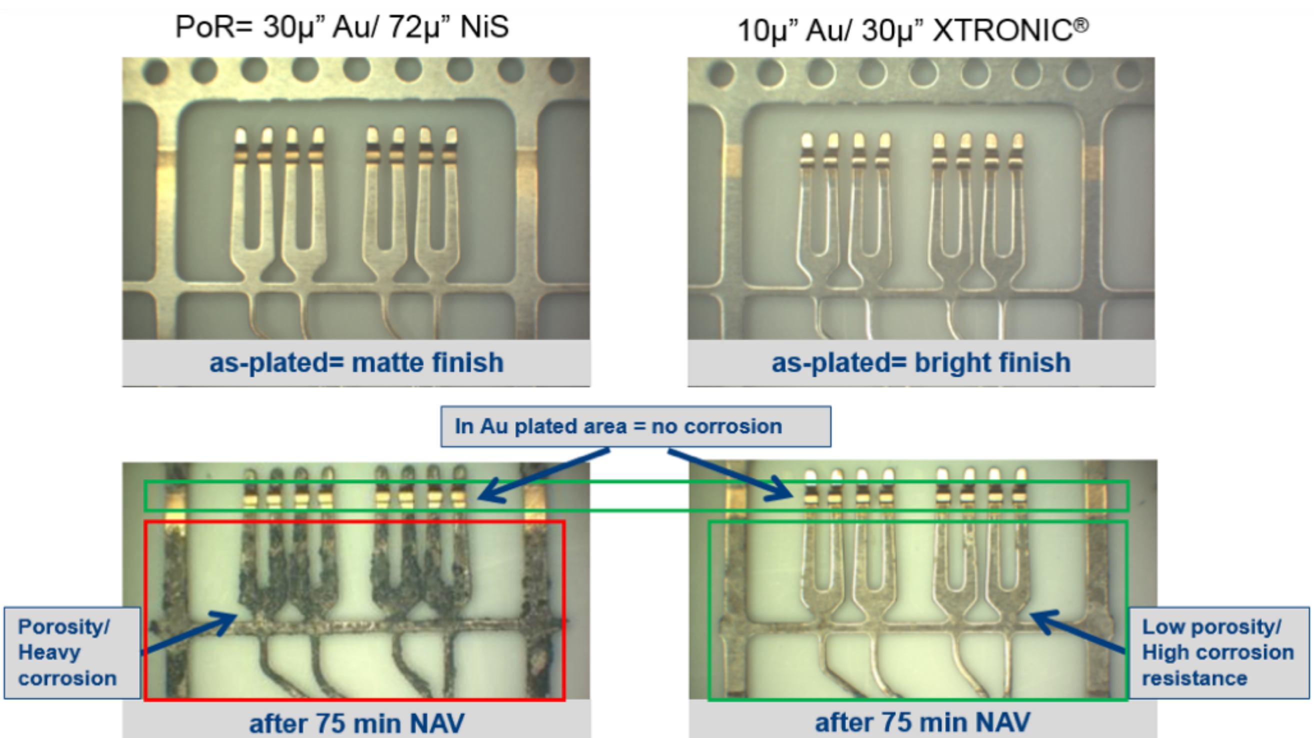


Figure 3

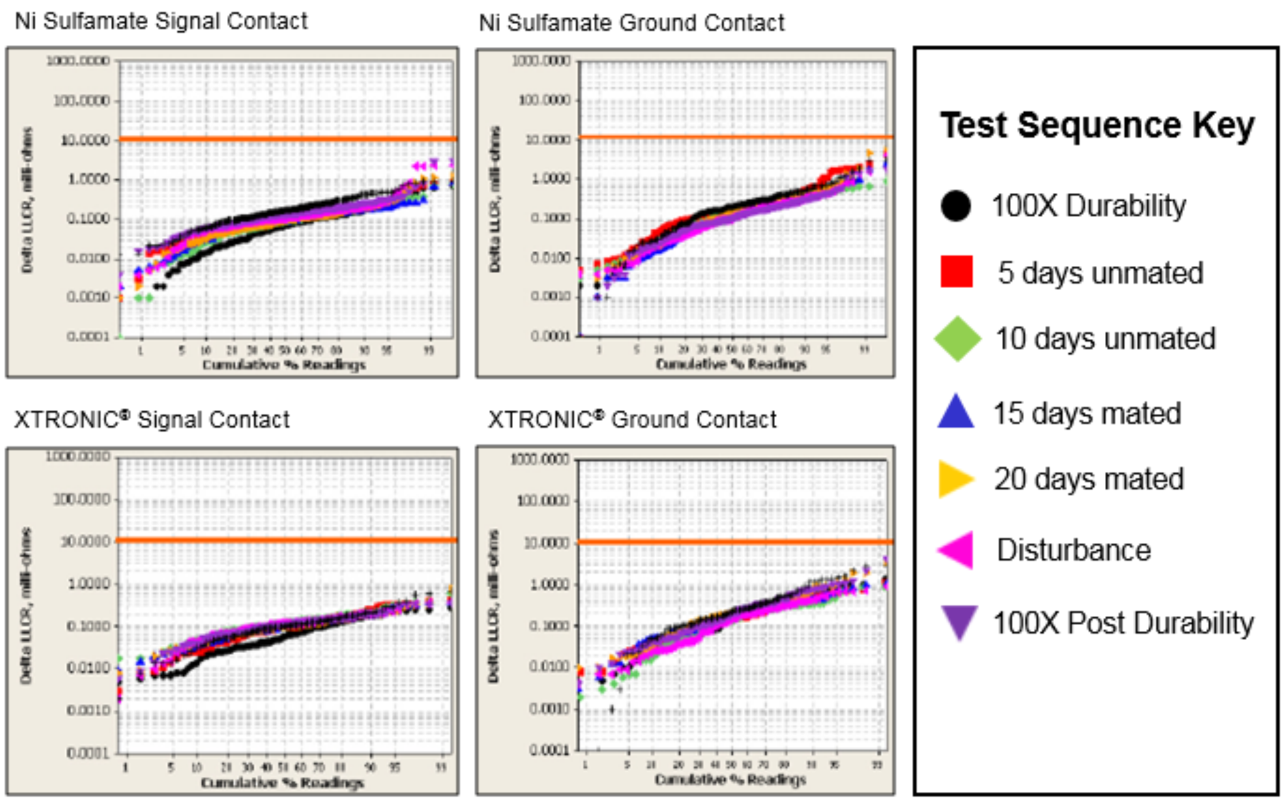
In the fully assembled product format, Fig. 4-5 (Do/Lund 2010 Holm conference) show the complete 20-day MFG qualification test of the VHDM product line Daughter card (DC) and Backplane (BP) contacts for both the PoR (30µ"Au/Ni Sulfamate) and 10µ" Au/XTRONIC®. As shown in the test data legends for these plots, the test sequence is:

1. Temp life (EIA-364-TP17)
2. 100 connector mate/unmate cycles (EIA-364-TP09)
3. Initial 5-day MFG exposure – unmated (EIA-364-TP65)
4. 2nd 5-day MFG exposure—unmated (EIA-364-TP65)
5. Initial 5-day MFG exposure—mated (EIA-364-TP65)
6. 2nd 5-day MFG exposure—mated (EIA-364-TP65)
7. Disturbance (EIA-364-TP110)
8. Final 100 connector mate/unmate cycles (EIA-364-TP09)

Low-level contact resistance (electrical testing EIA-364-TP23) is measured for every contact pair at each increment in the sequence. A comparison of these data sets reveals that the 10µ" Au/XTRONIC® stack has equivalent electrical performance through all of the durability and environmental test increments.

Fig. 4 shows the data for the same finish used on both sides of the connector (PoR against PoR, and XTRONIC® against XTRONIC®).

GR-1217-Core Group 4: MFG Class IIA Like-Mated

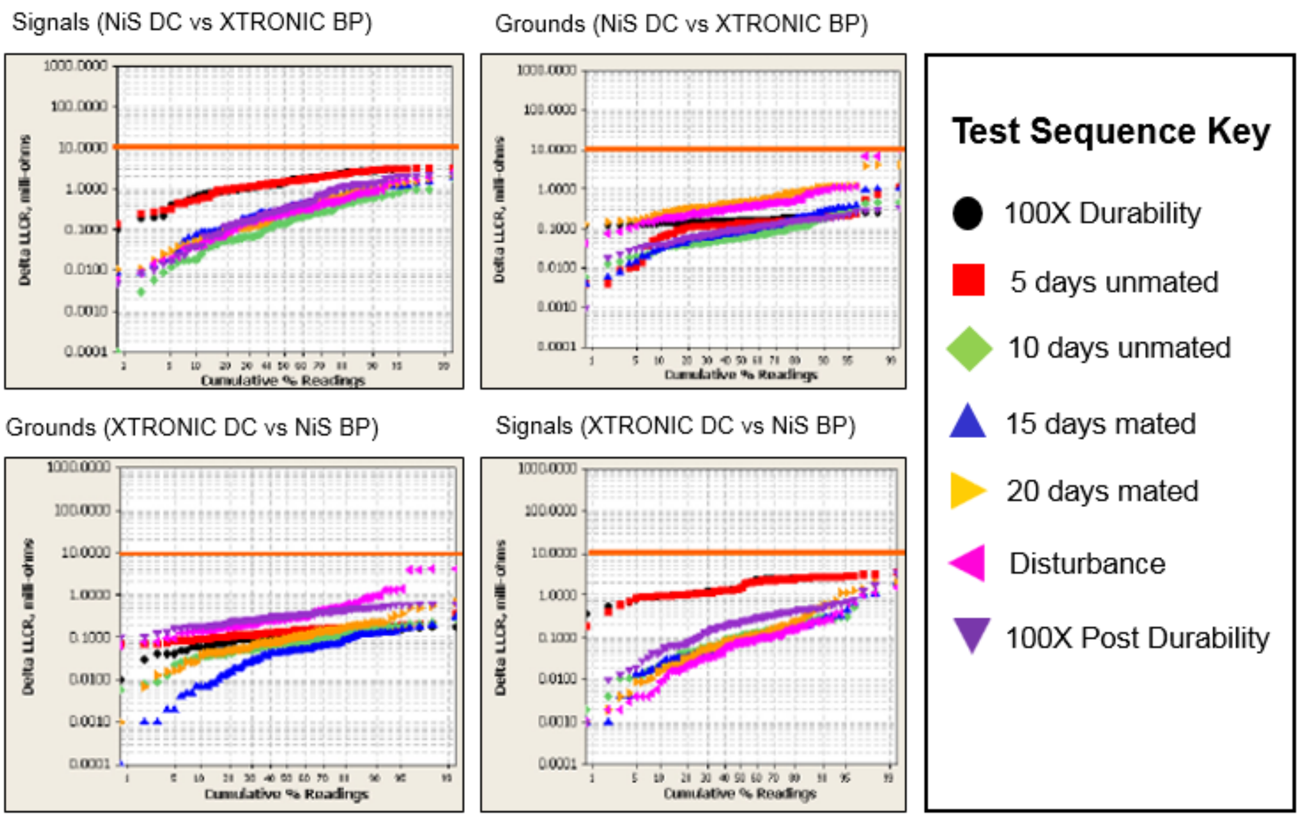


* All connectors pass the MFG sequence: ΔLLCR < 10 mΩ

Figure 4

Fig. 5 shows the data for the PoR on one side of the connector and mated against XTRONIC® on the other.

GR-1217-Core Group 4: MFG Class IIA Cross-Mated



* All connectors pass the MFG sequence: ΔLLCR < 10 mΩ

Figure 5

The use of XTRONIC® as a barrier layer in high-performance connector applications dramatically increases durability, corrosion protection, and product lifetimes. Customers take advantage of these XTRONIC® features to either increase end-product performance specifications or to maintain product performance while reducing connector material costs through the reduction of the amount of precious metal applied as a final contact finish. Customers can routinely reduce final contact gold thicknesses by 65-75%, resulting in 40-50% plated material cost savings per connector.

Path to Implementation

XTRONIC® can be introduced into existing production lines and equipment with only minor modifications. Capital investments in line modifications provide payback in two to three months or less of production. And since XTRONIC® requires a lower coating thickness than traditional barrier layers to achieve the same performance, higher production line speeds and increased productivity are often the result. Ongoing operating costs for XTRONIC® are the same as traditional nickel barrier layers, and are also usually lower than PdNi alloy coatings.

The implementation process for the XTRONIC® plating process is straightforward and fits easily into existing supply chains and product flow. Customer sample parts can be plated with XTRONIC® at either the Xtalic R&D center in Marlborough, Massachusetts, USA, or at any one Xtalic's partner production sites around the world. Production ramp-up is fast through an existing outsource production site. Or, if preferred, Xtalic can support the installation of the XTRONIC® technology into a customer's existing plating supply chain. All new installations are overseen by the Xtalic Technical Service team based locally near customer plating sites. At each new installation, Xtalic engineers conduct a thorough review and deliver a detailed plan before implementation. Once in production, the Xtalic team provides regular on-site support.

In production, Xtalic customers pay a fixed fee for each part produced. Xtalic ships all replenishment chemistry at no charge. Thus, customers pay no upfront costs for chemistry, pay only for the parts produced, and never face variability in their XTRONIC® production plating costs.

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