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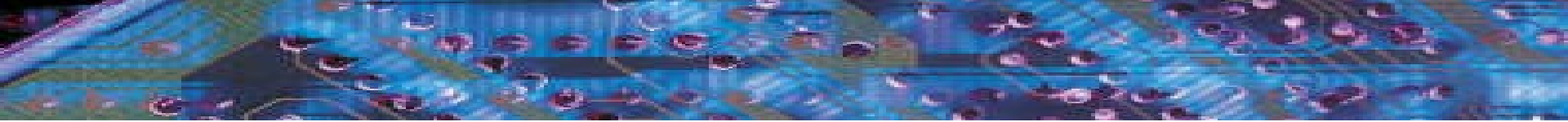
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Packaging's Role in RF and Micro-Electronics

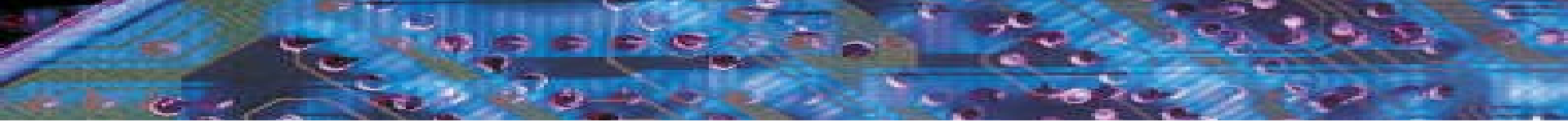
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The goal of this paper is to review advances in anti-Corrosion packaging in order to achieve enhanced protection for your high end electronics, because tarnish and corrosion does not only cause solderability issues, but also can increase the potential and probability of ESD events and are the reason for EOS - Electronic Overstress.

Changes in technology can be slow in the packaging world – but the demands on the packaging and what we need it to do are increasing. This industry cannot remain trapped in the packaging of the 50's, 60's and 70's. Even new barrier packaging still depends on technologies developed during these early eras



Need ESD packaging to also have Anti-Corrosion Protection that is effective not just at protecting against tarnish but also providing:

- Protection Against corrosive gases
- Permanent ESD protection – if you are not using ESD sensitive items the packaging needs to be ESD safe for the areas
- Compliance with European environmental regulations
- Ease of use
- Shelf life of 10+ years and long useful life
- RFID Compatibility
- Temperature independent: Effective -42oF to 160oF because of shipping and storage conditions around the world



Pollution – The Global Silent Killer

"A World Health Organization (WHO) report estimates that diseases triggered by indoor and outdoor **air pollution kill 656,000 Chinese citizens each year...** " [March 8, 2007].

“Air pollution is estimated to cause approximately two million premature deaths worldwide per year,” said Michal Krzyzanowski, an air quality adviser at the WHO Regional Office for Europe.

In neighboring India, air pollution is believed to cause 527,700 fatalities a year.

In the United States, premature deaths from toxic air pollutants are estimated at 41,200 annually.

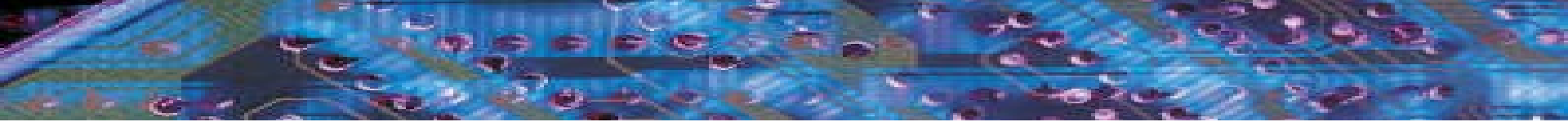
Kevin Holden Platt in Beijing,
July 9, 2007

for National Geographic News



It's an increasingly polluted world out there

- 27% of all deaths in China are now lung related
- If it is impacting tissue, what is it doing to metal objects, electronics?
- This pollution is not only impacting China – they are exporting it



Air Quality



- Images from May 2013 from Shanghai, before and after a heavy rain
- Last measurement of H₂S in the general area: 1,500 ppb
- Jointly with increased Cl levels on shore in Asia there are increased defects visible



Air Quality

The Air Quality in Asia is getting worse – and unfortunately it is impacting areas far from the shores of where the pollution originates.

Studies at the Waseda University in Tokyo show that humidity is not necessarily the prime culprit in non-ferrous (non-iron) based corrosion, but it's the pollution levels. In the case of electronics and the silver used in electronics, it's the level of Sulfur gases in the air that drive the corrosion rate.

H2S Levels Worldwide

Average Level USA	7 ppb
Average Level Europe	15 ppb
Brazil (Rio de Janeiro)	650 ppb
Shanghai, China (outdoors)	800 ppb
Suzhou, China (inside cleanroom)	1500 ppb



Air Quality

When looking at materials and what damages them, the same gases keep coming up. Controlling these gases you can positively impact assets.

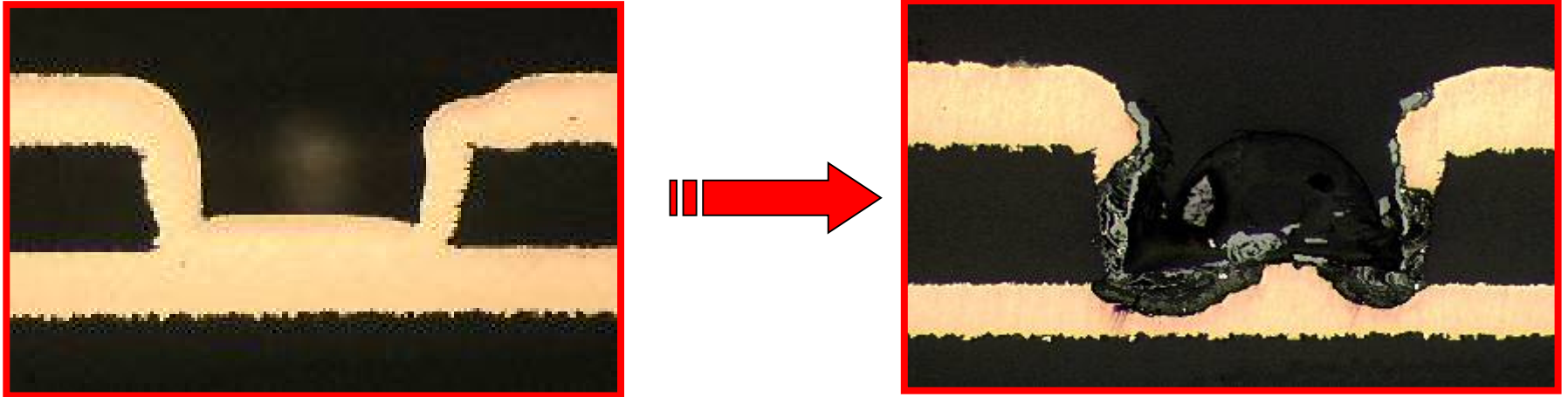
Metals	Rust/Corrosion, discoloration, staining & weakening from all corrosive gases .
Plastics	Strength loss & discoloration due to Ozone, UV Rays, & Nitrogen Oxides .
Rubber	Flexibility & strength loss due to Ozone, UV Rays, & Nitrogen Oxides .
Paint	Surface erosion by Sulfur Oxides, Hydrogen Sulfides & Nitrogen Oxides .
Fabric	Reduced strength & degradation by Sulfur Oxides & Nitrogen Oxides .
Paper	Embrittlement, degradation & discoloration by Sulfur Oxides .
Leather	Weakening & powdery surface by Sulfur Oxides .
Ceramic	Changing surface appearance by acid gases .
Digital/Magnetic	Changing surface topography by acid gases or erasure of data from electric fields .



Air Quality

Gas	Explanation
NO _x (Nitrous Oxide)	Effluent from gas powered vehicles – is an accelerant to corrosion
O ₃ (Ozone)	Ground level smog – is an accelerant to corrosion
HCl (Hydrogen Chloride)	Typically, high concentrations near ocean surfaces – can travel in high concentrations 50 miles or more from ocean
H ₂ S (Hydrogen Sulfide)	One of the most reactive forms of Sulfur gases
COS (Carbonyl Sulifide)	Prevalent near or on ocean surfaces – very reactive
SO ₂ (Sulfur Dioxide)	Requires particles in the air to be “reactive” – more of an issue in Asia, South America

Decreased Performance Increased Corrosion



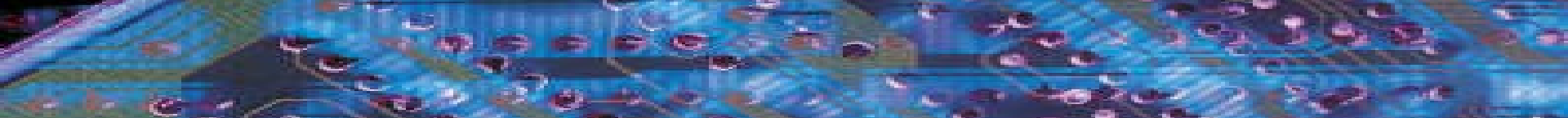
Based on actual shipment, RoHS compliant PWB with Via junction corrosion damage. Here an example of a board in storage for slightly over 6 weeks in India. China would / could be worse.

It was not ESD damage – it was corrosion



RoHS Threat to Lead-Tin Based Electronic Assembly Soldering Technology

- Future reliability of electronic assemblies is threatened by corrosion due to RoHS/WEE/Japanese Green trend away from lead based solder technology.
 - **See www.pb-free.info**
- Alternative immersion silver process is VERY sensitive to corrosion
- Asian PWB mfg sources may operate in environments highly corrosive to silver and gold processes
 - **800 – 1500 ppb H₂S levels (vs 7 ppb in No. America) are common in China and significantly accelerate corrosion**
 - **Storage/operating environments not always Temp & RH Controlled which accelerated corrosion and facilitates mildew growth**
- Corrosive shipping & end use environments further elevate corrosion rates
- Product failure and elevated warranty problems will likely escalate



RoHS - HASL Replaced by Corrosion Sensitive Immersion Silver Processes and Other Finishes

- Immersion Silver Process:
 - In higher density or frequencies, necessary spacing becomes tighter and extremely corrosion sensitive
- To conform to fine line spacing and in conjunction with RoHS, Immersion Silver process or other finishes (such as Immersion Tin or Nickel) will replace HASL
- Immersion silver process is highly sensitive to corrosion
 - Bell Labs tests show that bare PWB's that produced by Immersion Silver processes lose the Solderability in 6 months in No. American Region – considerably less time in more corrosive environments



Corrosion and Electronic Assemblies

- Reliability is adversely impacted by corrosion
- ESD events increase with corrosion
- Moisture accelerates corrosion
- Moisture also supports growth of mildew
- PWB solderability of is quickly degraded by surface attachment of corrosives/mildew

ESD susceptibility of electronics increases with corrosion

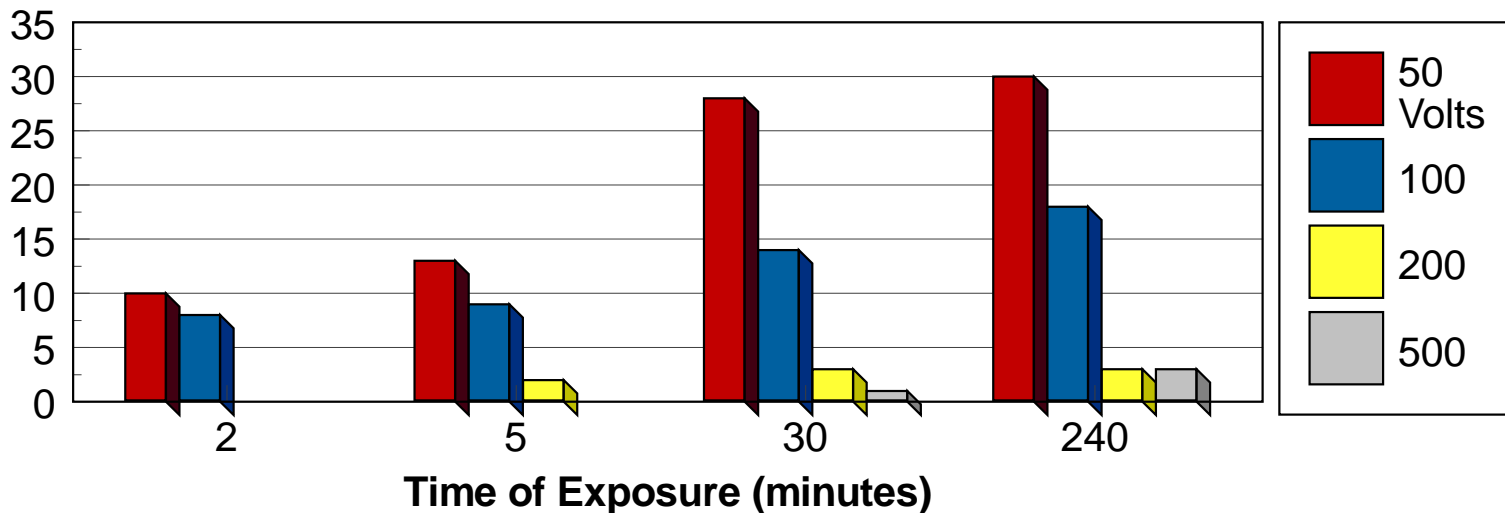
ESD Events with O2 Exposure

ESD Events in Generated Voltage

versus Time of O2 Exposure

(Testing of Copper Coupons at Bell Labs)

ESD Events



Test performed using CDM model

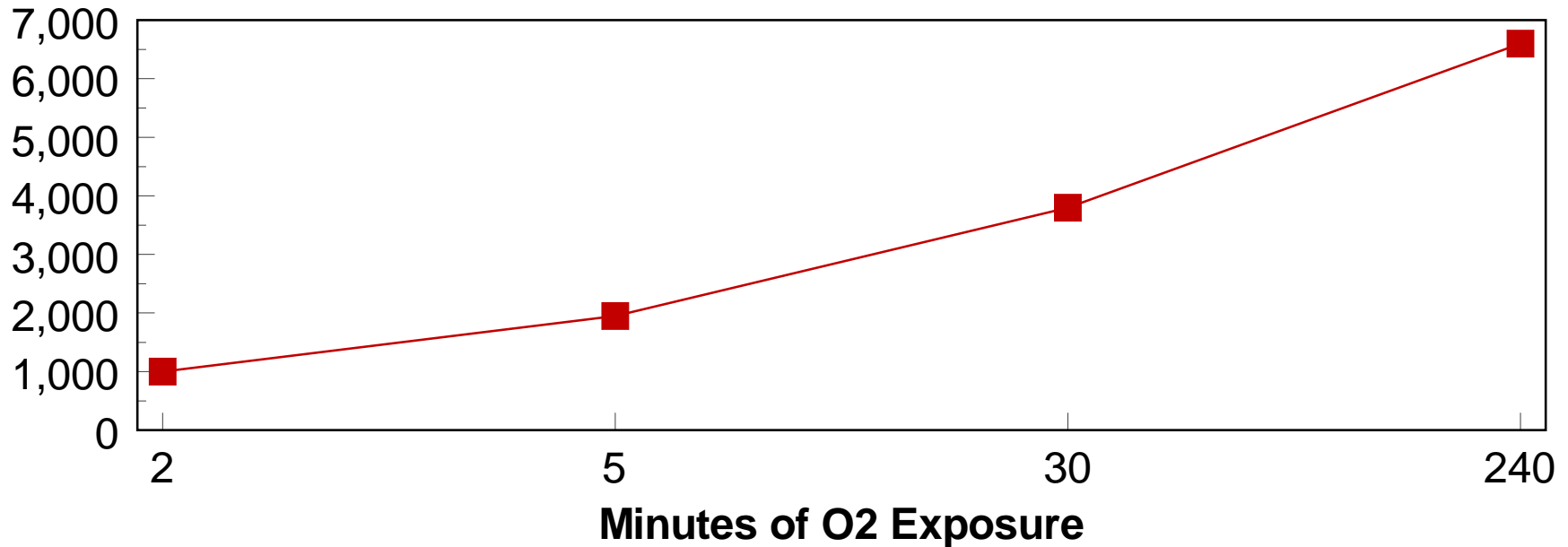
ESD events measured by Lucent Event Detector

ESD Events with O2 Exposure

Total Watts Discharged

(Testing of Copper Coupons at Bell Labs)

Watts of Energy (Peak Current)

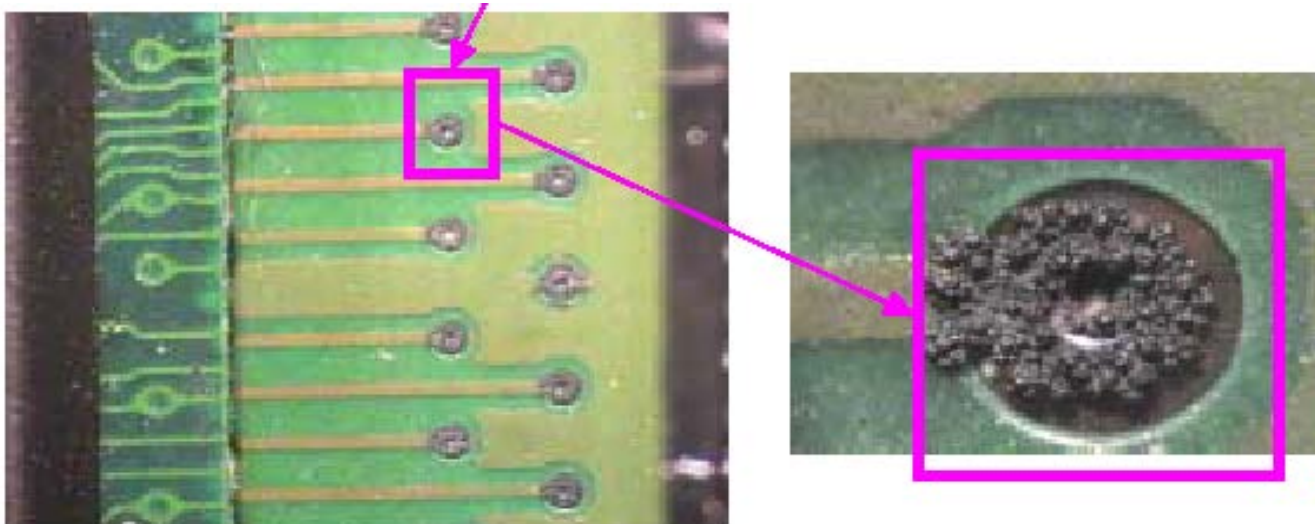


Behavior of this data is indicative of a logarithmic function
Previous research shows copper oxide films grow
at self limiting log rate - hence ESD is directly related



Corrosion Happens in 2% to 25% Faster Outside North American Region

Field failure





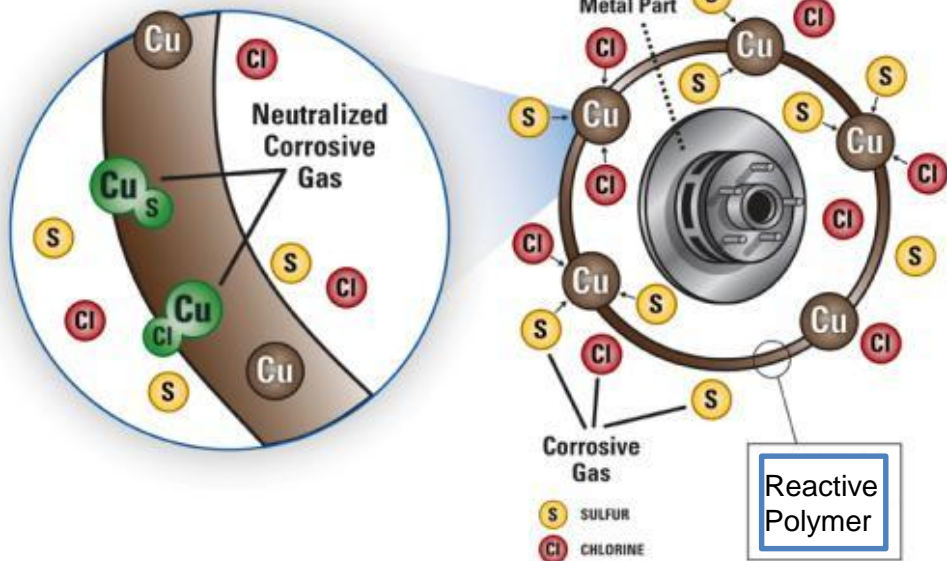
So... We need both ESD and Corrosion Control for Modern Electronics

There is a material that was developed by Bell Labs that is capable of providing both permanent ESD protection as well as long term corrosion protection – handling both sides of the demands being put on modern electronics. The material is a type of Reactive Polymer – providing solid state protection, using no volatiles or oils.

- Current ESD products have limited shelf life and use volatiles for their ESD protection
- Anti-corrosion products tend to water repelling oils – oils and contamination are not desirable for electronics

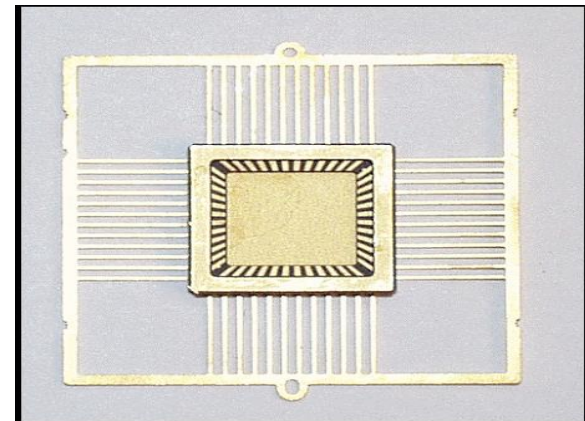
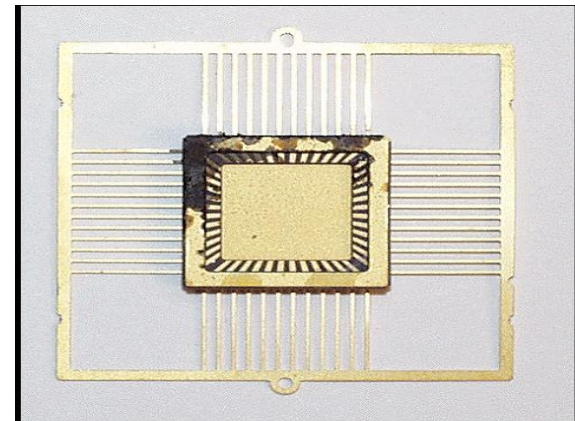
Reactive Polymer

Highly surface area copper particles are permanently reacted into a plastic matrix and permanently react with all corrosive gases and elements. The Technology was designed to protect all materials under all environmental conditions equally. The Technology protects ferrous (iron based) and non-ferrous metals, so no need for different bags for different materials.

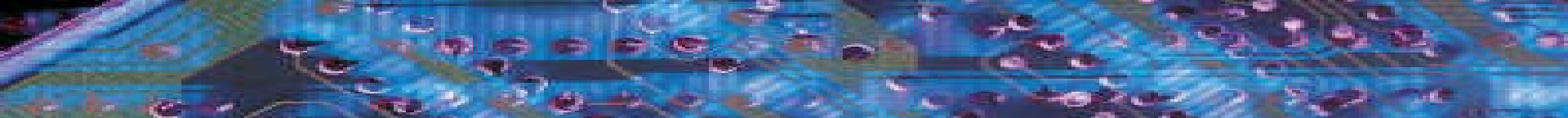


Reactive Polymer Corrosion Protection On Gold Plated Lead Frame

- Identical gold plated lead frames were placed in a moderate level sulfur chamber for two months. Top one was in standard ESD packaging, the bottom one was in a bag that has both ESD and anti-corrosion properties (Reactive Polymer). This is equivalent to 6 months in China.
- The Result?
The unprotected frame suffered serious undercoat corrosion and was rendered inoperable. The Reactive Polymer protected frame suffered no corrosion defects

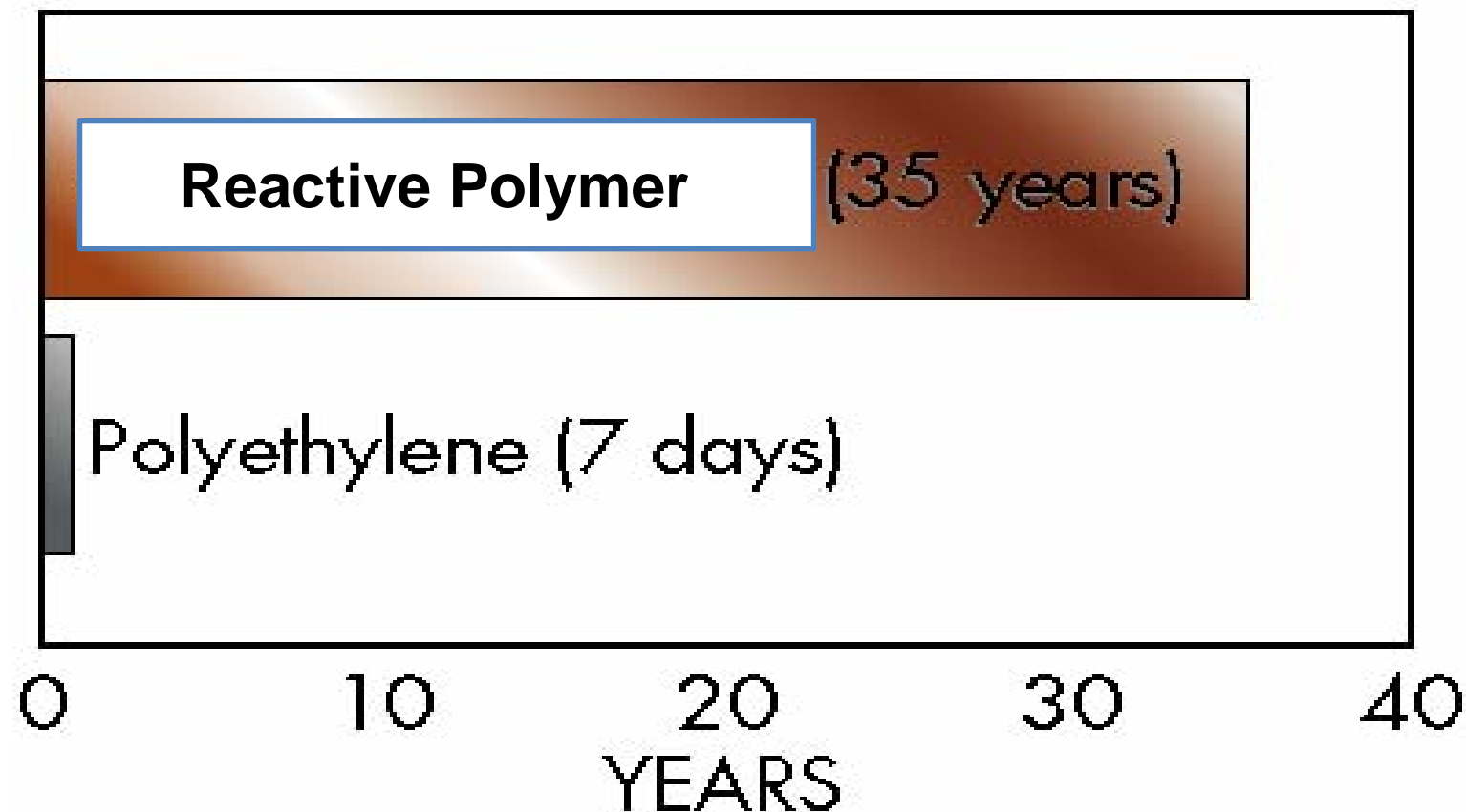


Reactive Polymer Protected



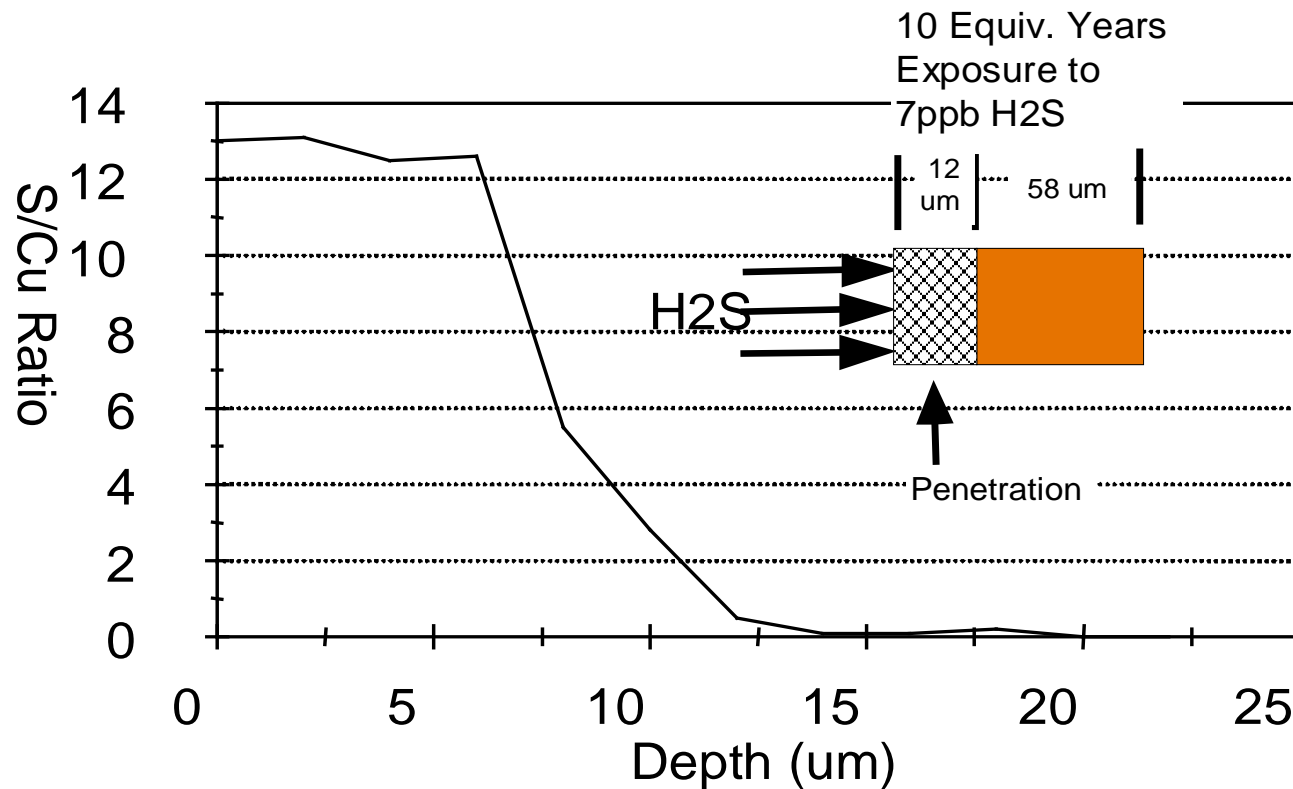
DuPont Chlorine Test

Years to breakthrough, 1 ppm Chlorine
Time chlorine takes to penetrate 2 mil plastic



Sulfur Penetration into 3 mil Reactive Polymer Film Test Using SEM-EDX (Scanning Electro-Microscope)

Reactive Polymer - Sulfur Penetration





Solderability – 168 Hour Salt Fog Test ASTM B117

RoHS Compliance - Silver

Corrosion / Contamination on the surface of Silver Coupon did not allow acceptable soldering

Comparison run simultaneously but protected in Reactive Polymer Bag



Samples sealed in Brand X bags



Figure 43 Coupon #16.



Figure 44 Coupon #17.



Figure 45 Coupon #18.



Figure 46 Coupon #19.

Samples sealed Reactive Polymer Bags



Figure 33 Coupon #1.



Figure 34 Coupon #2.



Figure 35 Coupon #3.



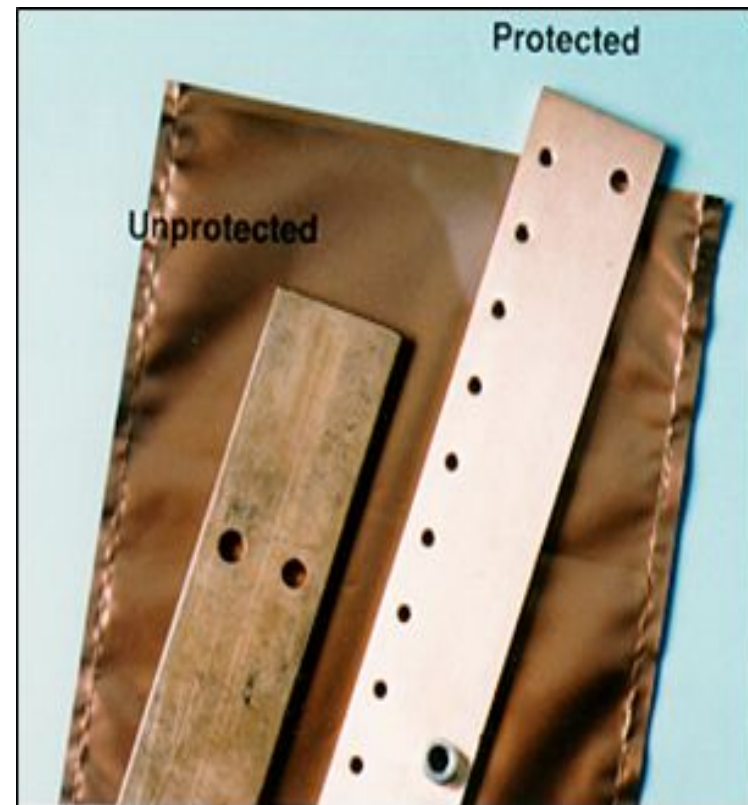
Figure 36 Coupon #4.

Solderability

Protects Even Copper and Tin

Due to the vast surface area of reactive CU particles, even similar metals will be protected.

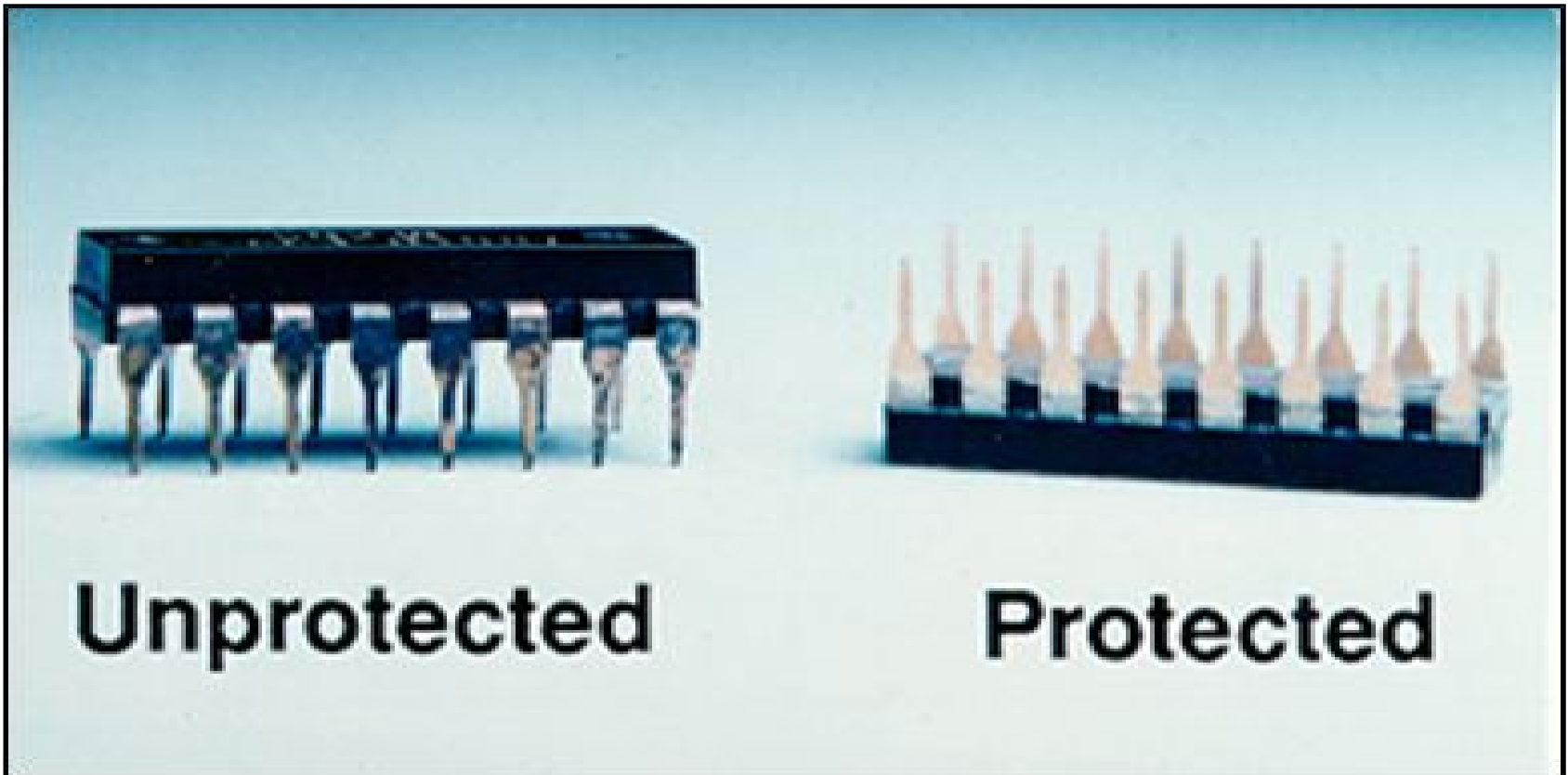
The picture show a trial of over 7 years of copper bus bars protected with 70 μ m (3 mil) Reactive Polymer



Solderability

Left – 6 months in a standard ESD bag

Right – Protected for 7 years in a Reactive Polymer Bag



RoHS - Compliance

Solderability Test



Control:
100% Coverage

**17 Years in Reactive
Polymer:** 95% Coverage

6 Months Asia:
No Solder Coverage
Even though full acid
cleaning and stored in
ESD Barrier Bag



Mold, Mildew and Bacteria

- Many molds and mildews secrete sulfur as a byproduct of respiration
- Intel was having mold and mildew issues on de-commissioned tools being put into storage
 - Testing showed Reactive Polymer would resolve the issue
 - Intel Crating Spec 2.0 switched from foil packing to Intercept which corrected the problem
- General Dynamics in the UK has seen an increase in the bio-burden on the electronics coming in from Asia (higher numbers of bacteria, mold, mildew)
 - Bacteria and mold/mildew cannot reproduce in the presence of Copper
 - Intercept has been shown to kill bacteria and the bio-loading coming in on electronics
 - Shielding bags nor foil have no ability to kill mold, mildew or bacteria



Properties and requirements	Reactive Polymer	Foil Packaging
Maintains corrosion protection if not hermetically sealed Maintains corrosion protection if folded or creased	Yes Yes	No No
Permanent ESD Protection (required since even components often go or are staged in ESD sensitive areas)	Yes	No
Provides protection against mold and mildew	Yes	No
Recyclable – Re-usable – Re-closable	Yes	No
Provides reactive barrier to corrosive gases (atmospheric pollution)	Yes	No
Humidity independent ESD protection	Yes	No
Clean, easy to use and will not cause cuts due to handling	Yes	No



Reactive Polymer vs Foil

- Permanent ESD protection
 - Humidity independent
 - No volatiles, no VOC' s
- Corrosion protection does not require hermetic seals or controlled RH under 37%
- Made up of Copper and LDPE – the level of Copper is below European REACH levels as well as US levels so can be simply be recycled as a colored PE
- Re-use is encouraged and designed into the product
- **Permanent, humidity Independent ESD Properties / Recyclable / Reusable / Provides long term corrosion protection**
- **Green Packaging**
- **ESD protection is key not only to what is being protected but what is around it (field effects)**
- The ESD and Corrosion protection have shelf life and VOC issues
- ESD properties impacted by moisture, low humidity, temperature, storage conditions
- They have not been shown to preserve solderability
- Requires hermetic seals and an absolute need to be kept below 37% protection
- Does not work if seal is broken
- Not designed nor recommended for re-use
- Any gases closed inside remain inside the package / does not do anything in protection from mold
- **ESD Properties Temporary / Not reusable**
- **Not Green Packaging**



Ionic Contamination

An-Ions
(Tested by Balazs Labs, USA)

An-Ions	Limits	RIBS /SI
Fluoride	0.8 ng/cm ²	Not detectable
Chloride	0.1 ng/cm ²	Not detectable
Nitrite	0.1 ng/cm ²	Not detectable
Bromide	0.2 ng/cm ²	Not detectable
Nitrate	0.2 ng/cm ²	Not detectable
Phosphate	0.2 ng/cm ²	Not detectable
Sulfate	0.2 ng/cm ²	Not detectable



Ionic Contamination

Cat-Ions-Measurement
(Tested by Balazs Labs, USA)

Cat-Ions	Limits	RIBS/SI
Lithium	0.1 ng/cm ²	Not detectable
Sodium	0.1 ng/cm ²	Not detectable
Ammonium	0.2 ng/cm ²	Not detectable
Potassium	0.2 ng/cm ²	Not detectable
Magnesium	0.2 ng/cm ²	Not detectable
Calcium	0.2 ng/cm ²	Not detectable



Summary

- The world is getting more polluted – these pollutant gases not only impact people, but also electronics
- Packaging has not kept up with advancements in electronics
- Its no longer acceptable just to protect against ESD
- Corrosion / Tarnish not only impacts solderability, it can also increase the chances and severity of an ESD event
- Standard ESD packaging protect against static and ESD events but do not protect against corrosion
- Technology developed by Bell Labs using Copper reacted into a polymer matrix created a new class of material
- This new PE material generically falls into a new class called Reactive Polymers
- Reactive Polymers can protect against both ESD and Corrosion, providing a new and balanced packaging scheme



Simply Better Protection

Anti-Corrosion • Anti-Rust • Anti-Mold & Mildew • Anti-Static

For more information:

www.LibertyPackaging.com

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Better for Assets • Better for Personnel • Better for The Planet