Cirrus Dopant

Nano-Composite Coatings

- Supports electrolytic & electro-less baths
- Maintains coating functionality
- Adapts to a wide variety of coatings, substrates and finishes
- No handling of nano-particles / powders

A *drop-in additive* to standard plating baths that produces nano-composite coatings without alteration to the existing plating process.

Glen Slater, Cirrus Materials | Stephen Flint, Auckland UniServices Ltd

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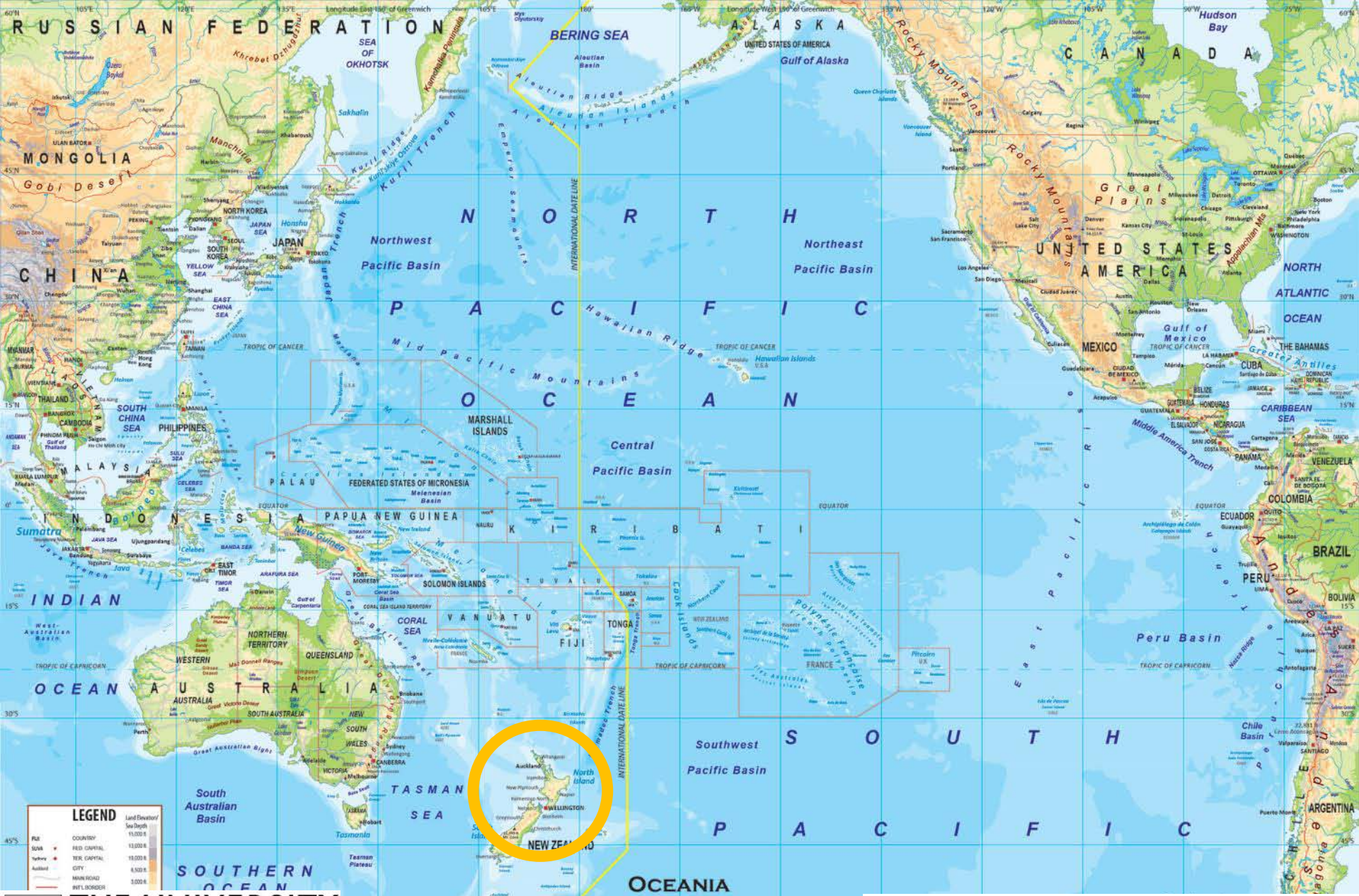

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Plan

- Introducing Cirrus Dopant
- How it works
- What it does
- Development path

Cirrus Dopant

- One-step additive for electrolytic/electroless
- Nano-particles form in the plating bath
- Nano-reinforced composite coatings with superior mechanical performance
- No handling of nano-powders or nano-materials

Curiosity-led Discovery

- Challenge - create “metal-ceramic matrix” nano-composite coating?
- Addition of nano-particles as powder to plating bath:
  - Particle Agglomeration and Precipitation
  - Agitation & Time
  - Handling nano-particles in the environment

Commercially-led Development

- Avoid expensive alteration to plating lines or standard processes.
- Be compatible with wide range of plating formulations and coating types.
- Easily adopted in both large scale manufacturing & in job-shops.
- Complementary to other coating improvement and nano-technologies.
- Ability to meet regulatory requirements.

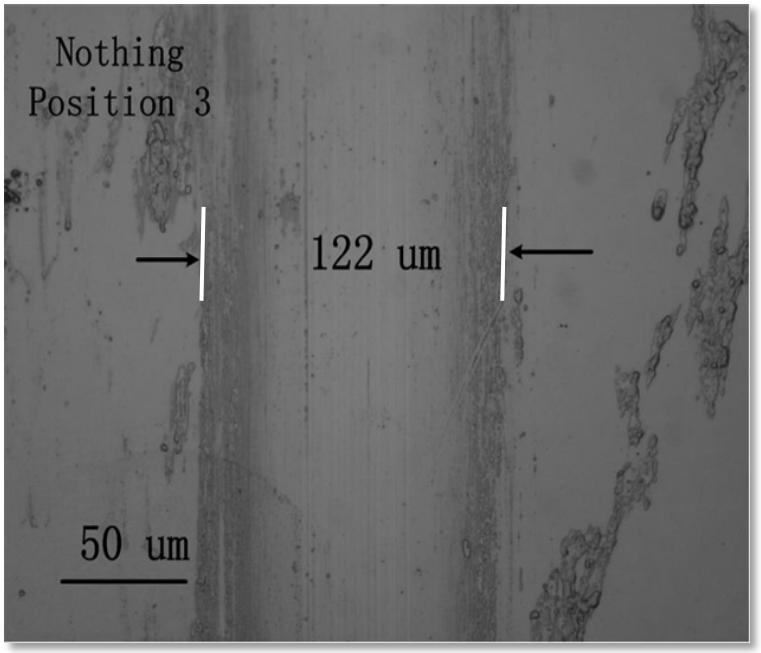
Investigate adjacent technology …

- Nano-coating technology – sol/gel
- Aim to unify two well understood technologies
- **Stopped trying to "add" nano-particles to plating bath.**

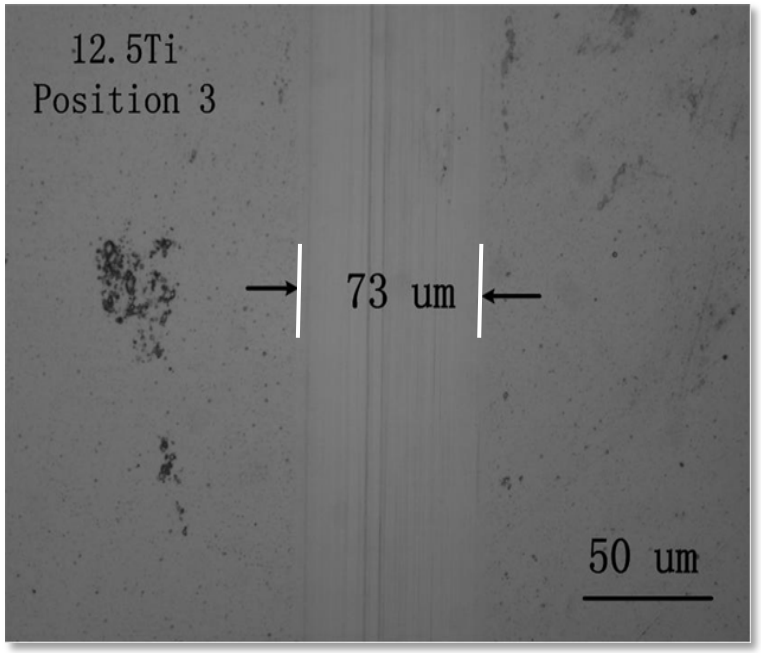
- 22k gold coatings
- Develop Ti dopant for decorative gold – pour in and plate
- Addition of <2% vol. dopant to produce 40% increase in wear & scratch resistance
- Smoother, less porous coating
- No change to conductivity, plating process, or coating appearance.

Focus on Au

22k Au – hardness 287Hv



Cirrus Ti doped 22k Au – hardness 356Hv

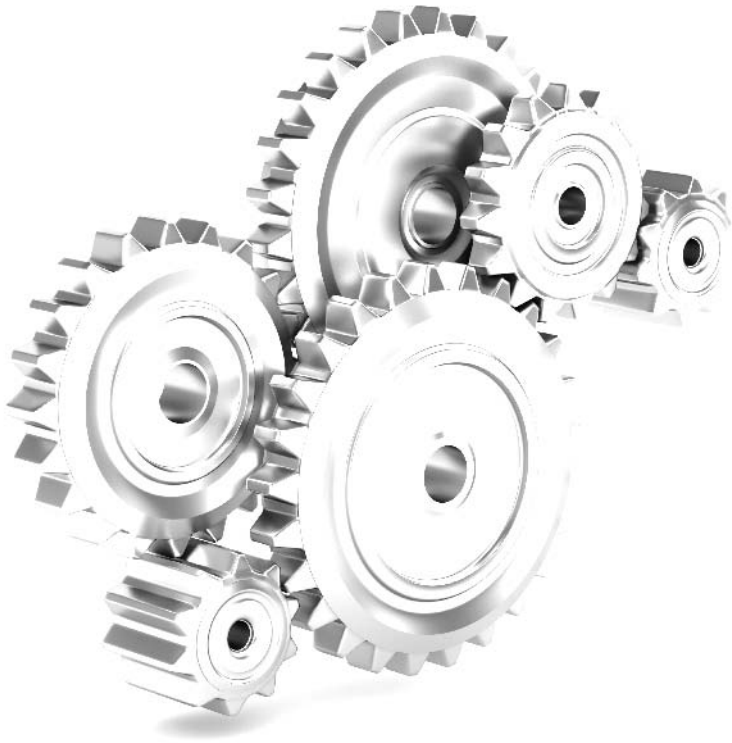


2 microns - 22k pulse plated Au on brass

Focus on Au

How it works ...

- The first step is to understand the bath …
- Particle creation process held in stasis until the dopant is added to the bath
- Determine addition, consumption, maintenance rates for each bath + dopant process
- Can be shipped by air freight, and is stable in storage at room temp for 3 to 6 months
- Nano-particles consumed more slowly than metals, so single addition lasts multiple metal turns
- Dispersion strengthening & grain refinement



Cirrus Dopant R&D progress so far …

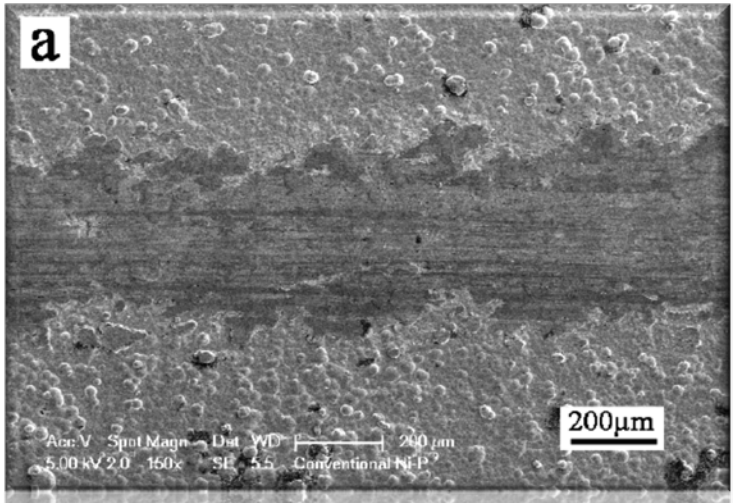
Process	Dopant	Nano-particles	Coatings
• Electroless • DC Plating • Pulse Plating	• Aqueous • Organic • Inorganic	• Ti • Zr • Al • Zn • Yr • Si	• Au • Ag • Sn • Cu • Zn • Ni • NiB • NiCo • NiP

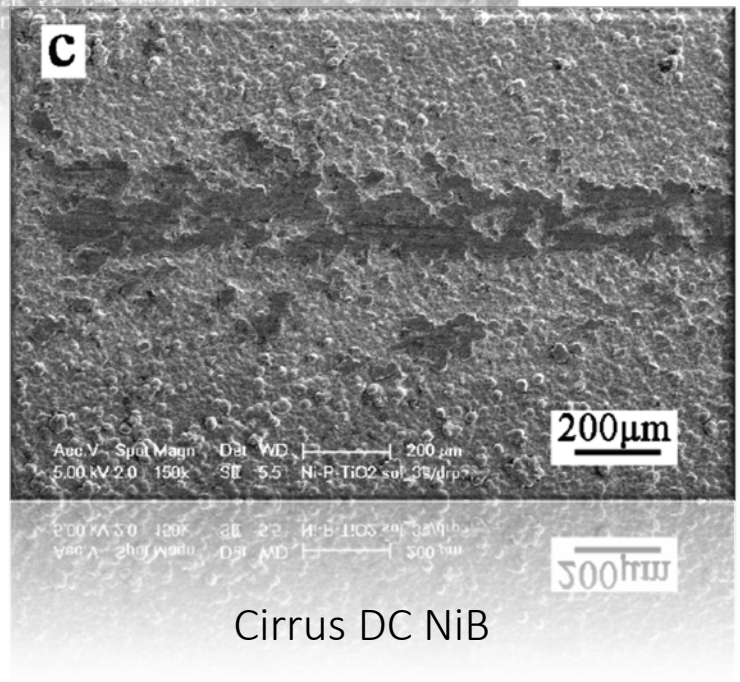
cirrus Broadened Application beyond Au

… all with industry partners …

… all with commercial baths formulations.

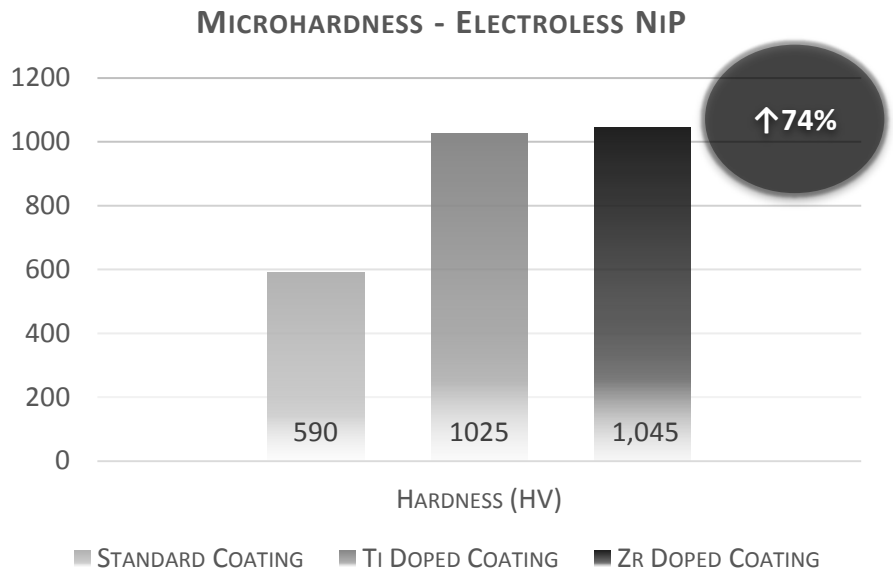
Standard DC NiB





Cirrus DC NiB

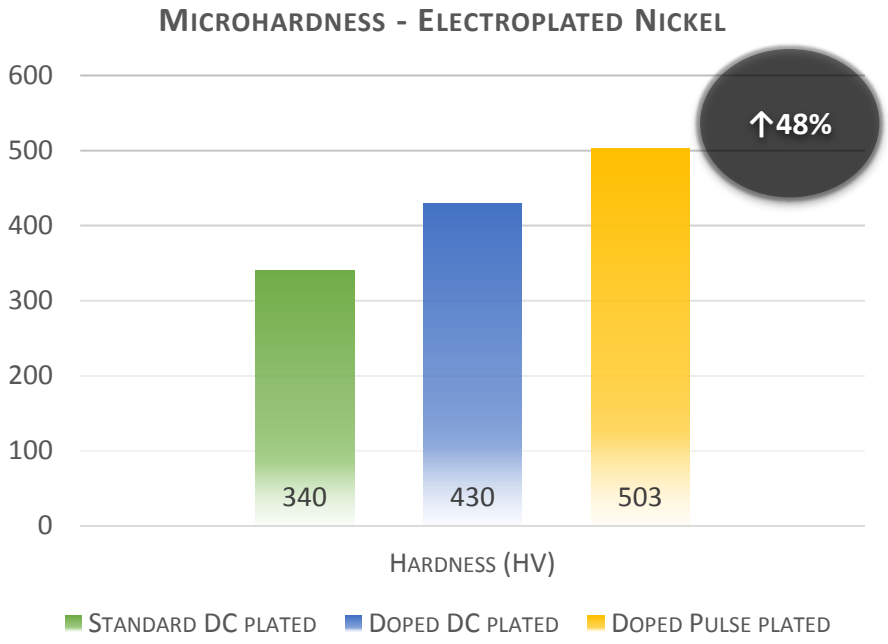
cirrus wear resistance

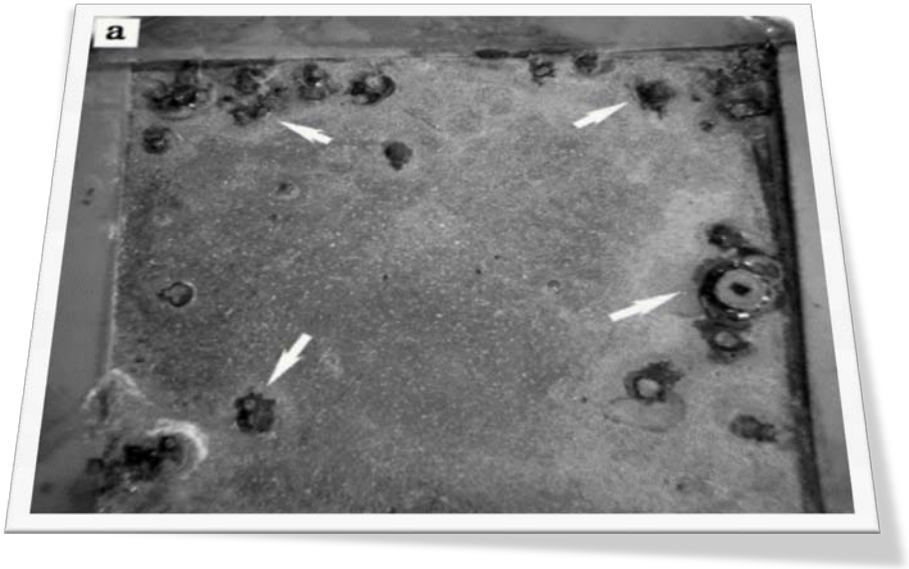


15 microns Electroless Nickel Phosphorus versus cirrus Zr nano-composite Nickel Phosphorus on Magnesium

cirrus corrosion resistance

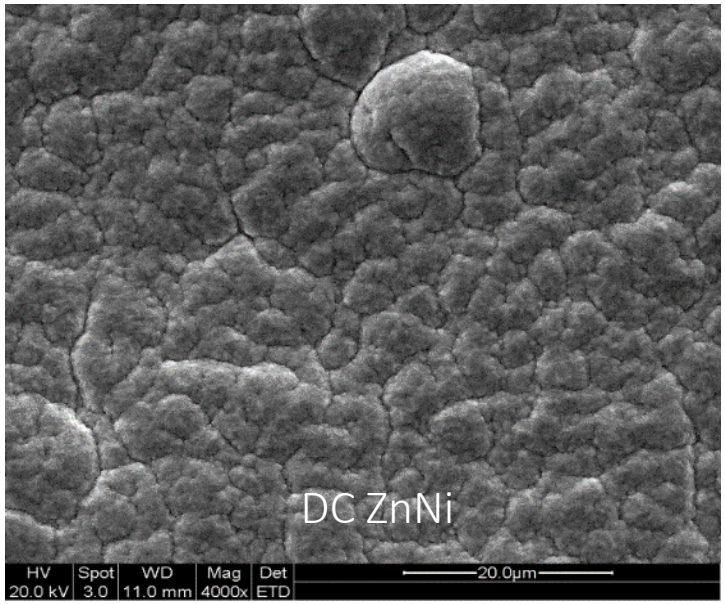
15 micron duplex Nickel versus cirrus Ti nano-composite Nickel on Mild Steel

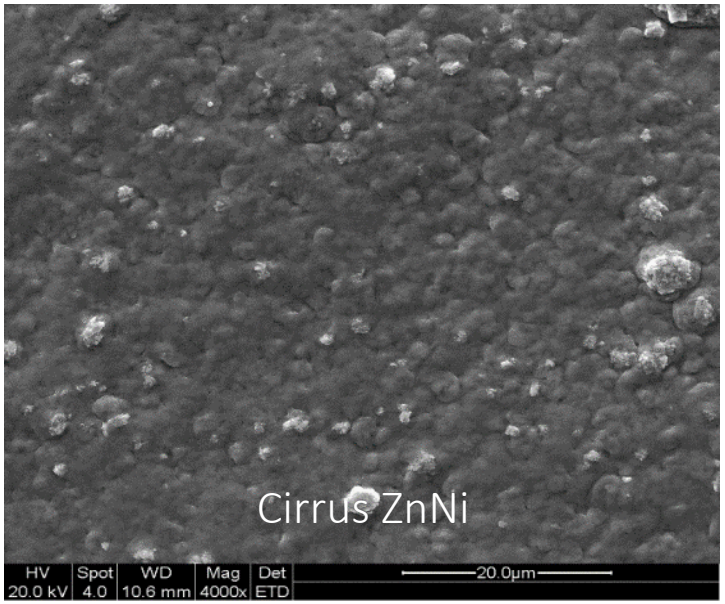




Duplex Ni

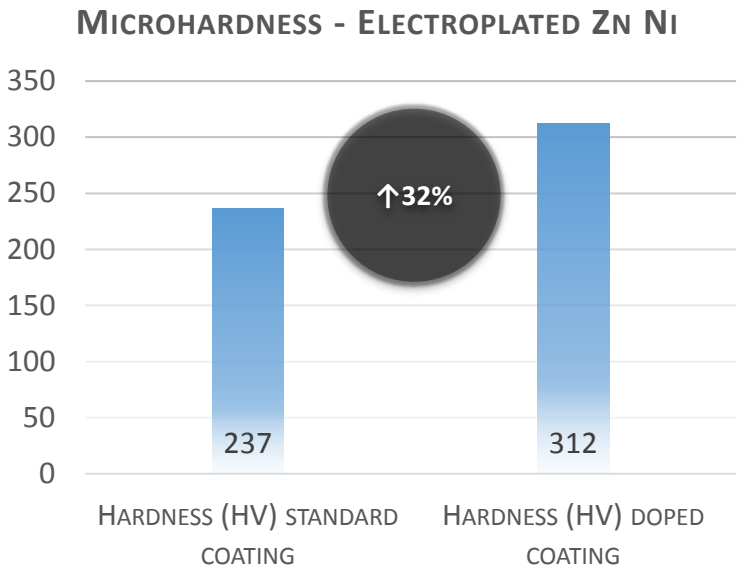
Cirrus Ti doped Ni

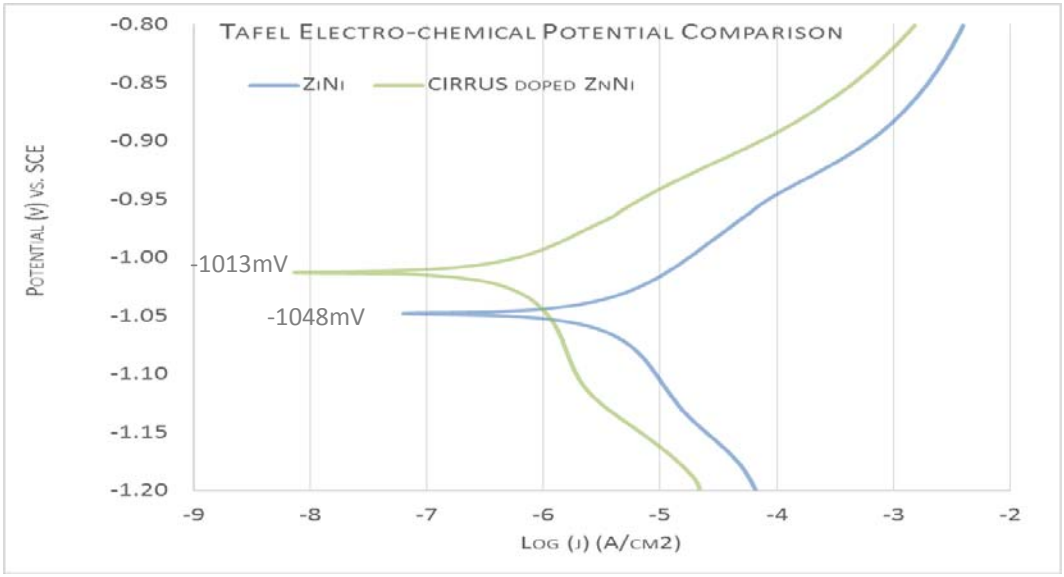




ZnNi

10 micron ZnNi versus cirrus Al nano-composite ZnNi on Mild Steel





Current Test Applications

- Harder, stronger plated coatings across wide range of materials
- Creates potential to substitute less costly coatings, or produce longer lasting coatings.
- Fine with heat treatments – some increase in thermal stability
- No change in coating functionality (corrosion resistance, conductivity etc.) or appearance.

cirrus nano-composite coatings

Summary

- Low volume, simple, drop in additive to existing plating process
- Softer coatings become more durable – hard coatings get harder
- Potentially changes performance expectations of wide range of electroless & electrolytic coatings
- New technology – focus is on niche applications where Cirrus can have impact
- Early stage – seeking industry partners for co-development

Thank you

Glen Slater, Cirrus Materials