

Electrolytic Plasma Processing for Sequential Cleaning and Coating Deposition for Cd Plating Replacement

**SERDP Project
Initiated in August 2004**

**Overview Presentation
HCAT Meeting
January 2006**

Bruce Sartwell

Naval Research Laboratory

Stathis Meletis

University of Texas

Aleksey Yerokhin and Allan Matthews

University of Sheffield, UK

Edward Daigle and Pankaj Gupta

CAP Technologies LLC

Vic Champagne and Scott Grendahl

Army Research Laboratory

Cid Richards (Naval Air Depot North Island), Tony Pollard (Anniston

Army Depot), Craig Edwards (Ogden Air Logistics Center)

Keith Legg

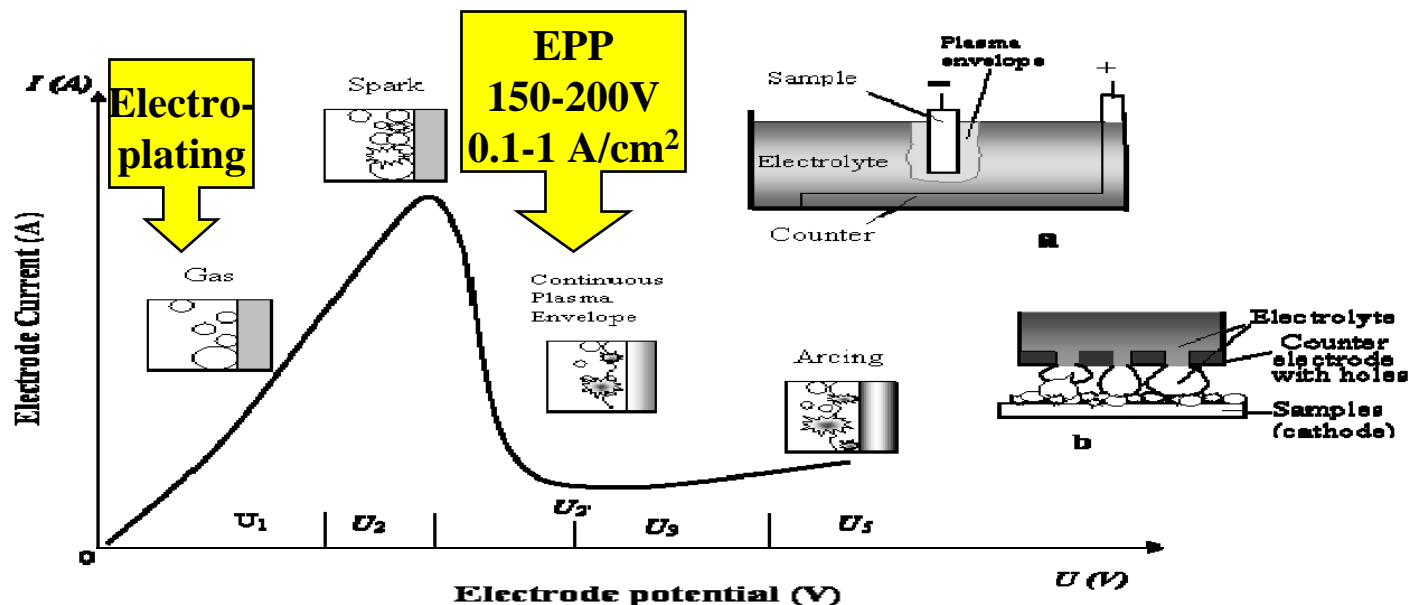
Rowan Technology Group

Technical Objective

Develop electrolytic plasma processing technology as an environmentally benign process for:

- **Surface cleaning of high-strength steels in preparation for coating application**
- **Application of coatings exhibiting properties equivalent or superior to cadmium plating on high-strength steels**
 - **Capable of uniform deposition on internal surfaces and complex geometries**
 - **Does not degrade performance characteristics (e.g., fatigue) of base steel**
 - **Does not cause hydrogen embrittlement**

- **EPP is an aqueous process involving two phenomena**
 - electrolysis of liquid by high potential (200V vs a few V for plating)
 - production of a plasma at or in the vicinity of the cathode (workpiece)
- **Figure shows typical current-voltage characteristic curve**
 - most electroplating operates in U_1 gas generation region
 - EPP operates around U_2 , where continuous plasma envelope forms on surface
- **Near-surface heating due to plasma enhances cleaning but bulk temperature remains relatively low**



Technical Approach – Year 1 Cleaning

Study the characteristics of EPP-cleaned surfaces by varying process parameters to understand and optimize their effect

Motivation is not only the degree of surface cleanliness obtained but also the surface morphology and impact on properties of HSS

Property/Characteristic

Oxide thickness, organic contamination

Surface morphology (roughness)

Heat-affected zone thickness/ μ structure

H content near surface

H embrittlement

Residual stresses near surface

Methodology

SEM/EDAX, AES, XPS

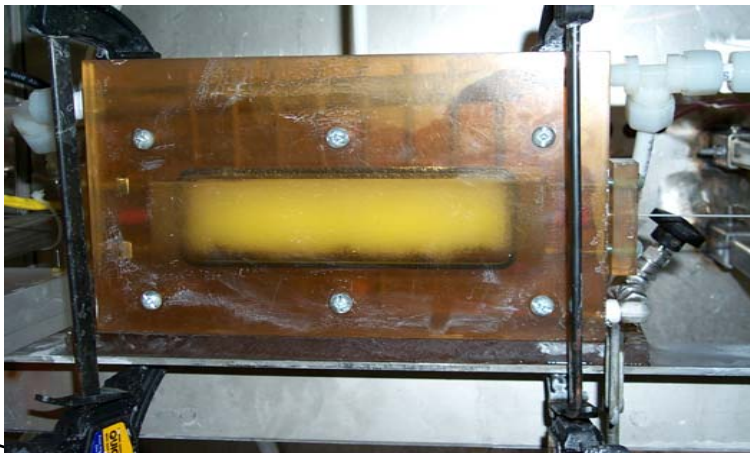
Optical profilometry, SEM

Xsection TEM and microhardness

Nuclear reaction analysis

ASTM F519 test

low-angle XRD



Reactor at CAP Technologies for studying cleaning and coating deposition

Develop capability for deposition of Al, Zn-Al, Zn-Ni and Zn-(Al-O/OH) composite coatings by varying process parameters to determine effects on composition and required performance characteristics

Motivation is to determine ability of EPP to deposit different coating compositions such that performance characteristics can be modified depending on in-service applications

Property/Characteristic

Thickness uniformity, morphology

Composition, porosity

Microstructure

Residual stress

Adhesion

Microhardness

Methodology

SEM, optical profilometry

SEM/EDAX (plan-view or Xsection)

TEM

XRD

ASTM D4541

Vickers or Knoop indenter

Measure performance characteristics of coatings developed in first year in comparison to cadmium plating and determine effects on base HSS material

Property/Characteristic

Hydrogen embrittlement
Electrochemical evaluation
Salt-fog corrosion behavior
Fatigue
Wear
Torque/tension test (fasteners)

Methodology

ASTM F-519 test
Anodic polarization
ASTM B117 test
ASTM E466 axial test
Pin-on-disk test
ARL-developed test

If previous studies prove efficacy of process related to coating performance and impact on base material, then:

- **Demonstrate process for cleaning and coating of external and internal surfaces, and complex geometries**
- **Demonstrate process on selected components obtained from Naval Aviation Depot North Island, Ogden Air Logistics Center, and Anniston Army Depot**
- **Generate conceptual design of prototype EPP cleaning/coating system that could be utilized as a demonstration unit at a repair depot**