DEVELOPMENT ON METAL SURFACE CLEANING USING NOVEL ELECTRO-PLASMA PROCESS (EPP)

M.A. Wahab*#, Jiandong Liang*, and S.M Guo*

*Dept. of Mechanical Engineering, Louisiana State University, Baton Rouge, L.A. 70803, U.S.A.
*# Contact Person; E-mail: wahab@me.lsu.edu, Telephone: 1 225 578 5823

Introduction:

For decades, plasma discharge in electrolyte has been studied and used for its high efficiency and the suitability of the unique surface morphology after treatment. This project is to develop a new approach to control the power level associated with EPP for controlled surface microstructure preparation. In the conventional electrolytic plasma process, EPP induces plasma on the metal surfaces by overcharging the liquid-gas phase till the breakdown voltage or working voltage, which is often larger than breakdown voltage when the plasma becomes stable. The characteristic current-voltage behavior was reported earlier (Yerokhin 1999, Gupta 2007). Electrolyte concentration is commonly used to control the onset of electro-plasma. The authors believe that the EPP can be determined by several other crucial parameters, e.g. temperature and pressure. In this paper, the characteristic parameters like threshold voltage and current density are presented under different working pressures.

Pressure of a gas phase is important in plasma physics, which usually studies the plasma in single gas phase. Paschen's Law states that the breakdown voltage of a gaseous volume varies with the value of the product of the pressure and the gap-distance until some extension (not correct for pd>200 Torr.cm, when Townsend's avalanche mechanism is valid) (Bazelyan & Raizer,1997). Thus in the regime of this Law, the breakdown condition could be controlled by altering the working pressure and the electrode gap. As for EPP, multiple phases are involved, but the basic physics of ionized gas still applies, except that the case could be more complicated. By varying the breakdown condition, the discharge energy exerting on the substrate could vary and hence the resultant surface morphology varies. This study reports the difference in the resultant surface and process parameters between atmospheric EPP and the pressurized EPP (pressure > 14.7 psi).

Experimental Program:

Conventional Contact-Glow-Discharge-Electrolysis (CGDE) configuration has been adopted in this experimental study. The sketch of the circuit is shown in Fig. 1. Then the solution bath, together with the electrodes was enclosed in a chamber, which could be sealed and pressurized (Fig. 2).

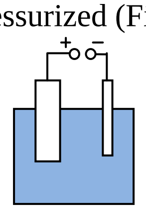

Fig. 1: Sketch of CGDE

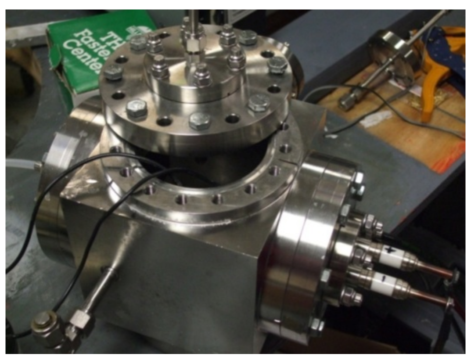

Fig. 2: EPP assembly

The cathode materials used in the tests are aluminum plate (Al-1100) and low carbon steel plate (1008/1012 carbon steel). They are shaped into the same size (0.3 mm x 3.0 mm x 12.0 mm). All cathode materials are sand-blasted on one side only. The anode material is a mild steel slab (10mm x 40mm x 100 mm). This electrode arrangement ensures that the plasma appears on the cathode surface (Sengupta & Singh, 1981). The solution was made with 10g of Na_2CO_3 dissolved in 200 ml. of H_2O and the electrolyte conductivity is in the vicinity of 30.50 mS. Power supply is a DC current source (Magna Power PQA 250-26, Maximum voltage 250V, Maximum current 26 A).

Result and Discussion:

As expected, the current-voltage curves shift with increase of environmental pressure, so does the power density, Fig. 3. At all three pressure levels, the initial electrolysis follows Ohm's law. After the gas liberation reaches a certain level, where the gas sheath covers most of the surface area; then the current voltage behavior is dependent upon the resistance of the gas sheath. And obviously environmental pressure affects the density of the gas sheath and thus in turn, it modifies the electric breakdown of the gas layer.

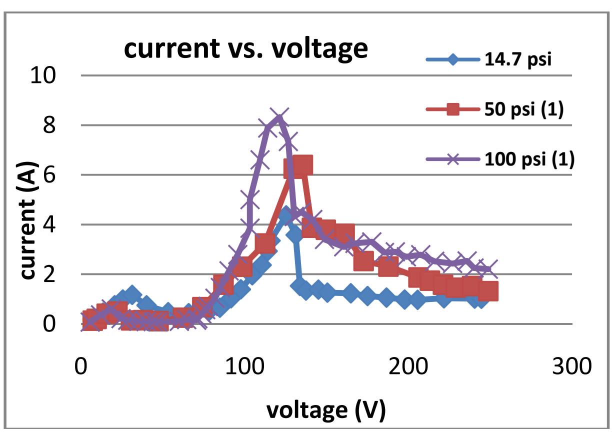

Fig. 3a: Current-voltage curve with different pressures

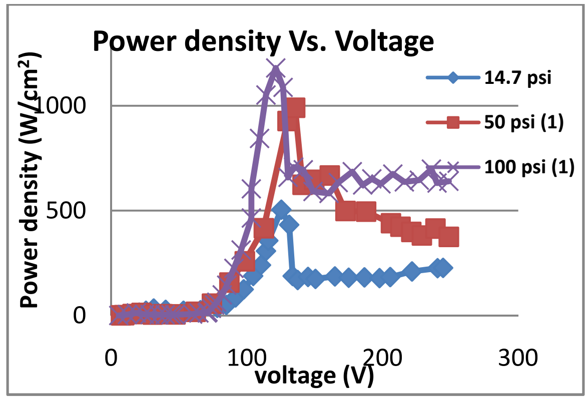

Fig. 3b: Power density vs. voltage

Conclusion:

The aluminum and low carbon steel plates were tested as the cathode in a pressurized EPP process. The resultant current and power plots indicate that the required breakdown condition rises with elevated environmental pressure and then the resultant surface morphology could be predicted to vary as well.

Reference:

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