Instrument for Continuous Monitoring of Individual Anode Currents in a Plating Bath

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An important plating parameter that is not usually continuously measured is the current flowing from each anode of an electroplating system. This instrument provides simultaneous visual display of ten or more anode currents. A deviation from normal current distribution between anodes is quickly noted by an operator glancing at the instrument panel. Exact current from any anode can be displayed by changing a switch setting, or can be remotely logged by a computer system through an I/O connector. Data will be presented indicating effectiveness in detecting common anode problems.

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Introduction

Most electroplaters measure the total current in a bath by means of the main ammeter in the power supply or possibly the current at individual tanks served by the same power supply. Plating current is obviously an important parameter to monitor and is convenient to measure at the power supply or at main current buses. Total current, however, will not indicate how the current flows to each work piece. For example, a problem with one anode may have little effect on total current but will adversely affect the quality of the finish on work pieces near the anode with diminished current. Another example is that if the set up of the work pieces with respect to the anodes and baffles is not correct, the plater will not have uniform finish thickness. Knowing the total current does not help troubleshoot either of these problems.

An instrument has been developed that will monitor the individual anode currents. Measurement and display capabilities of this instrument are presented. Typical anode problems are simulated, and the resulting individual anode currents displayed and analyzed.

Description of Anode Current Monitor

It is important to insure that the anode current sensors do not disturb the electrical current path. Toriodal ferrite rings were used with Hall Effect sensors, similar to the DC clamp-on ammeters used by many platers to spot check currents. The anode wire passes through the inner diameter of the toroid which is 2.54 cm (1.00 in). These sensors are commercially available from F.W. Bell and from Honeywell/ Microswitch. The high permeability ferrite torus captures the magnetic field from the current in the anode wire. A Hall Effect magnetic field sensor is placed in a slot cut through minor diameter of the torus.

A cable connects each current sensor to a central control unit which simultaneously displays ten anode currents. Currents are displayed by two methods. One method is a twenty segment vertical bar graph that provides a continuous display of all anode currents. Another method is to scan and display each anode current on a digital meter. The bar graph shows a quick qualitative view of all the anode currents, while the digital display indicates exact current if desired.

The front panel of the control unit is shown in Figure 1. The Anode Current Monitor shown has a display

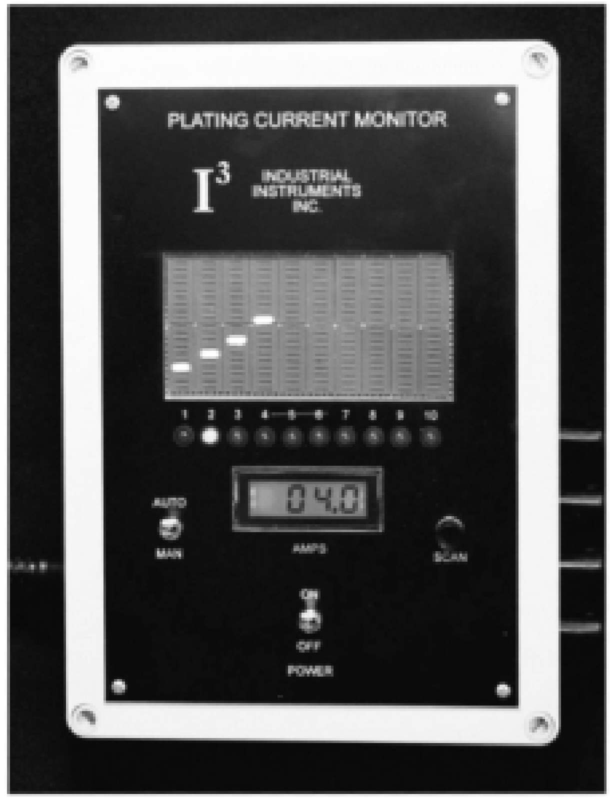

Figure 1. Front Panel of Anode Current Monitor control unit.

for ten anodes although only four are connected and displayed. An LED under each bar graph is illuminated when that anode's current is shown on the digital display. In this case, the current in Anode #2 is 4.0 A. The stair step current pattern in Figure 1 is for four adjacent anodes with the cathode offset to one side. As the anodes become closer to the cathode, the current increases.

Experimental Set-Up and Results

A plastic tank with dimensions 46 cm (18 in.) x 30 cm (12 in.) x 25 cm (10 in.) depth is used with a single cathode on one side to simulate the work piece and four anodes in a row on the other side of the tank. The overall current to the bath is monitored with a calibrated digital ammeter and each anode wire is passed through an FW Bell model FW200 Hall Effect sensor. All four Hall Effect sensor outputs are wired to the Anode Current Monitor control unit shown in Figure 1. A 0 – 30 A DC regulated power supply is used as a rectifier.

In the first experiment to simulate a typical plating application, all four anodes are arranged in an evenly spaced row with the cathode centered and placed on the opposite side of the tank 30 cm (12 in.) away. Overall current was set to 18.7 A using constant current regulation on the power supply. The readings for the individual anode currents are

Anode 1: 4.4 A
Anode 2: 5.3 A
Anode 3: 4.8 A
Anode 4: 4.4 A.

As expected, the middle anodes have slightly higher currents as shown in Figure 2.

To simulate a problem with one anode (corroded electrical connection or passivated anode), the wire to Anode 2 was disconnected. The overall current remained 18.7 A because the power supply was current regulated. The individual anode currents are

Anode 1: 7.1 A
Anode 2: 0.0 A
Anode 3: 6.6 A
Anode 4: 4.9 A

As shown in Figure 3, the current in Anode 2 goes to zero, but the adjacent Anodes 1 and 3 have a marked increase in current. This change in the bar graph display would be readily apparent to an operator on a production line.

Finally, two anodes were disconnected, resulting in the anode currents shown in Figure 4. The individual anode currents are

Anode 1: 9.7 A
Anode 2: 0.0 A
Anode 3: 0.0 A
Anode 4: 9.3 A

The currents in Anodes 1 and 4 increase dramatically, an effect easily seen on the bar graph display.

The previous experiment was then replicated using constant voltage regulation on the power supply. With all four anodes connected, the current evenly divided among the anodes at 7.4 A. Total current was 29.5 A measured at the cathode. Surprisingly, when anode 3 was disconnected, total current decreased only 2 % to 28.9 A. When two anodes were disconnected total current decreased to 25.2 A, a drop of 15%. This data is shown in Table 1.

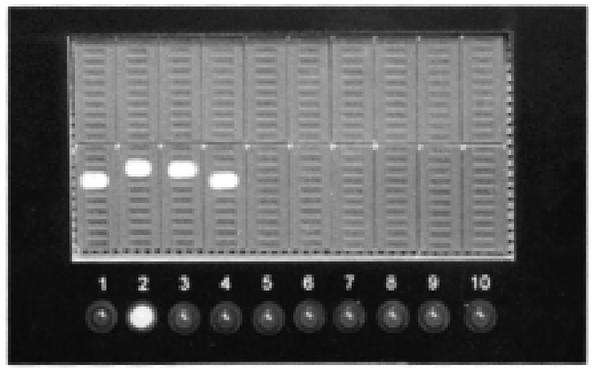

Figure 2. Anode current distribution for a typical Application.

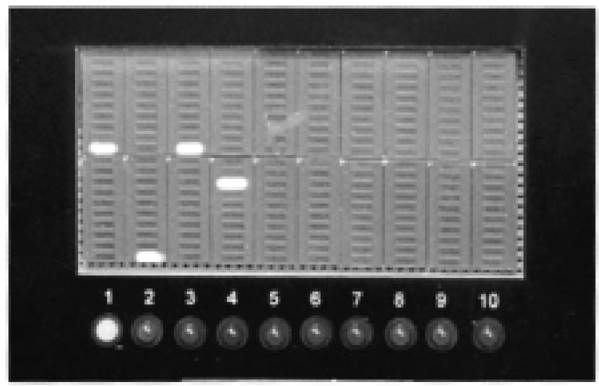

Figure 3. One anode disconnected.

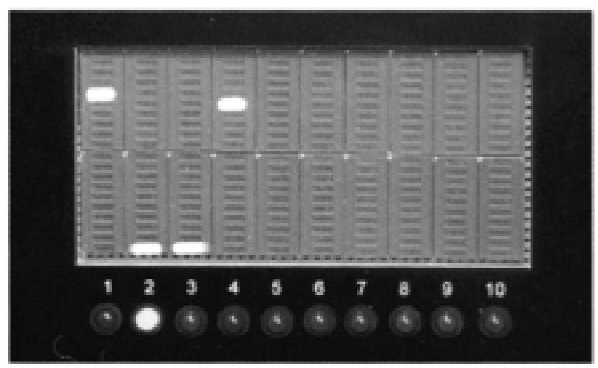

Figure 4. Two anodes disconnected.

Table 1. Anode currents with Constant Voltage regulation.

Anode No.	Normal	1 Anode Disconnect	2 Anodes Disconnect
1	7.4	8.3	13.6
2	7.4	10.6	0.0
3	7.4	0.0	0.0
4	7.4	10.0	11.6

Conclusions

Continuous monitoring of individual anode currents will be an important asset to plating shops. The use of noninvasive Hall Effect toroidal current sensors on each anode wire and an readily interpreted anode current display enable the plater to quickly diagnose the severity and location of anode problems. When there is a problem with an anode causing a drop in current to that anode, the overall bath current change may be small, making detection of the problem difficult. Continuous monitoring of all anode currents allows clear diagnosis when a problem occurs with an anode such as a corroded electrical connection or depletion of anode metal.

The next phase of the project will be to add a computer interface to the control unit so that continuous monitoring and alarms can be utilized by the production line's computer system. A program will be written in LabView (or a similar package) to provide data acquisition and storage.

Acknowledgement

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