

# Galvanic Corrosion of Aluminum in Metal Stacks

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## Abstract

We report an analytical method and results for a chemical's potential for corrosion of metal contacts. Corrosion rates were measured via a galvanic cell, where we measure the current and potential between two wafers coated with dissimilar metals, submerged in process solvents, strippers, and etch solutions (see Figure 1). Galvanic corrosion was more closely correlated to the current of the galvanic as opposed to the potential in static solvent tests. In addition to the static-solvent tests, large current spikes were observed when transitioning from one solvent to another as shown in Figure 3 and Figure 4. Based on these results, the fundamental design of the metallization scheme as well as multi-solvent process flows can be optimized to minimize galvanic corrosion and subsequent electrical and visual defects.

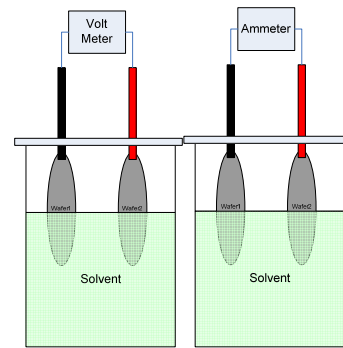
Visual defects were observed on metal stacks consisting of metals with high galvanic potentials, specifically Aluminum (Anodic), Nickel, Platinum and Gold (Cathodic). The corrosion effect was verified to be due to galvanic corrosion versus purely chemically etching the metal layers by solvents. Electrically isolated Al pads were unaffected by process chemistry, while Al pads overlapping with Au/Ni pads showed severe corrosion patterns.

## INTRODUCTION

Visual defects were observed on metal patterns composed of Al, Ni, and Au layers after a multi-solvent liftoff process. The visual defects were found to be especially severe near overlapping layers composed of Pt. The localized nature of the defects suggested that it may be due to galvanic corrosion of the Al layer. An investigation was launched to verify whether this was galvanic corrosion, and also determine which process chemical was inducing it.

## EXPERIMENTAL SETUP

An apparatus was constructed to create a galvanic cell and measure electrical potential and current between two wafers coated with various metal films. The apparatus was submerged into process solvents, strippers, and etch solutions (see Figure 1) and the potential and current were recorded between the two metal types.

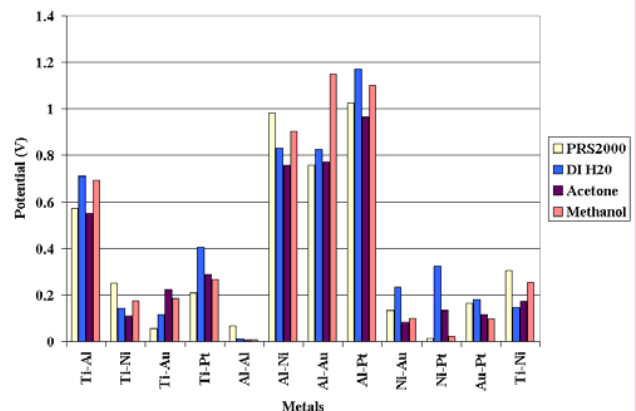


**Figure 1 - Galvanic Potential and Current Measurement Setup**

In addition to recording the galvanic current between two wafers in static solvent baths, the current was also measured while transitioning wafers from solvent to solvent. This allowed for corrosion rates to be measured for the metals under conditions that wafers normally see in the solvent liftoff process.

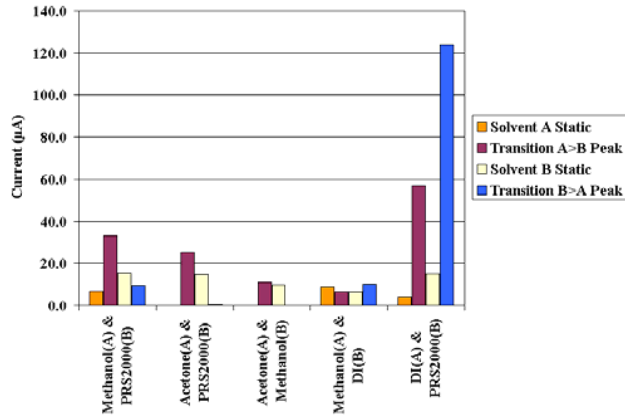
## RESULTS

Figure 2 shows the galvanic potentials between various metal types in several process solvents. The potential is largely independent of the solvent type. Certain metal combinations generate a high galvanic potential between the two metals regardless of solvent type. Galvanic potential was observed to be highest between Al and three other metals (Ni, Au, and Pt).



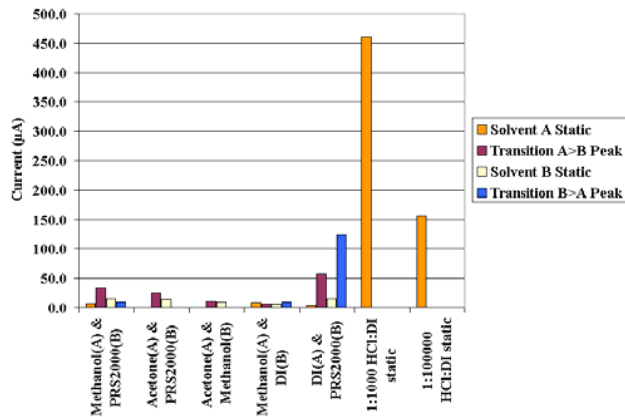
**Figure 2 - Galvanic potential of various metal combinations in process solvents**

The galvanic current generated by the Au-Al metal combination in various process solvents can be seen in Figure 3. The data indicates that the transition between process solvents in a multi-step solvent process can generate a large amount of galvanic current that is not observed in single solvent tests.



**Figure 3 - Galvanic Current Measurements in Process Solvents (Al - Au)**

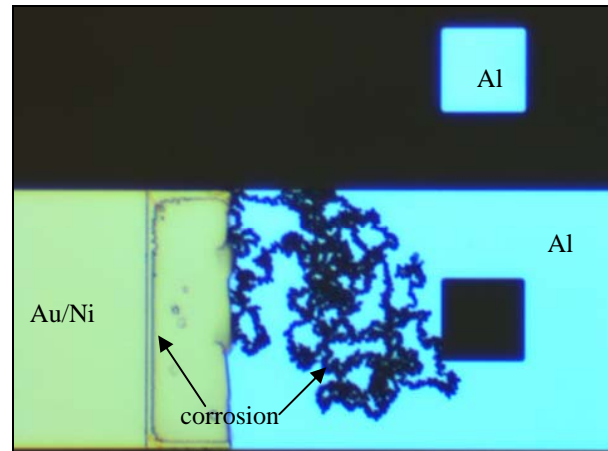
The specific defect observed on process wafers could not be reproduced, even when wafers underwent the worst-case solvent transition which was DI water to PRS2000. Additional chemicals were evaluated with the apparatus (dilute HCl). The galvanic current for the Al-Au combination submerged in dilute HCl can be seen in Figure 4. HCl induced a very large galvanic current between the two metals.



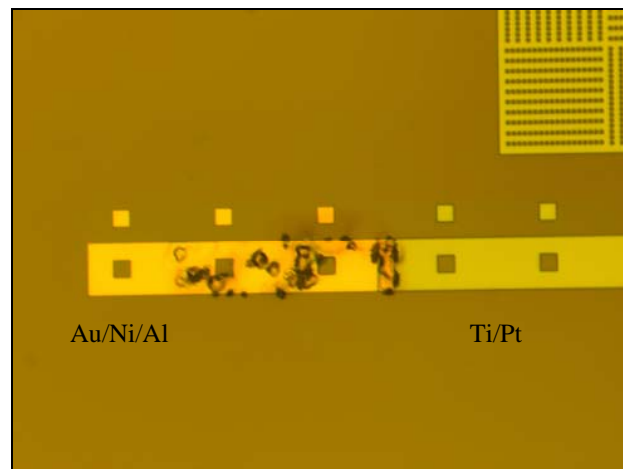
**Figure 4 - Galvanic current induced by dilute HCl. (Al - Au)**

To test whether immersion in HCl could induce the visual defect observed on production wafers, overlapping layers of Al and Au/Ni were deposited on a non-conducting surface. The wafer was then submerged in dilute HCl. Figure 5 is an optical photo of defects generated after soaking metal patterns in dilute HCl. This defect is very similar to those observed on actual process wafers (Figure 6), and also

indicates that it is due to galvanic corrosion of overlapping layers. Isolated Al pads are not affected, while severe corrosion can be seen where Al comes into contact with the Au/Ni layer.



**Figure 5 - Evidence of Galvanic Corrosion in Al layer (right) by overlapping Au/Ni layer (left). Electrically isolated Al pattern (top) is unaffected.**



**Figure 6 - Evidence of Defect induced by Pt containing Patterns (actual process wafers)**

#### CONCLUSIONS

It can be seen that in order to minimize the potential for galvanic corrosion in metal stacks, metal combinations with high galvanic potential should be avoided if possible. In the event that high potential metals are required in metal stacks, multi-chemical processing transitions should be optimized to minimize galvanic currents. Using a galvanic cell to take direct measurements of the corrosion current is also helpful in determining whether a chemical will induce galvanic corrosion while in a static bath, or transitioning from one chemical to another. When Al layers are in contact with high nobility metals such as Gold, Nickel and Platinum, acids such as HCl, even in dilute forms, should be avoided.

#### ACKNOWLEDGEMENTS

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