

## INTRODUCTION

In this application note, we demonstrate a novel method for controlled chemical reaction with a high degree of spatial and volume accuracy using the Nano eNabler™ system. The Nano eNabler™ system can deliver attoliter ( $10^{-15}$ ) to picoliter ( $10^{-12}$ ) volumes of liquid with a high degree of spatial accuracy [1]. In this manner, patterning reactive solutions such as metal etchant to a reactive metal surface could form etched micro-patterns and micro-structures which are not conveniently achievable by bulk wet etching methods [2]. For example, only a very small portion of the metal coating on a device may need to be removed, however, conventional photolithography cannot be applied due to the roughness of the device surface, fragile structures on the device, or an irregular device shape. We successfully demonstrate the patterning of etchant on a gold surface to form an array of holes using the Nano eNabler™ system. It can be further extended to form more complicated etched patterns.

## DATA SUMMARY

The reactive solution delivered was  $KI/I_2$  gold etchant mixed with 10% glycerol (1:1). Glycerol was added to prevent dehydration. The etchant was back loaded onto a surface patterning tool (SPT™ print cartridge) via hand pipetting. A silicon chip coated with 5 nm Cr and 10 nm Au was used as the etching surface. Figure 1 shows an optical image of the etchant array as deposited on the gold surface. The spot size was approximately 10  $\mu m$  and the spacing was 25  $\mu m$ . Ninety-six uniform etchant spots were generated on the gold surface with high spatial accuracy as shown in Figure 1. A single SPT™ print cartridge back loading as performed here can sustain the printing of thousands of spots. Figure 2 shows an AFM image of the same surface after the etch process and subsequent cleaning. The diameter of the etched hole was enlarged to about 12  $\mu m$  due to lateral etching. The etched area had a sharp edge after an average of 10 minutes in a 60% humidity chamber.

## CONCLUSIONS

Using the Nano eNabler™ system, hundreds of uniform etched spots can be easily created on a gold surface with high spatial accuracy. The amount

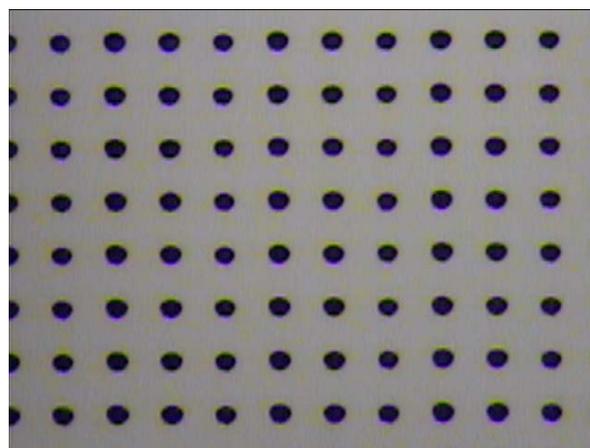


Figure 1. Gold etchant array on gold surface.

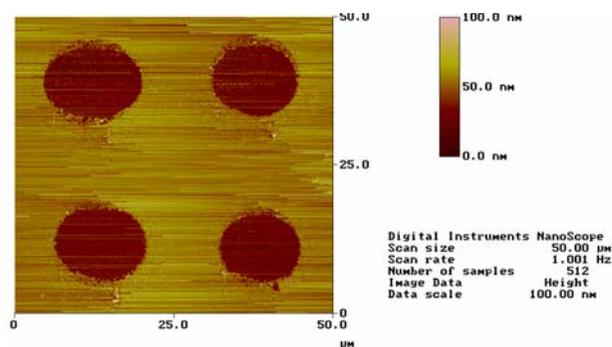


Figure 2. AFM image of etched holes.

of etchant delivered in each spot can efficiently remove the gold within its covered area. The etched gold layer could further serve as a mask to etch the materials underneath to form microwells. Instead of delivering gold etchant, other types of reactive solutions can also be used in the Nano eNabler™ system for custom purposes.

## REFERENCES

- [1] Xu, J., Lynch, M., Huff, J., Mosher, C., Vengasandra, S., Ding, G., and E. Henderson. Microfabricated quill-type surface patterning tools for the creation of biological micro/nano arrays. *Biomedical Microdevices* **6** (2): 117-123, 2004.
- [2] Lewis, A., Kheifetz, Y., Shambrodt, E., Radko, A., and E. Khachatryan. Fountain pen nanochemistry: Atomic force control of chrome etching. *Applied Physics Letters* **75** (17): 2689-2691, 1999.