INTRODUCTION

Recent advances in MEMS technology have generated considerable interest in microcantilever devices, capable of detecting extremely small masses, as sensors with unprecedented sensitivity. Although devices can be easily fabricated with multiple cantilevers, the technology to functionalize them individually is lacking. We have developed instrumentation (The Nano eNabler™ system), surface patterning tools (SPT™ print cartridges) and a methodology for delivering femtoliter to attoliter volumes of liquid precisely to a defined domain. In this manner it becomes possible to independently functionalize each cantilever of a multiplexed device, with the potential for further multiplexing on each cantilever. We have constructed protein arrays directly on the cantilever of an AFM probe and demonstrated the functionality of the arrayed proteins by fluorescence microscopy. This enabling technology will assist in the development of multiplexed microcantilever based sensor devices.

DATA SUMMARY

The ability to deliver femtoliter quantities of liquids precisely to specific domains enables a variety of novel applications. These include the construction of ultramicro arrays for detection of analytes from very small volumes (in the order of 100 - 500 nl) with very high specificity and sensitivity (on the order of pg/ml in the case of proteins). We have developed patent-pending instrumentation (Nano eNabler™ system), tools (SPT™ print cartridges) [1,2] and the methodology for delivering fluids precisely in the femtoliter range. The Nano eNabler™ system enables the direct transfer of materials onto various surfaces with high spatial resolution. In brief, the Nano eNabler™ system consists of high precision X and Y stages (20 nm resolution), a coarse Z axis stage, a high precision fine Z axis stage, a video monitoring system, an environmental control system for the instrument enclosure, a force feedback system to control and maintain printing force, and a graphical user interface for easy pattern design and instrument control. The SPT™ print cartridges are microcantilever devices that have been specifically designed to facilitate fluid flow and transfer to surfaces with high reliability and efficiency. These can be used to precisely transfer attoliter volumes of liquids onto surfaces. Typical designs include features such as a reservoir for the material to be deposited, channels to transport these materials to the distal end of the microcantilever and micron scale gaps at the distal end to control material flow on the surface. These SPT™ print cartridges have been used to functionalize whole cantilevers as well as to construct arrays of rabbit IgG directly on an AFM cantilever. The arrays were tagged with a fluorophore labeled anti-rabbit IgG and observed by fluorescence microscope (Figure 1). The arrayed spots had a diameter of 1 µm and a pitch of 5 µm.

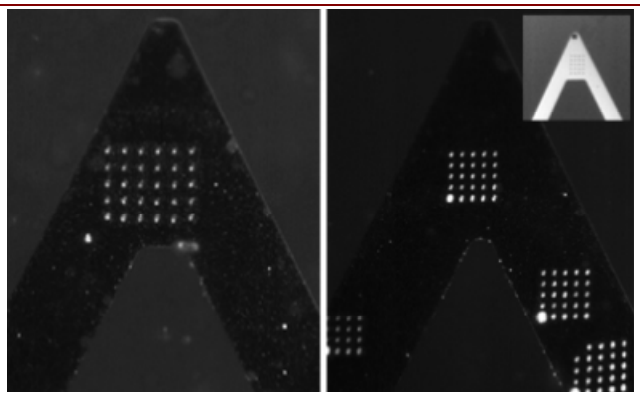

Figure 1: Fluorescence micrograph of nanoarrays of rabbit IgG printed on silicon nitride cantilevers. Spot diameters are approximately 1 µm, with a pitch of 5 µm. The inset in the top panel shows a bright-field image of a similar array.

CONCLUSIONS

The Nano eNabler™ system technology has been used to functionalize microcantilever based sensors and construct ultramicro arrays of proteins on various surfaces including cantilevers. Arrays with domain sizes less than 10 µm have been used to capture and detect proteins at picogram/ml levels thus far. A microcantilever functionalized in this manner could be of great utility for monitoring local concentrations of specific analytes in small volumes.

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. *Biomed. Microdev.* **6 (2)**: 117-123, 2004.

[2] Xu, J., Lynch, M., Nettikadan, S., Mosher, C., Vengasandra, S., and E. Henderson. Micromachined biomolecular ink cartridges — Surface patterning tools for the printing of multiplexed biomolecular arrays. *Sensors & Actuators B: Chemical,* 2005, in press.