INTRODUCTION

An interesting problem facing MEMS engineers is the assembly of complex devices containing elements that cannot be fabricated in a single process path. For example, the precise placement of femtoliter volumes of adhesive would enable the construction of multilayer devices with intricate mechanical or optical properties. In addition to bonding applications for MEMS or surface mount components, the dispensing of small volumes of adhesive has utility for the task of underfilling small flip chips as well.

Many adhesives are somewhat viscous and, therefore, may be more difficult to manipulate at the micron scale. To begin to address this issue we have tested the ability of the Nano eNabler™ system to deposit a UV curable adhesive in defined patterns on silicon wafer surfaces.

DATA SUMMARY

A surface patterning tool [1,2] (SPT™ print cartridges, BioForce catalog # SPT-S-C30) was inserted into the Nano eNabler™ system and front loaded with a thiolene-based UV curable adhesive (Norland optical adhesive #81). Front loading was straightforward, with no apparent impediment resulting from the viscosity of the adhesive. The SPT™ print cartridge was then used to create spots on an indexed silicon chip (Sindex™ chip; BioForce catalog # Sindex-15-100). Contact times varied according to desired spot size, but were generally <100 msec. Resulting spot diameters were in the 1-6 µm range. The spots were visible via bright field illumination through the high magnification video system in the Nano eNabler™ system. Relative humidity was maintained at 50% during the deposition process.

Once deposited, the adhesive was cured *in situ* for 10 minutes using a UV light source (TipCleaner™; BioForce catalog # NT.TC.001) and the resultant arrays were imaged by AFM (Figure 1). Multiple arrays such as those shown in the figure were readily created. The spots were uniform in dimensions in each array and it was possible to create arrays with spot sizes from 1 µm to 6 µm in diameter. Upper and lower limits of spot size were not determined, however selection of alternate SPT™ print cartridge designs would have a significant effect on the spot or line diameter. Interestingly, the spots had a topographically heterogeneous appearance.

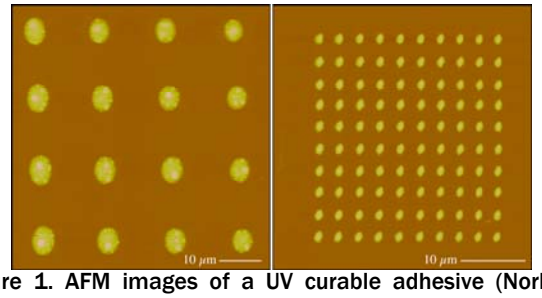

Figure 1. AFM images of a UV curable adhesive (Norland optical adhesive #81) arrayed on a silicon surface. The left hand panel shows an array of spots approximately 6 µm in diameter with a pitch of 15 µm. The right hand panel shows an array of spots approximately 1 µm in diameter with a pitch of 3 µm.

CONCLUSIONS

The Nano eNabler™ System, and specifically, SPT™ print cartridge, can be used for precise deposition of UV curable adhesives. As electronic components continue to shrink and MEMS research continues to expand, the semiconductor industry will need advanced production solutions for device bonding and underfilling. The simultaneous evolution of micro and nanotechnologies will only increase this need as researchers race to build complex multicomponent 3D architectures.

The technique we have demonstrated here should not be restricted to UV curable adhesives, although they are easier to handle than most thermosetting two-part epoxies. In fact, the realm of utility can be greatly expanded by the use of adhesives with electrical or thermally conductive properties. Other characteristics may be produced by the addition of foreign materials to the polymer matrix such as colloids, metallic nanopowders, quantum dots, carbon nanotubes and nanowires.

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] Xu, J., Lynch, M., Nettikadan, S., Mosher, C., Vengasandra, S., and E. Henderson, Microfabricated "Biomolecular Ink Cartridges" - Surface patterning tools (SPT™ print cartridges) for the printing of multiplexed biomolecular arrays. *Sensors and Actuators B* (in press).