



TRANSFER PRINTING BASED NANO/MICROMANUFACTURING

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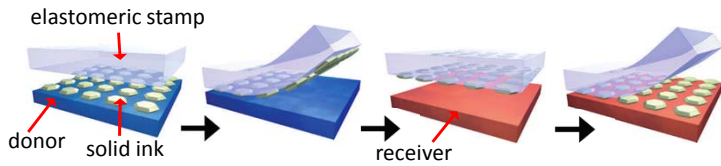
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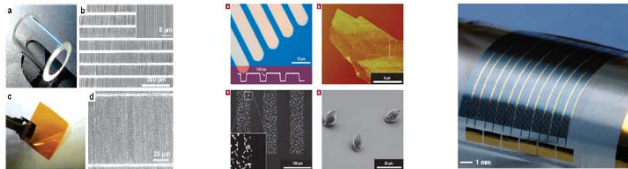
Objective

Demonstrate unique assembly capabilities of transfer printing that are suitable for small batch and rapid fabrication of diverse 3D MEMS structures and nanodevices.

Transfer Printing



The use of a soft stamp to transfer solid micro/nanostructured materials (solid inks) from a substrate (donor) where they are generated or grown to a different substrate (receiver) for device assembly

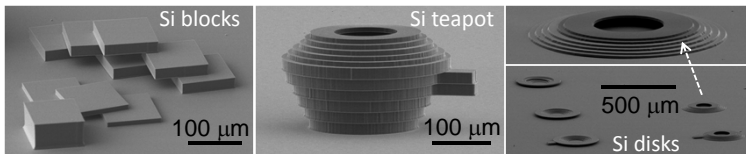
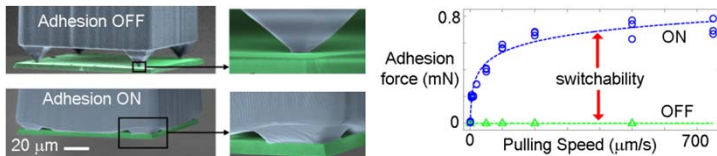


CNTs Mica, Graphite, Silica, Pollen Si PV Cells
nanometers micrometers millimeters

*Meitl, et al. *Nat Mater* 2006

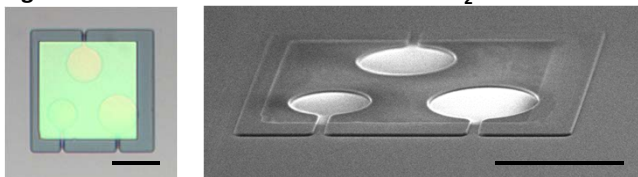
Advanced Modes of Transfer Printing

The full or partial fabrication of nano/microsystems from solid components transfer printed by soft stamps and bonded together



Silicon Nano-Membrane Resonator Structures

Images of 300 nm thick Si membranes on SiO₂ structures

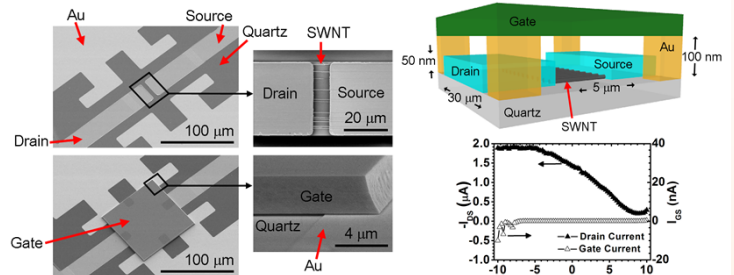


*Scale bars represent 50 μm

Theoretical and Experimental Results

Device	Theoretical f_0 (MHz)	Measured f_0 (MHz)	Estimated Q-factor
60μm diameter membrane	1.43	1.01	7900
20μm diameter membrane	12.95	9.31	14000

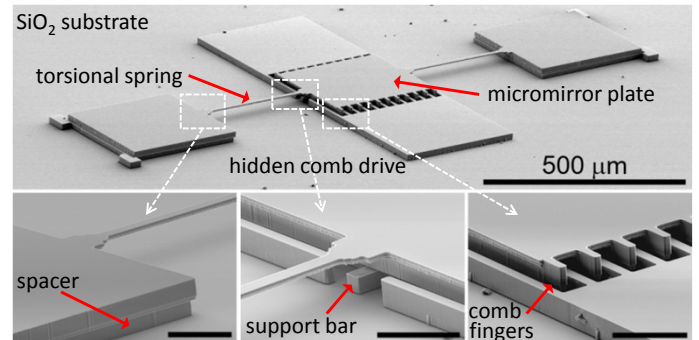
CNT Field Effect Transistor with Air Gap Dielectric



SEM images before (up) and after (down) transfer printing of top silicon gate Schematic illustration (up) and I-V curve (down) of CNFET

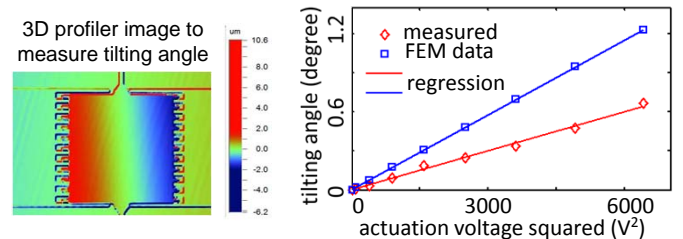
Silicon Hidden Comb Drive as a Microscanner

SEM Images of Si Hidden Comb Drive



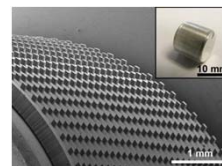
*Scale bars represent 50μm

Experimental Results

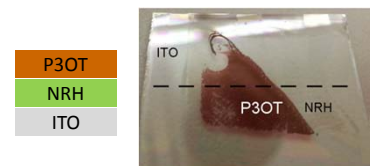


Future Directions

1. Scalable Roll-to-Roll
2. Dry Integration of Nanomaterials



SEM image of a cylinder surface wrapped by elastomeric stamp array



P3OT (poly(3-octylthiophene)), NRH (nanorod heterostructures) printed on ITO glass

Conclusions

Transfer printing is a straightforward **dry assembly** procedure for **small batch and rapid fabrication** of diverse 3D MEMS structures and nanodevices, thereby complementing monolithic microfabrication and solution-based nanomanufacturing.