

DEPOSITION OF FERROELECTRIC FILMS

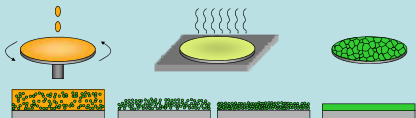
FERROELECTRIC MICROMACHINING

W. M. Keck Smart Materials Integration Laboratory (SMIL)

PZT CHEMICAL SOLUTION DEPOSITION

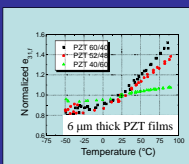
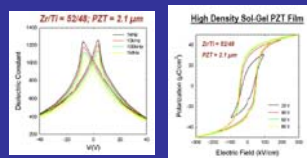
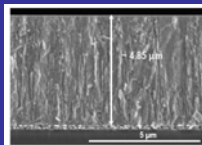
Precursors: Zn n-propoxide, Ti iso-propoxide, and Pb Acetate Trihydrate in 2-Methoxyethanol

- 1 Spin Precursor
1500rpm for 30sec
- 2 Pyrolysis
250 to 550°C in air on hot plate for 1min
- 3 Crystallization
RTA at 700°C in 1 atm of O₂



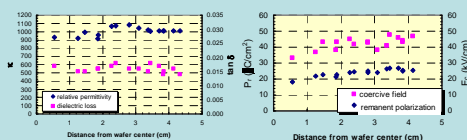
- Process is cycled to build up film thickness
- Resulting films are stable to at least 700°C, and will remain piezoelectric after exposures to >150°C

- Film from 200 nm to 3 microns are available on piece parts, 4" and 6" platinumized Si wafers
- Thicker films (up to 5 microns are available on a research contract basis

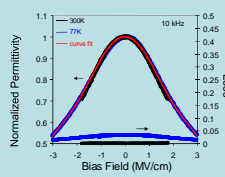
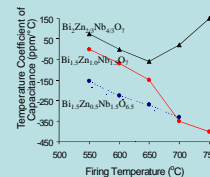
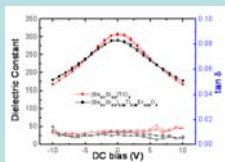


Pt Thickness (nm)	Zr/Ti ratio	PZT Thickness (µm)	K _t ²	Freq (MHz)	ε (50MHz)	α (dB/cm)
500	52/48	2.1	28%	800	-420	2000
150	52/48	2.1	25%	663	-460	2000

PZT UNIFORMITY



TUNABLE DIELECTRICS



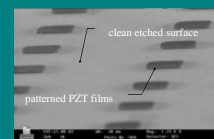
- A Kurt J. Lesker sputter tool is available to deposit Pt-coated Si bottom electrodes on SiO₂ buffered Si
- Cr/Au top electrodes are also routinely available



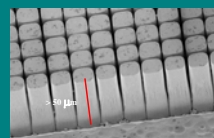
Penn State has >15 years experience in the deposition, characterization and integration of complex oxide thin films for piezoelectric, pyroelectric, tunable dielectric and electrooptic applications. Films such as

- PbZr_{1-x}Ti_xO₃
- PLZT
- Pb_{0.9}Ca_{0.1}TiO₃
- BaTiO₃
- Ba_{1-x}Sr_xTiO₃
- PtMg_{1-x}Nb_{2-x}O₇
- PbTiO₃ and Bi_{1-x}Zn_xNb_{1-x}O₅ can be deposited in a class 100 clean room

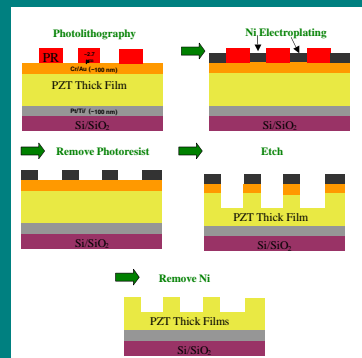
WET ETCHING



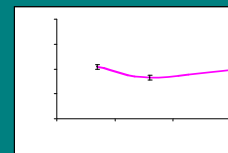
DRY ETCHING



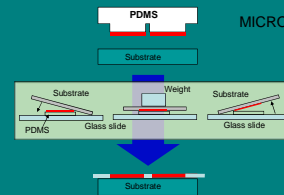
Several methods for patterning ferroelectric ceramics, single crystals, and thin films are available, including wet etching and reactive ion etching. Ion milling and microcontact printing should be transferred from research labs to the NNIN site shortly.



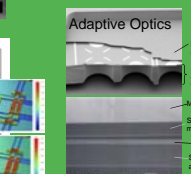
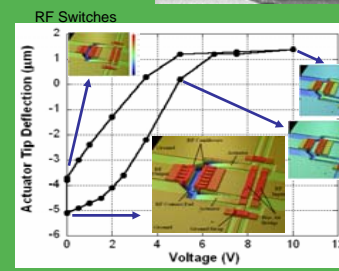
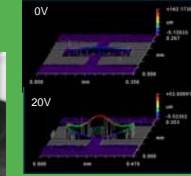
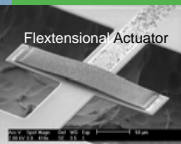
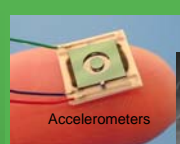
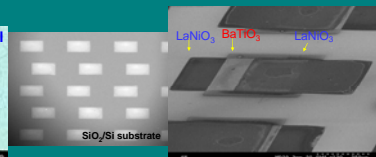
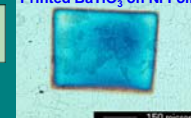
DRY ETCHED PZT FILMS



MICROCONTACT PRINTED THIN FILM CAPACITORS



Printed BaTiO₃ on Ni Foil



Penn State examples of the integration of piezoelectric and pyroelectric thin films into microelectromechanical systems. Work was done in collaboration with Northrop Grumman Corporation, Geospace Research, Wilcoxon Research, the Jet Propulsion Laboratory, and the Army Research Laboratory

For additional information, contact Dr. Theresa Mayer (tsm2@psu.edu)

<http://www.nanofab.psu.edu/hyperlinks/hyperlink.to.nnin.htm>

