

Multifunctional Ferroelectric Nanostructures

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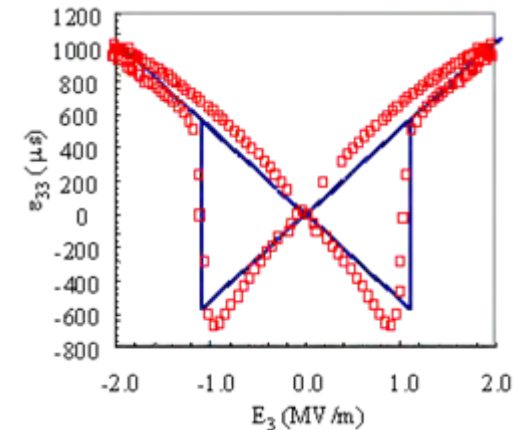
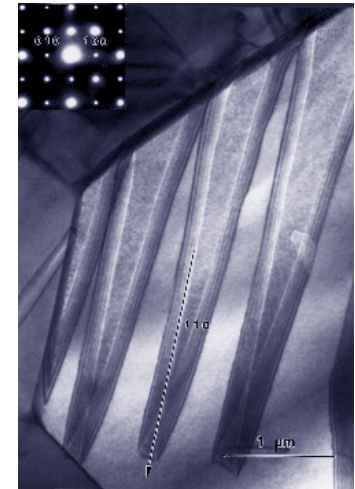
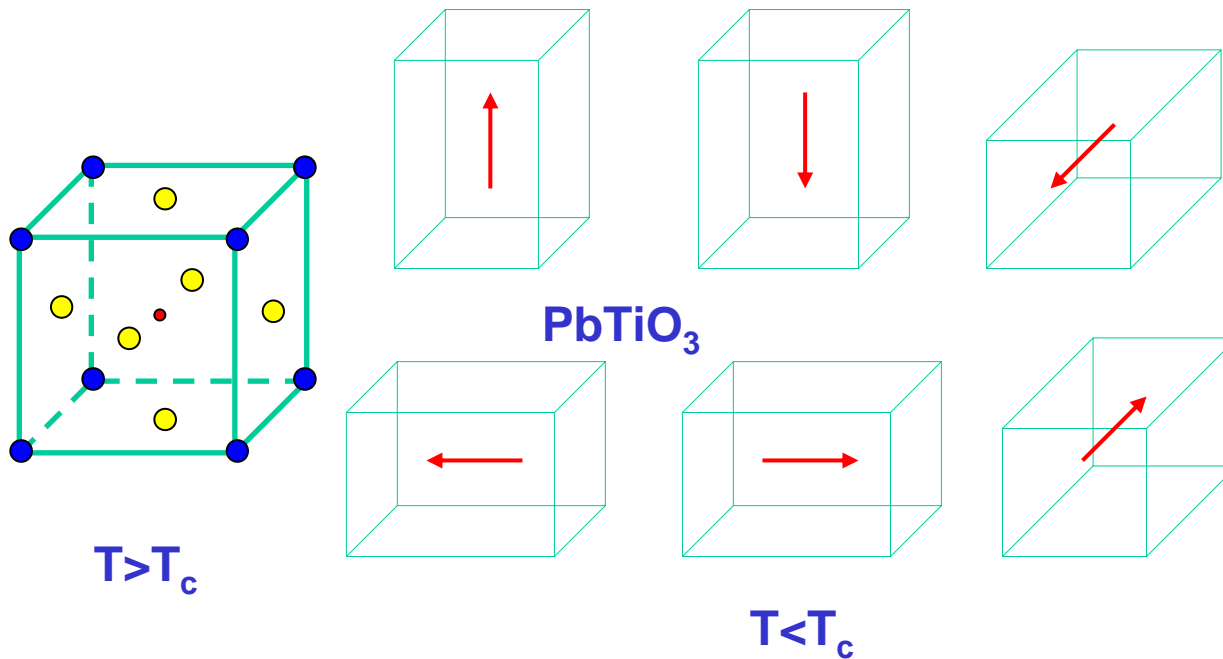
AMTAS Spring 2007 Meeting

Seattle, WA

April 12, 2007

Ferroelectrics

Ferroelectric crystals are spontaneously polarized below the Curie temperature



- The crystal may be polarized in any of the crystallographically equivalent directions
- A crystal may be polarized in different directions in different “domains”

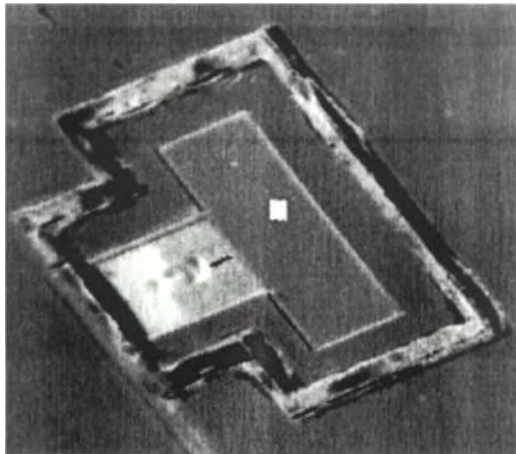
Applications



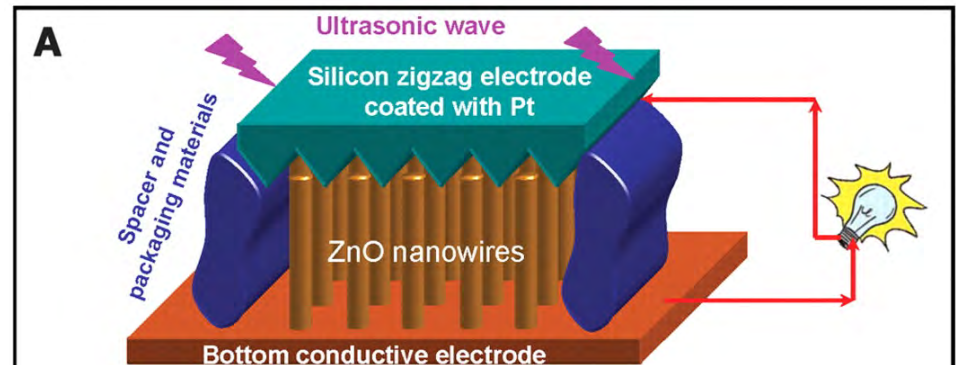
Active rotors and control surfaces



Vibration control

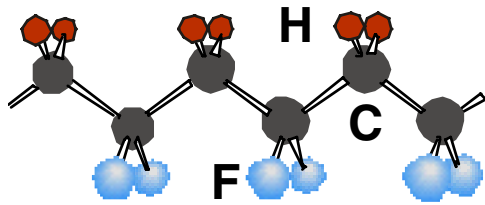


Microsensor

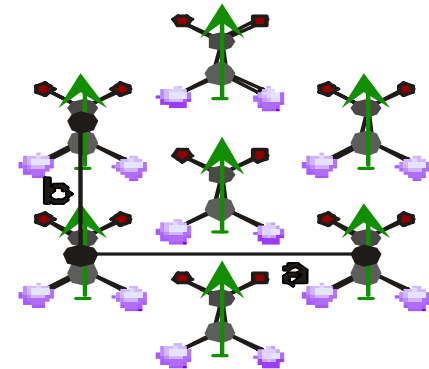


Energy harvesting

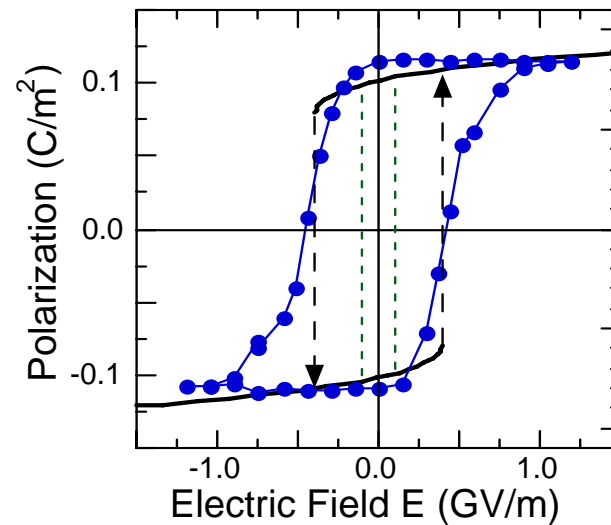
PVDF Ferroelectric Polymer



All-trans conformation

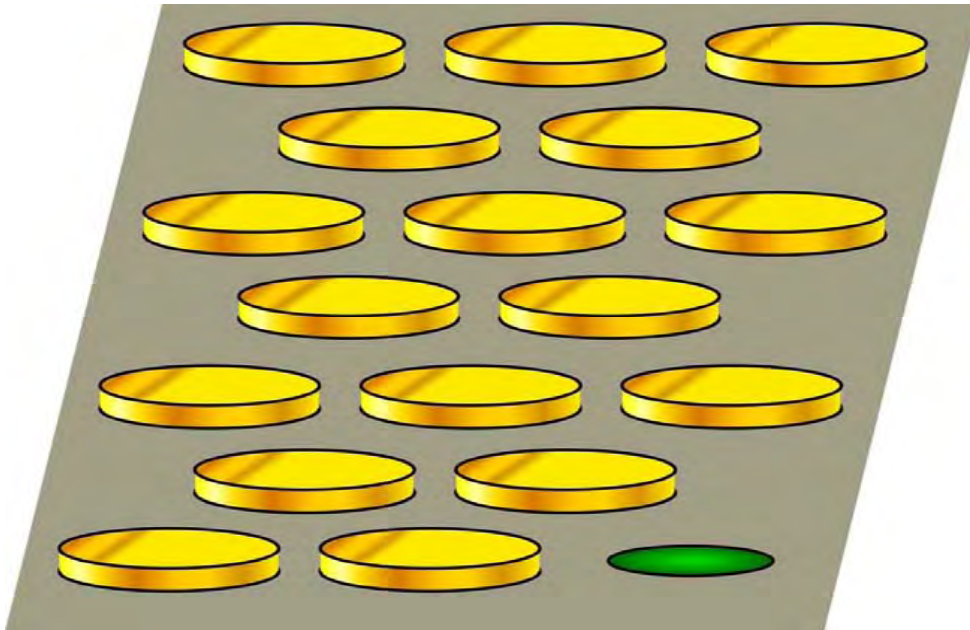


β phase lattice



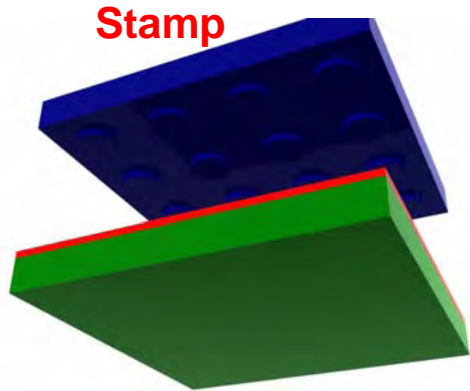
Ferroelectricity

Multifunctional Nanostructure



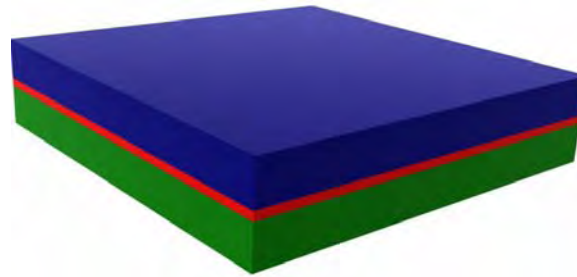
- Energy harvesting
- Energy storage
- Sensing
- Actuation
- Structure morphing
- Self-healing/cooling

Nanoimprint Lithography

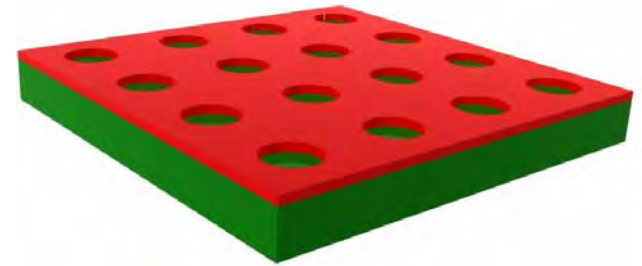


Stamp

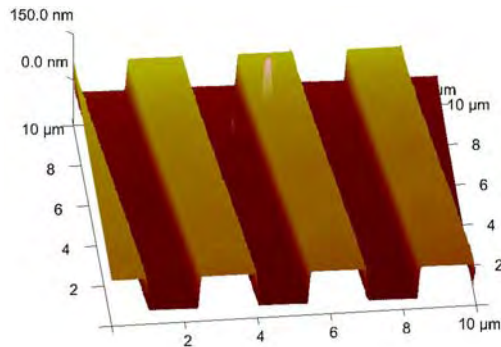
Film on substrate



Pattern transfer



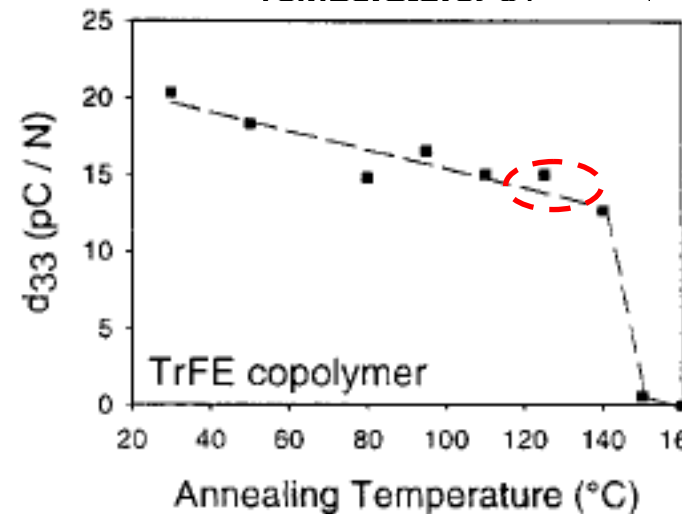
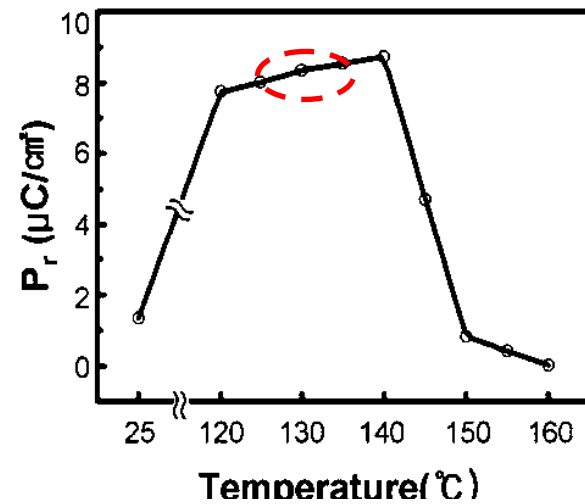
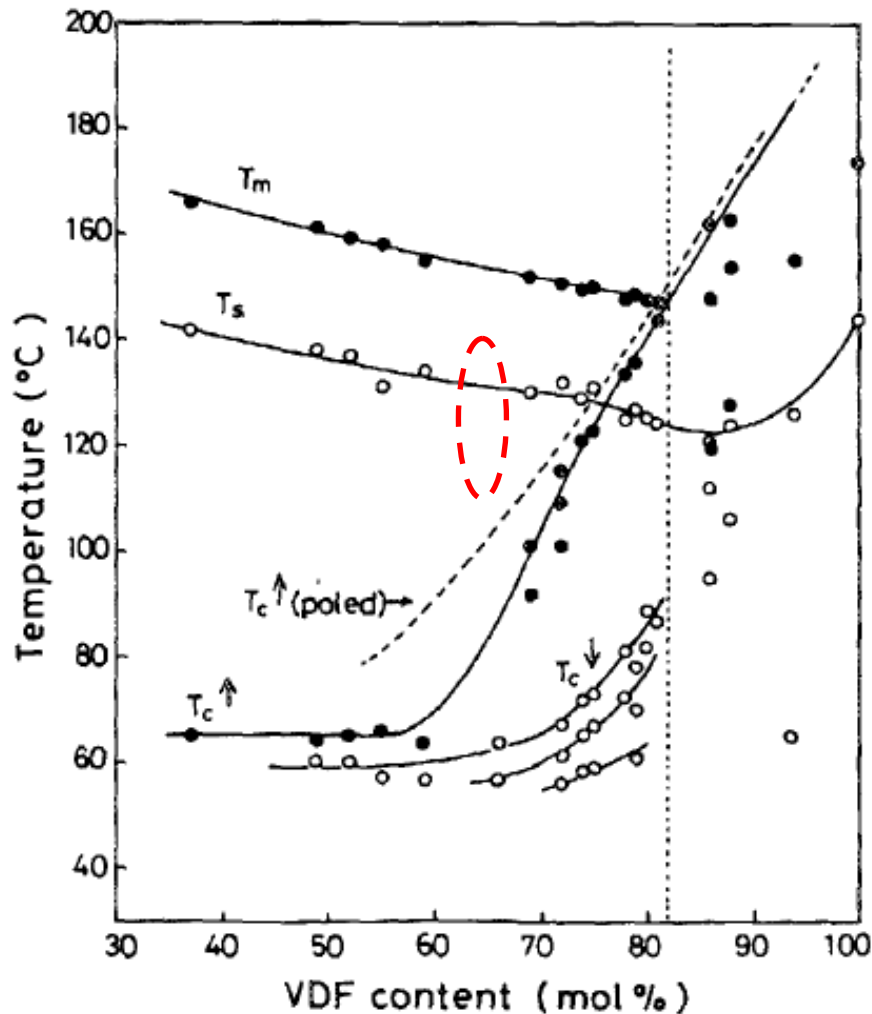
Transferred pattern



Silicon stamp

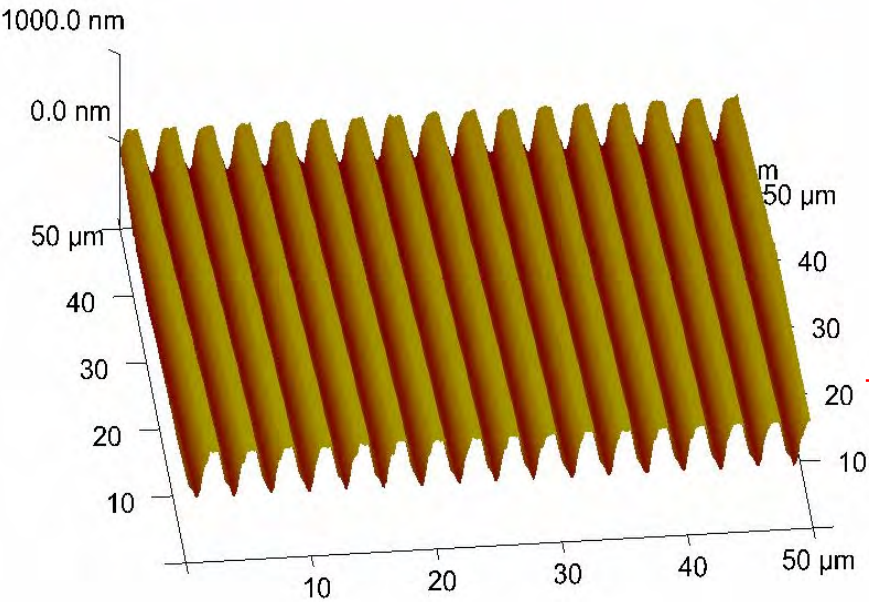


Phase Diagram of P(VDF-TrFE)

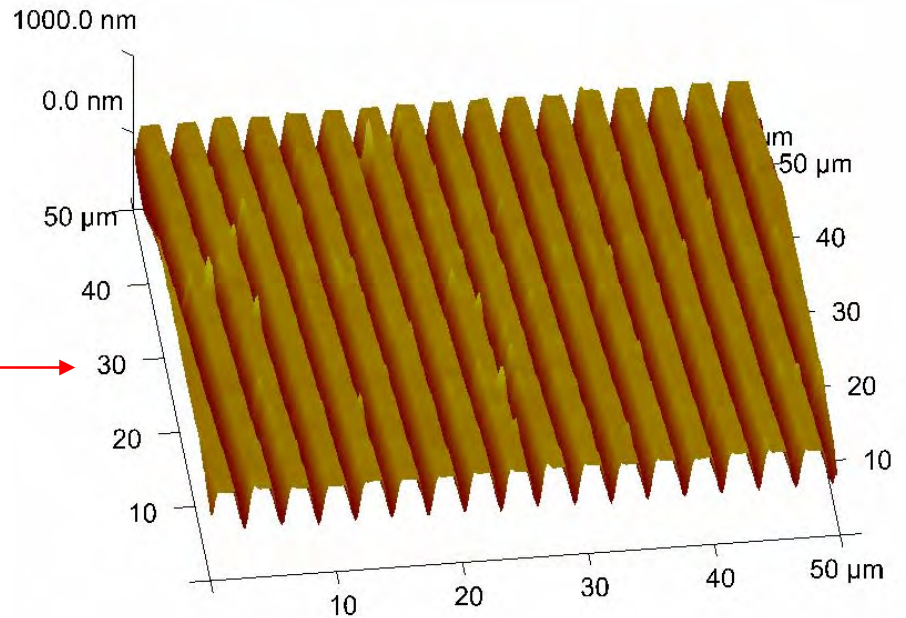


Patterned P(VDF-TrFE) Wires

P(VDF-TrFE) (65/35), T=135°C, Time=1.5hrs. Pressure: 1800PSI.

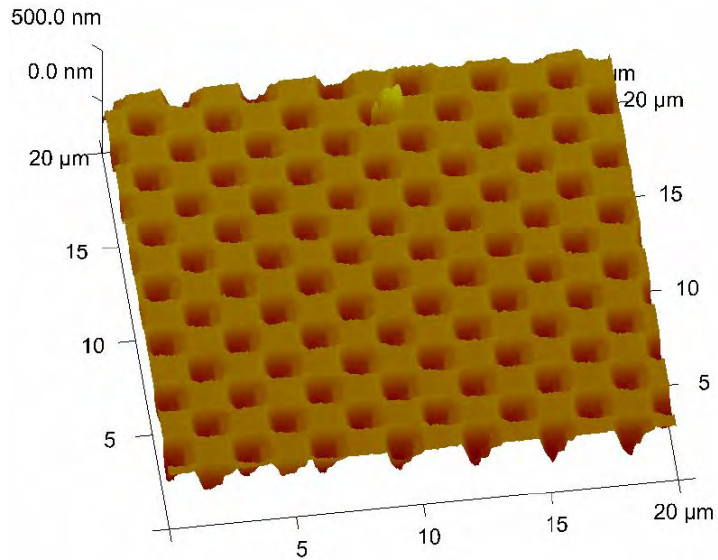


Silicon Mold

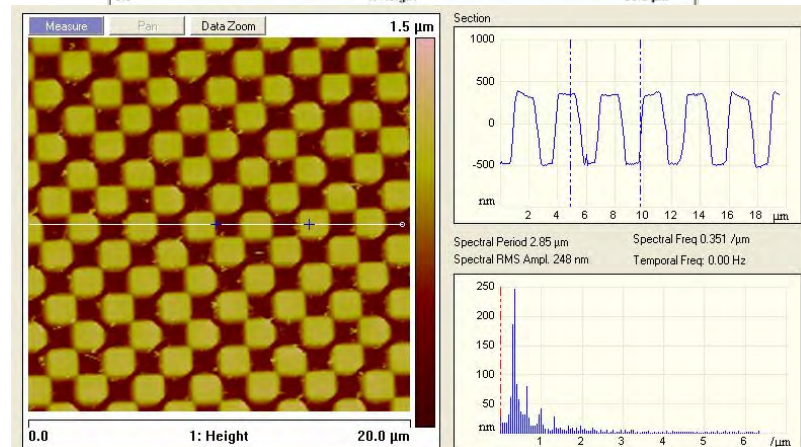
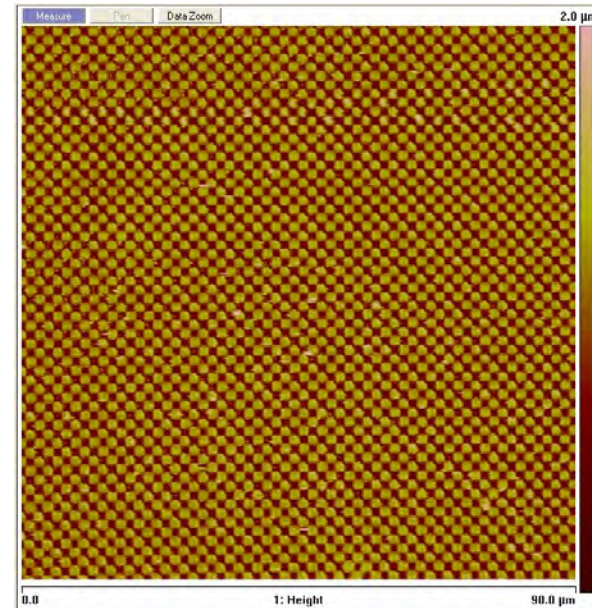


Patterned P(VDF-TrFE) Film

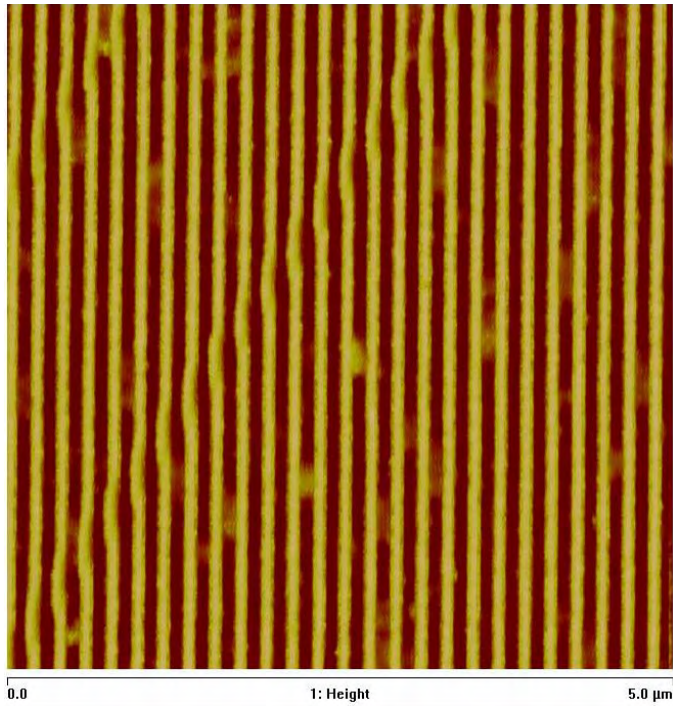
Patterned P(VDF-TrFE) Mesas



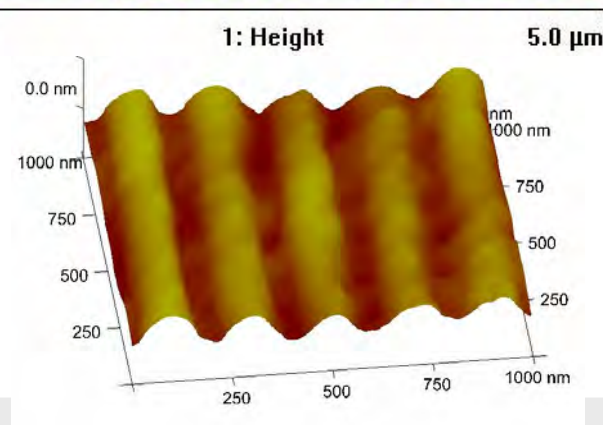
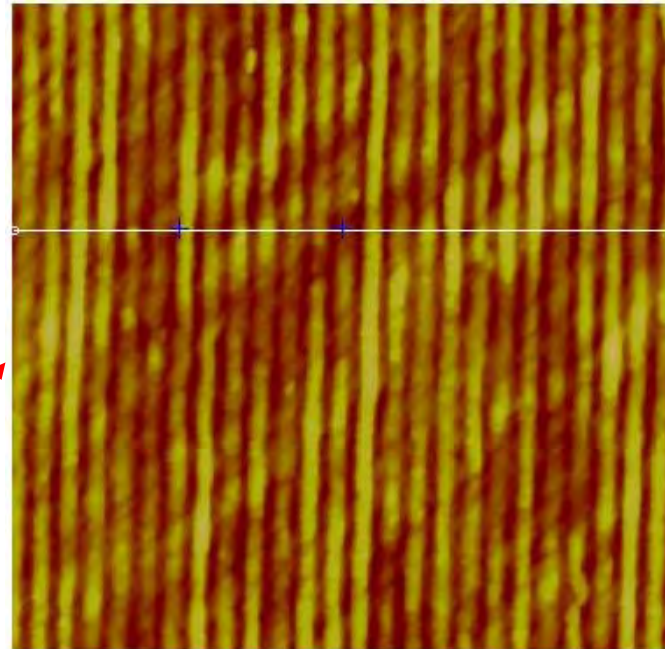
Silicon Mold



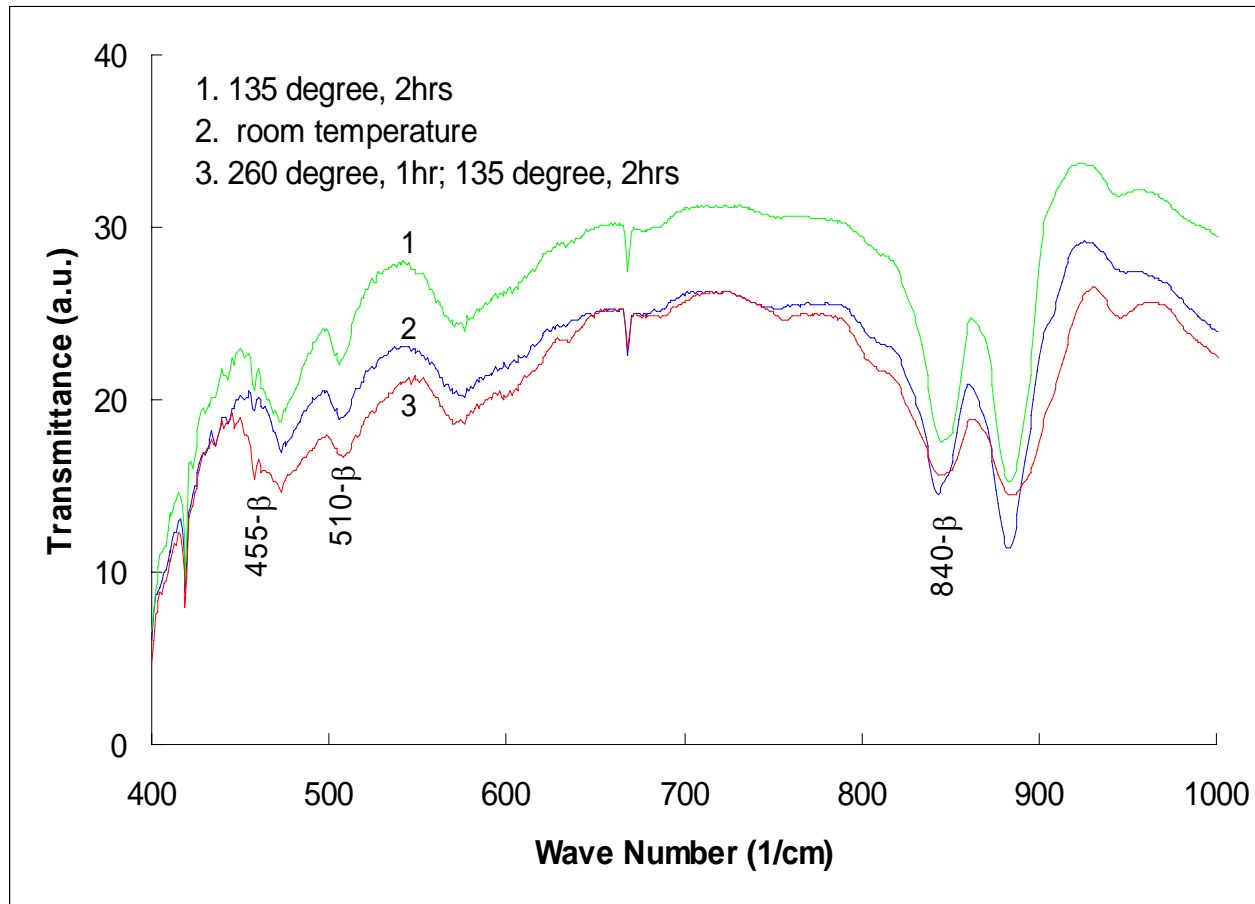
Nanoscale P(VDF-TrFE) Pattern



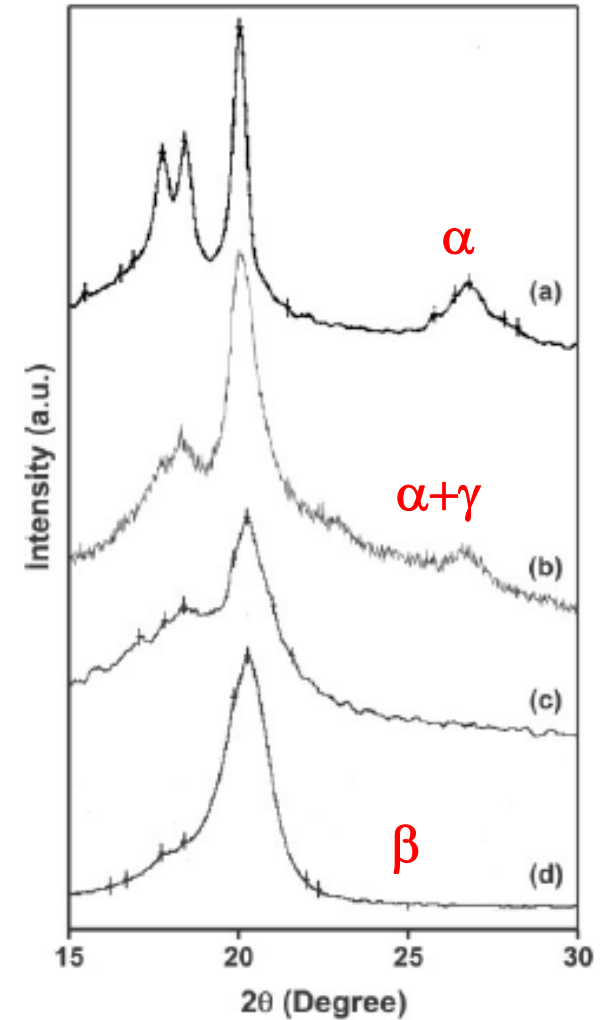
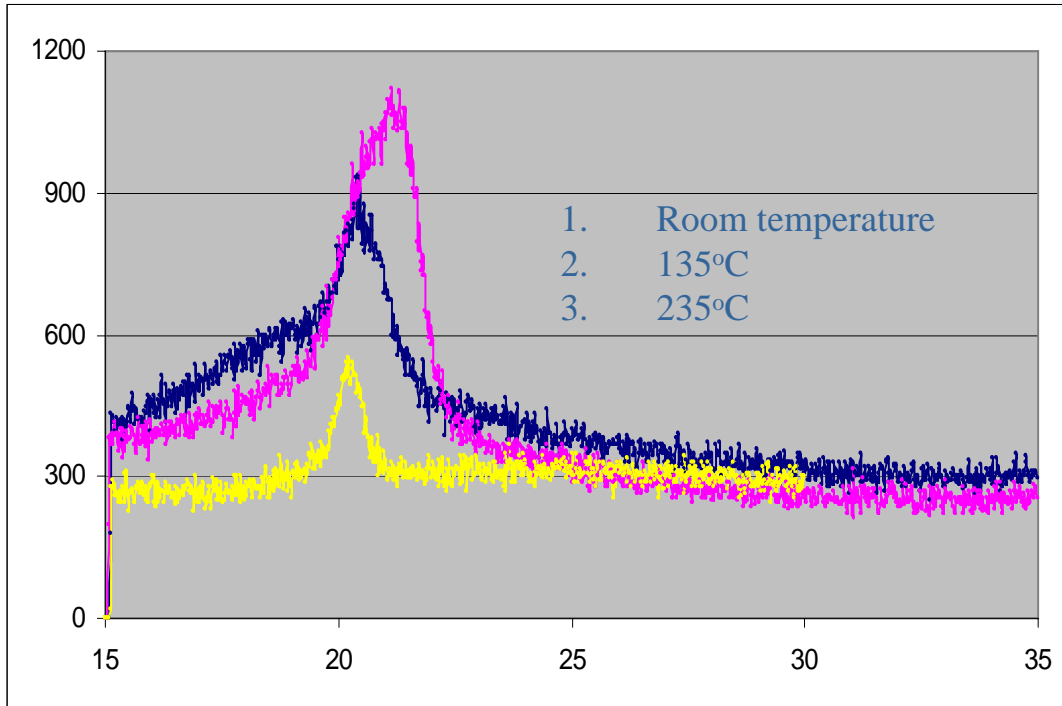
Epoxy Mold



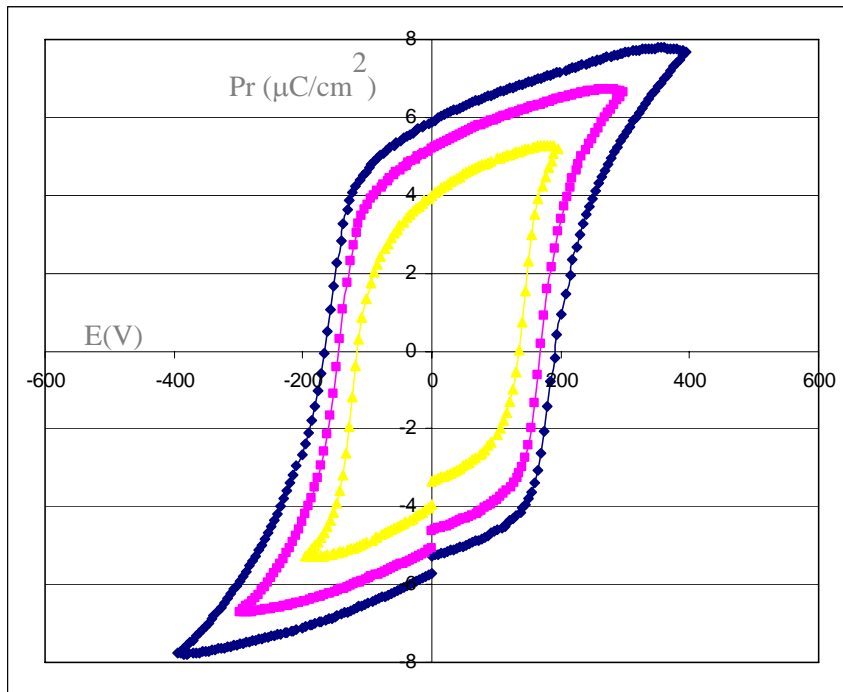
FTIR Spectrum



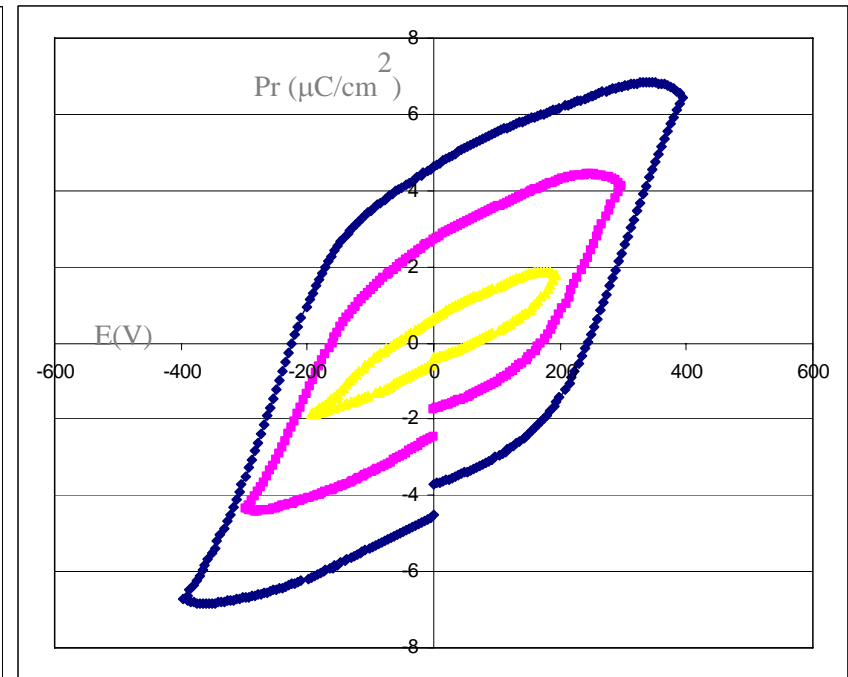
X-ray Diffraction



Ferroelectric Hysteresis

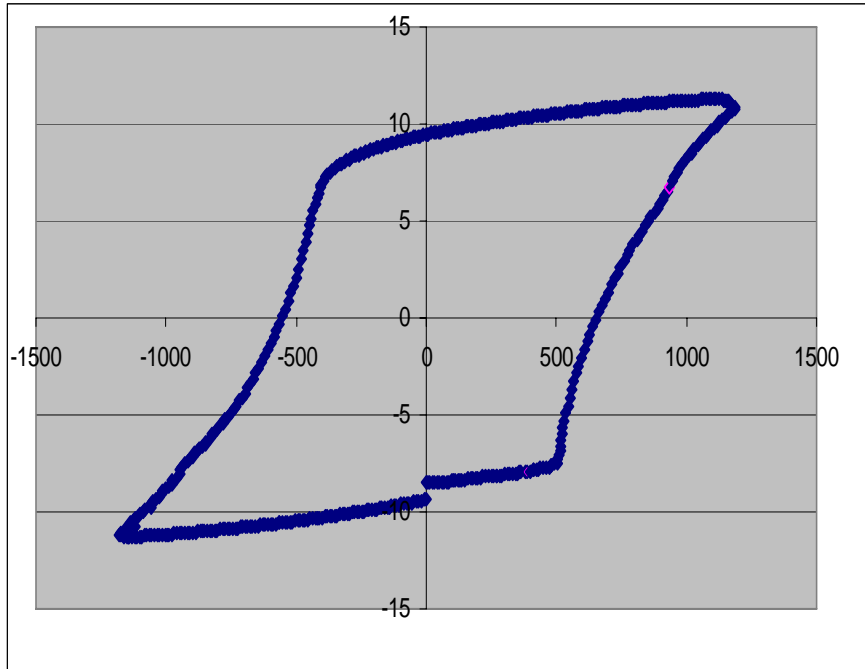


Uniform Film

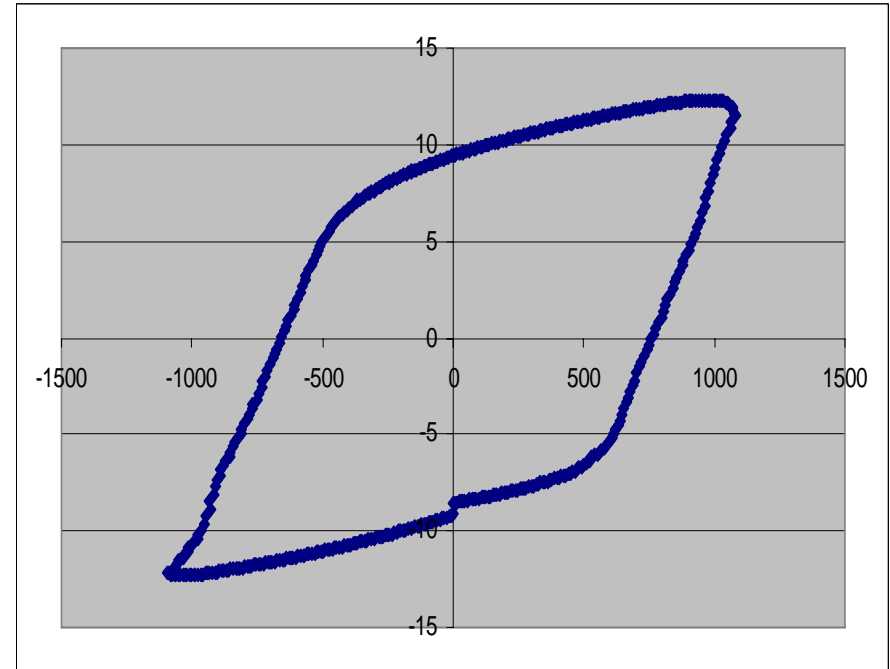


Patterned Film

Ferroelectric Hysteresis

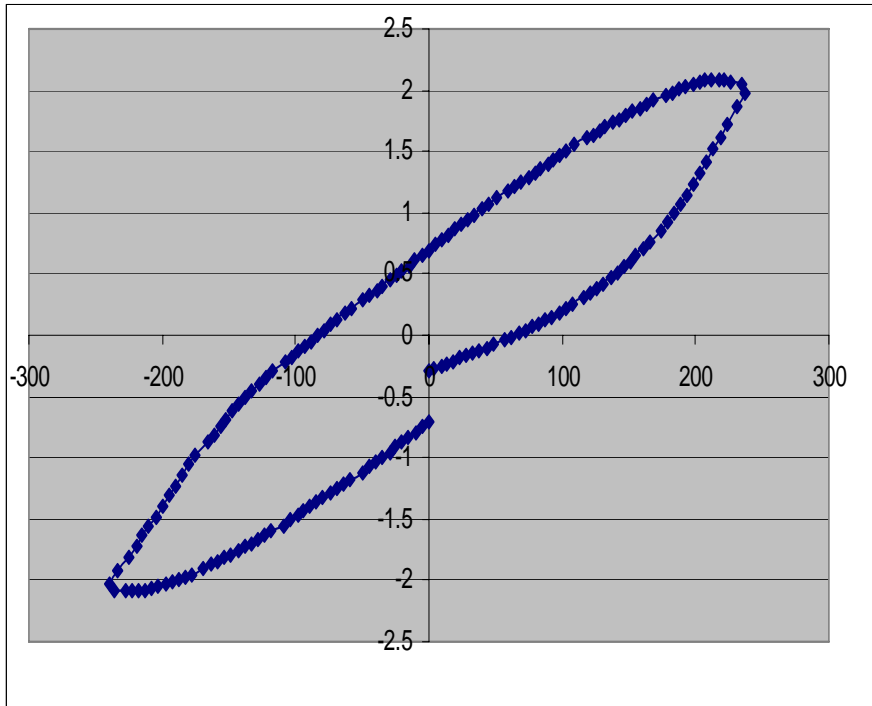


Uniform Film

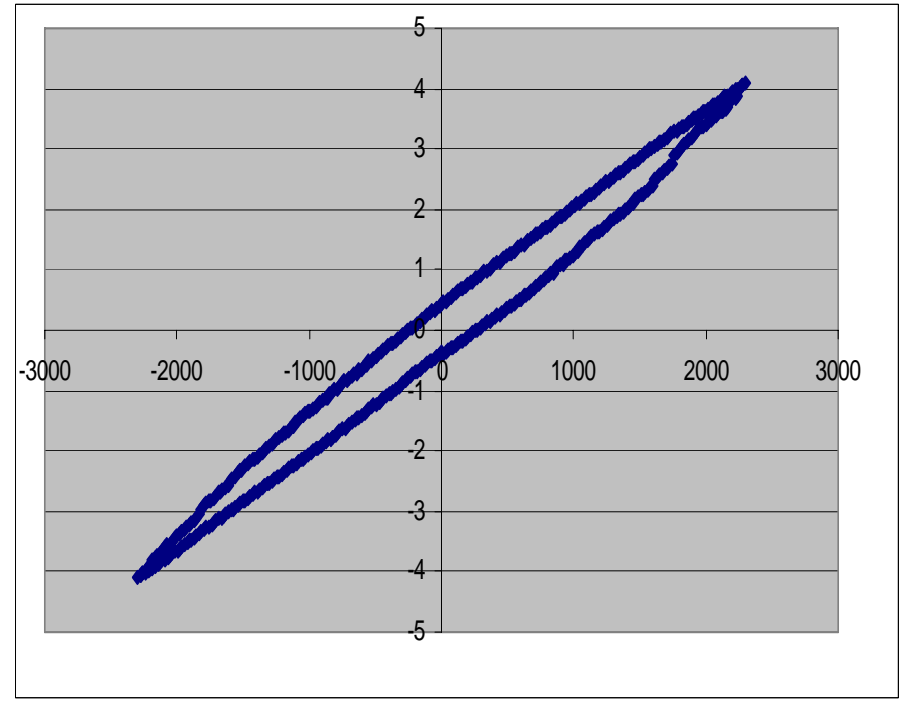


Patterned Film

Ferroelectric Hysteresis

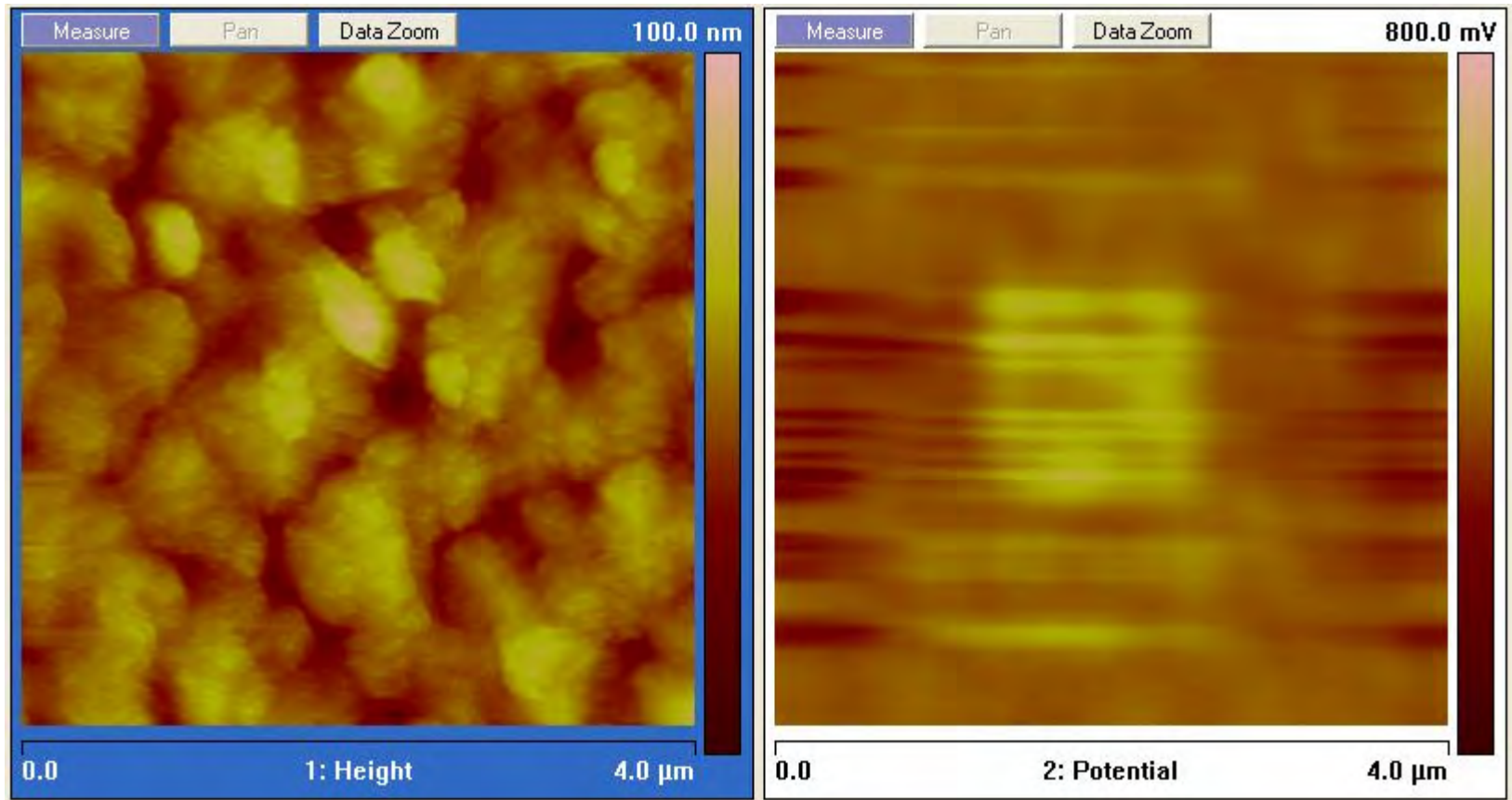


Uniform Film



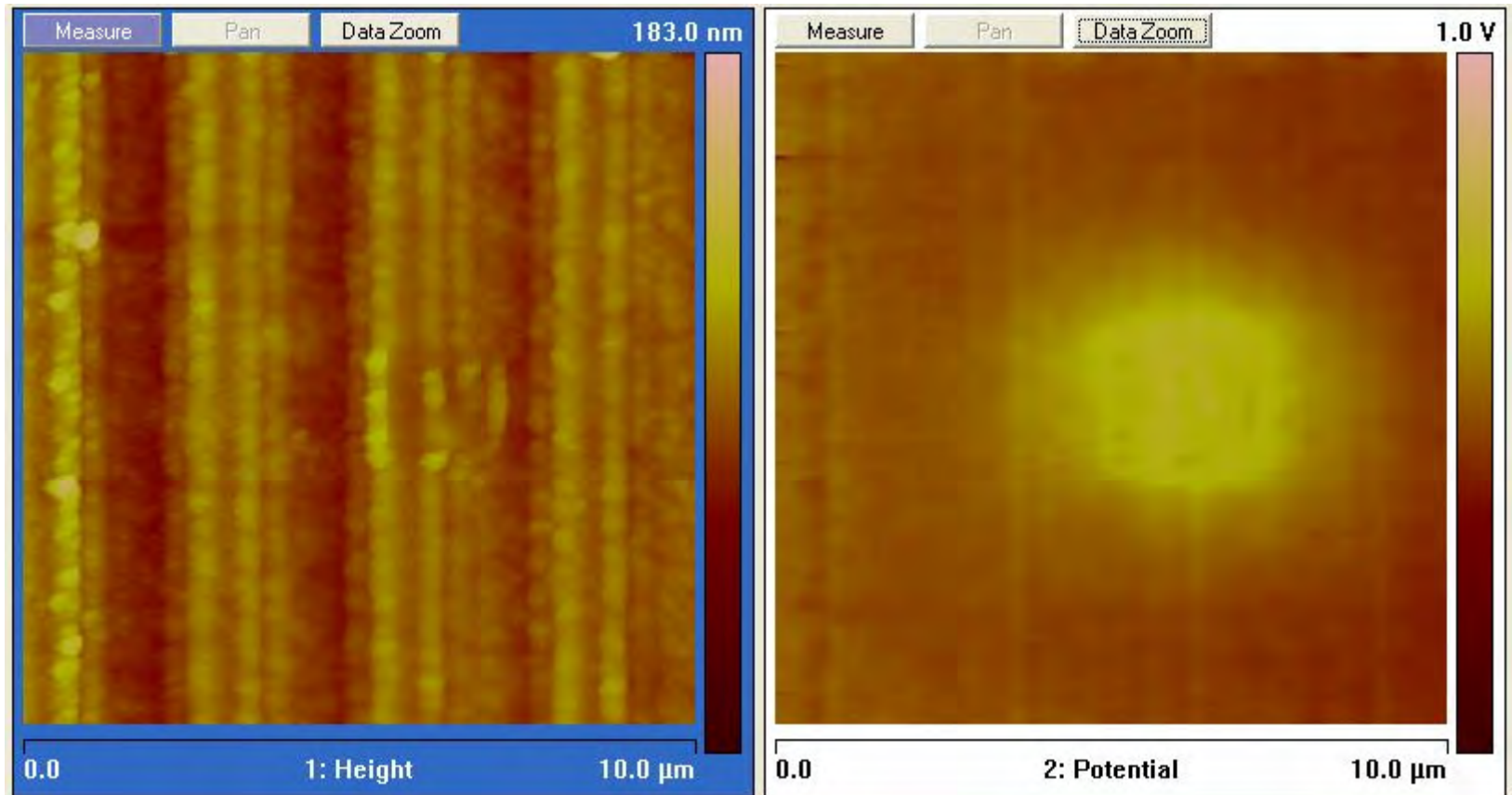
Patterned Film

Electrostatic Force Microscopy



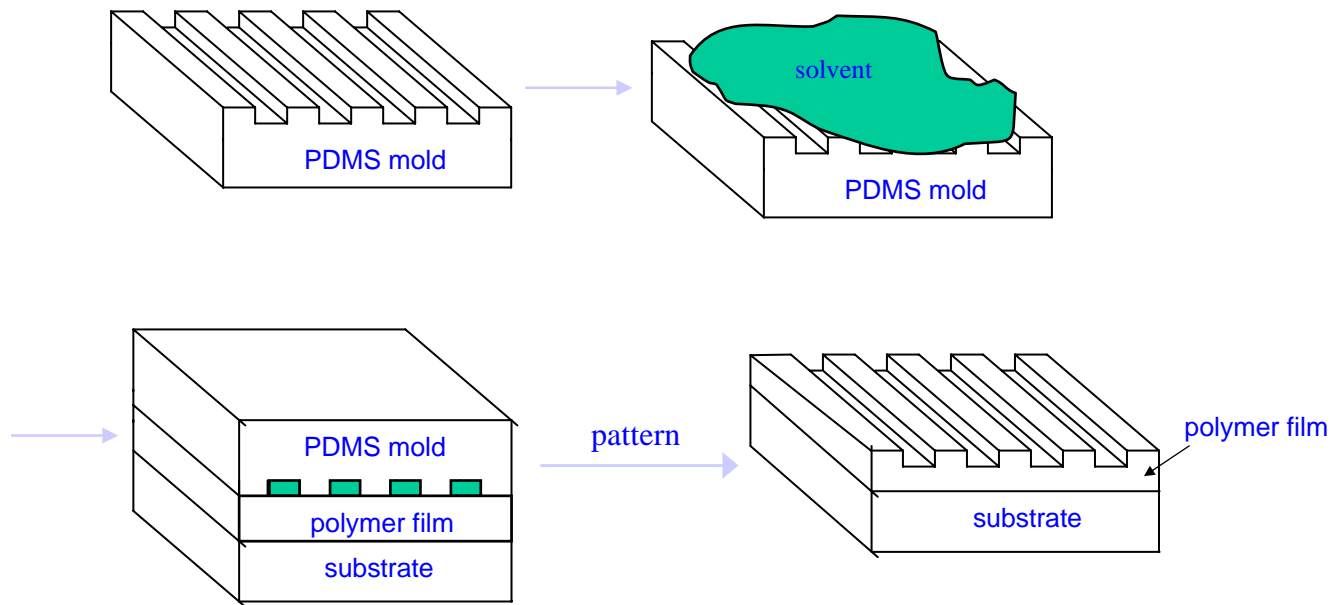
Uniform Film

Electrostatic Force Microscopy

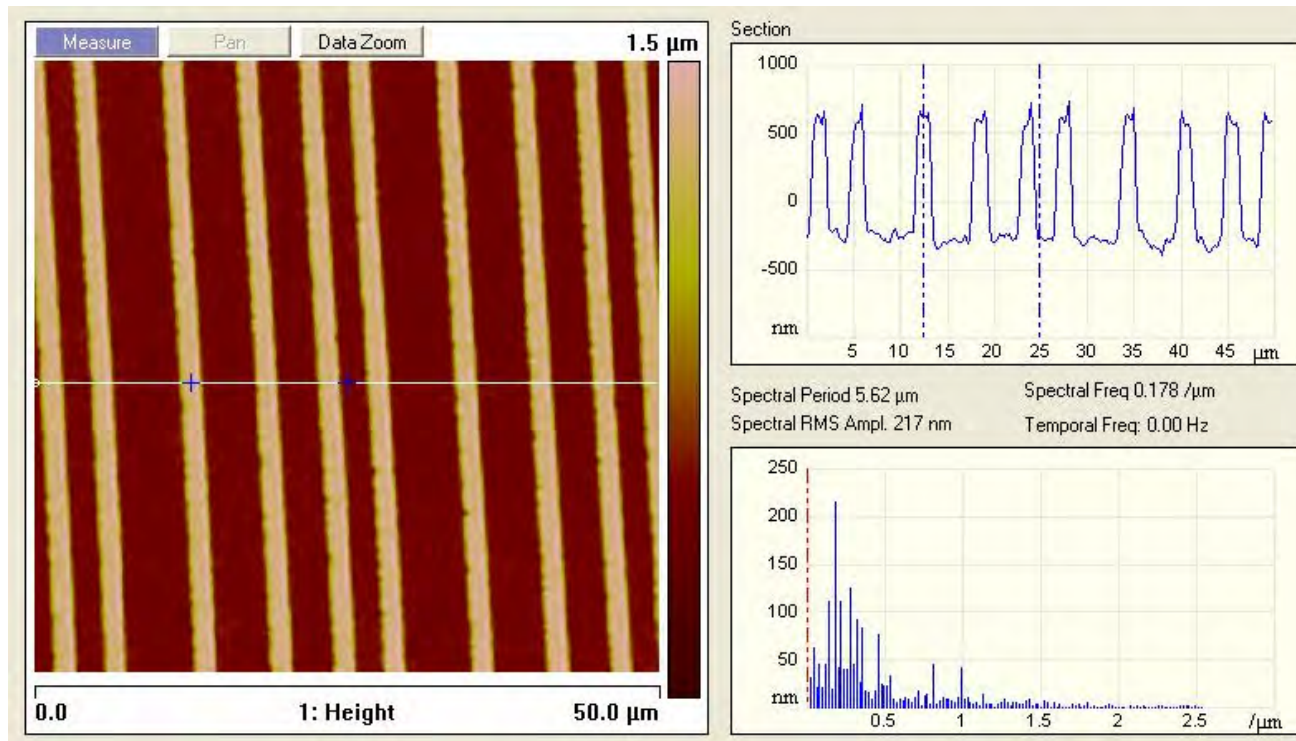


Patterned Film

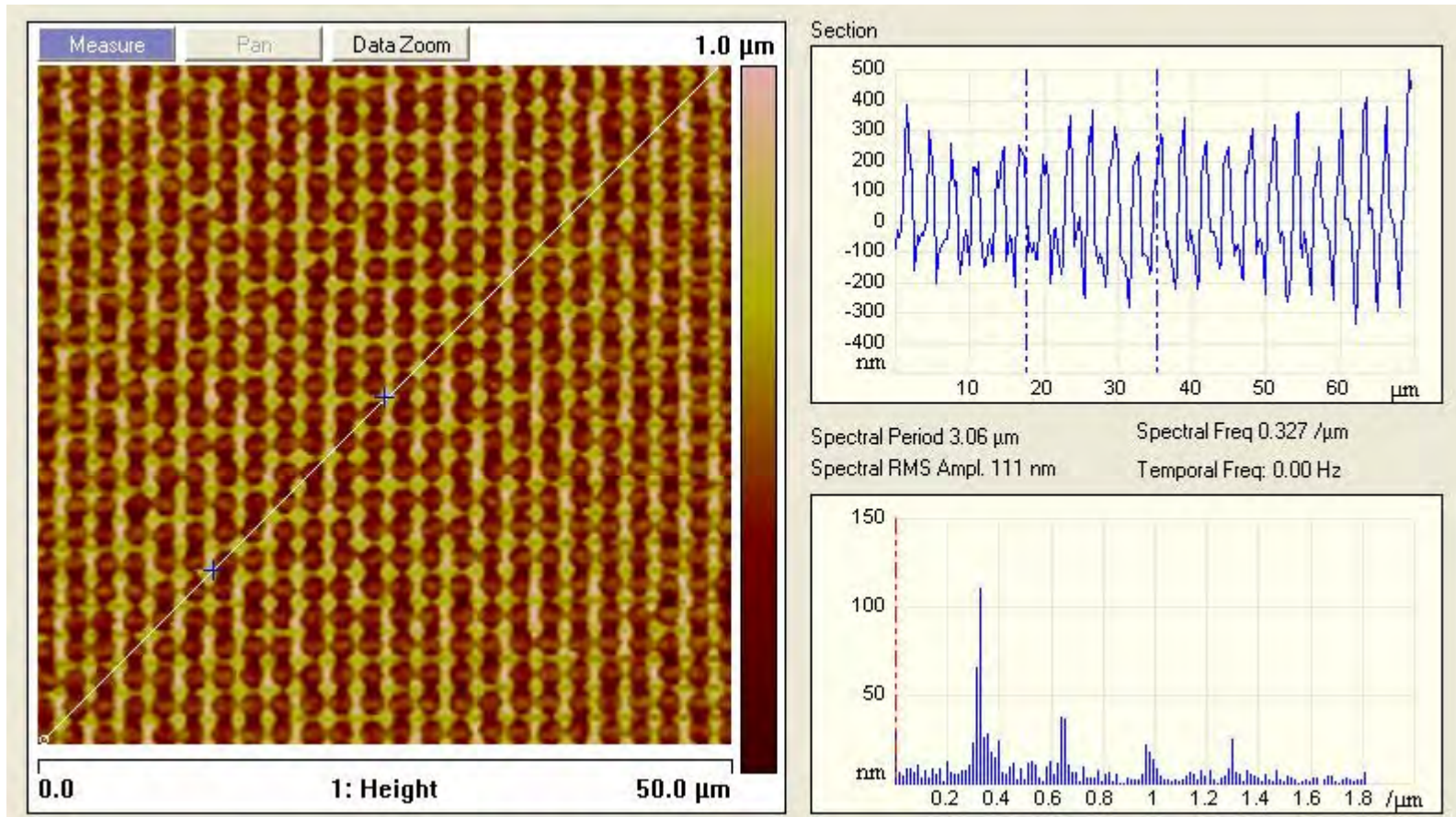
Solvent Assisted Microcontact Molding



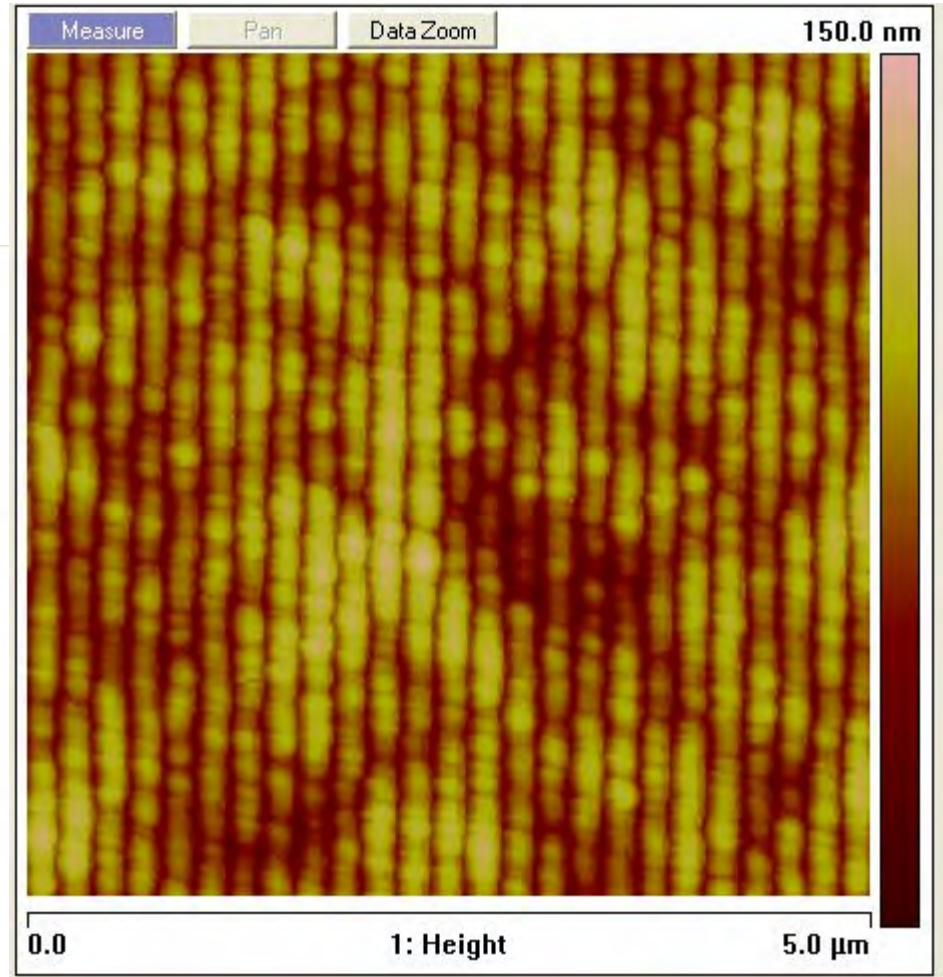
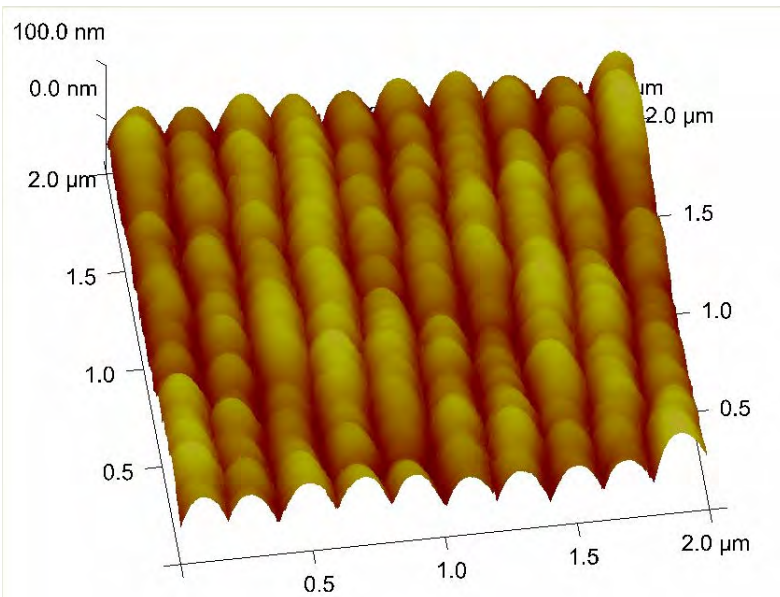
P(VDF-TrFE) Pattern by SL



P(VDF-TrFE) Pattern by SL



P(VDF-TrFE) Pattern by SL



Summary

- ❖ **Nanoimprint lithography and soft lithography techniques have been developed to pattern P(VDF-TrFE) nanostructures**
- ❖ **Patterned β phase P(VDF-TrFE) films have been confirmed by FTIR Spectrum and XRD**
- ❖ **Ferroelectricity of patterned P(VDF-TrFE) films have been confirmed by hysteresis measurement and EFM**
- ❖ **The patterned P(VDF-TrFE) nanostructures are promising for multifunctional material systems**