

True Operational Range of Piezoelectric Actuators



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- 1) Operational range of piezoactuators
- 2) Lead zirconate titanate
- 3) Lead-free piezoelectrics

SFB 595



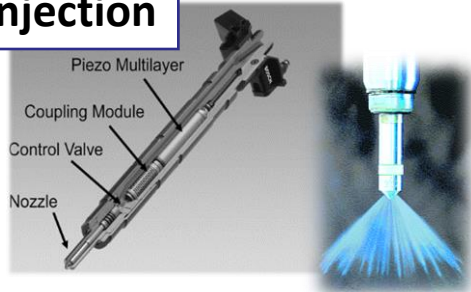
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Project D6

Piezoelectric actuators

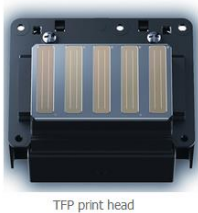
Fuel injection



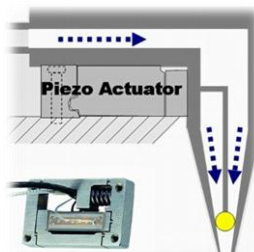
Precision positioning systems



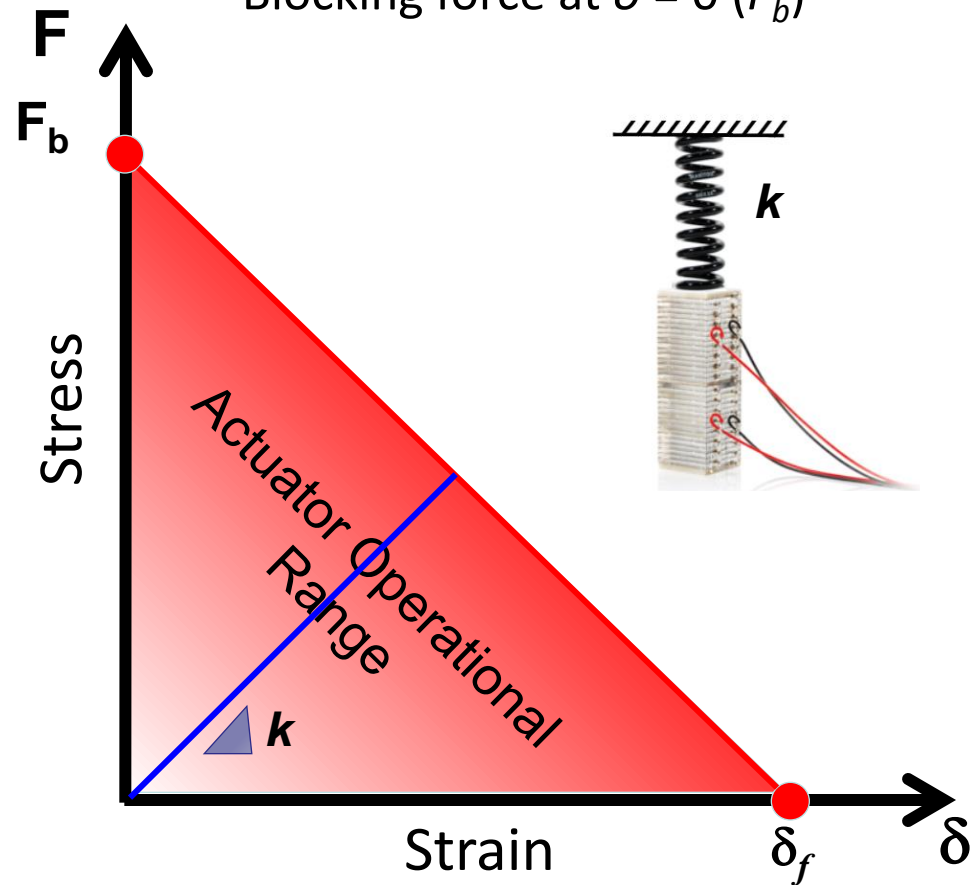
Piezo print head



Valves



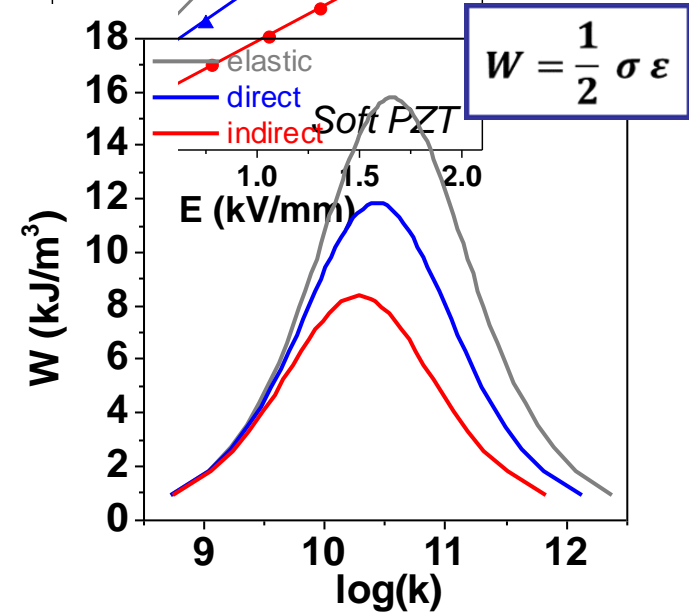
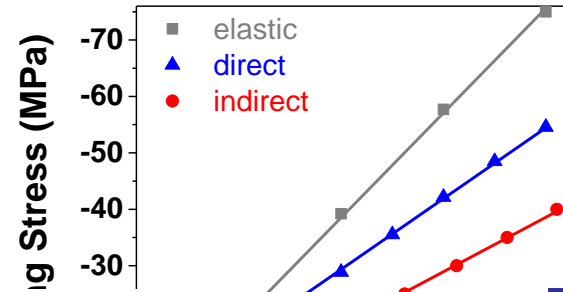
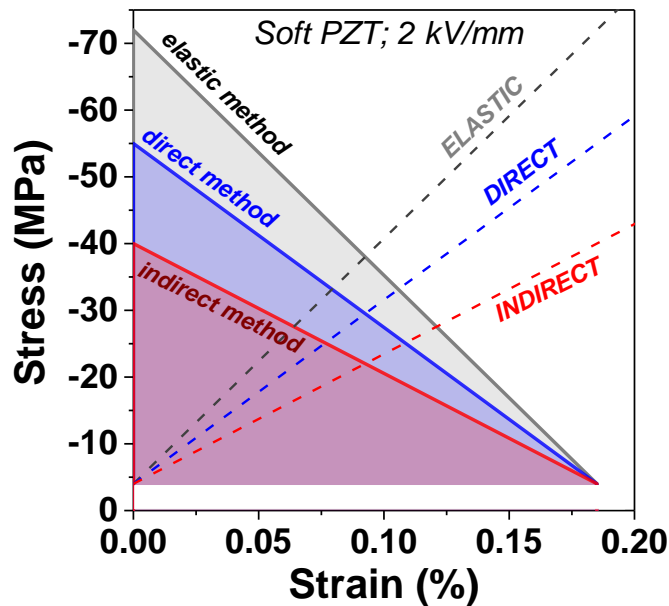
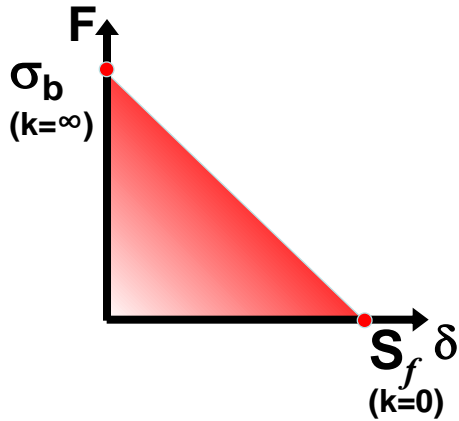
Free displacement at $F = 0$ (δ_f)
Blocking force at $\delta = 0$ (F_b)



Methods for determining the operational range

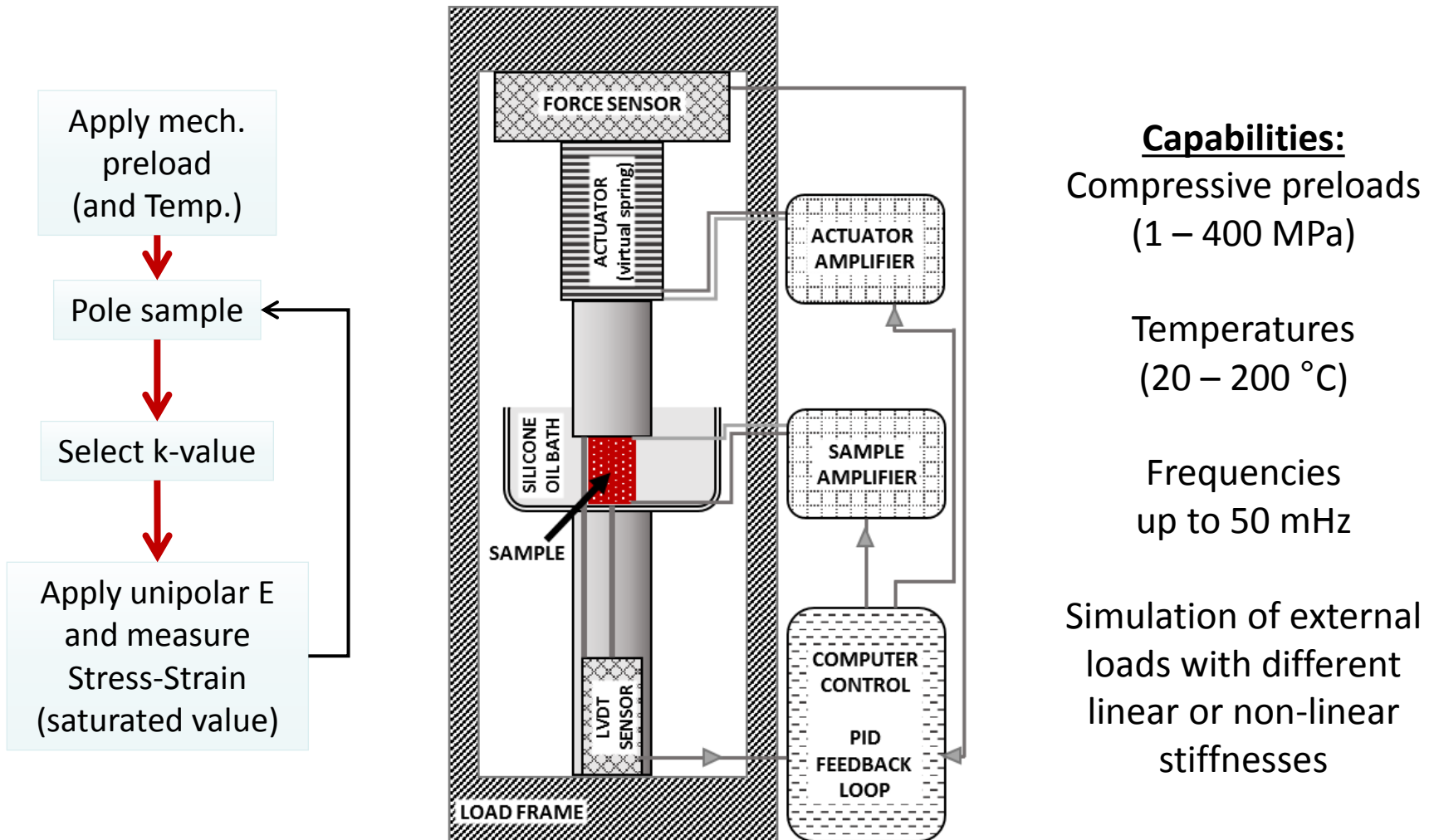


- Elastic, direct and indirect method
- Linear actuator materials – same value
- Ferroelectrics?



Need to assess the true operational range of piezoactuators.

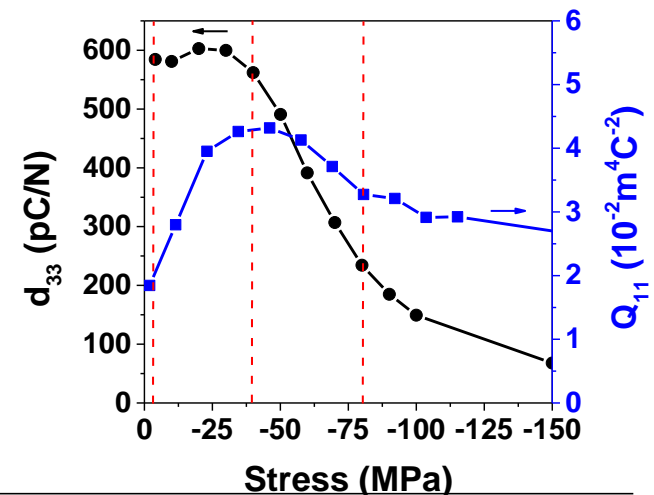
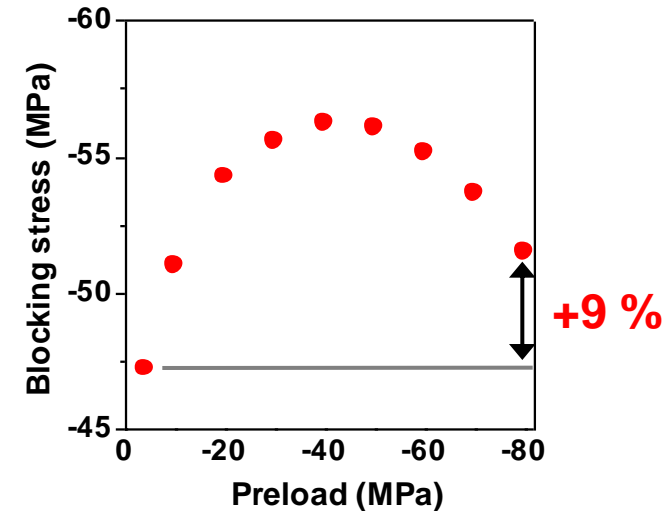
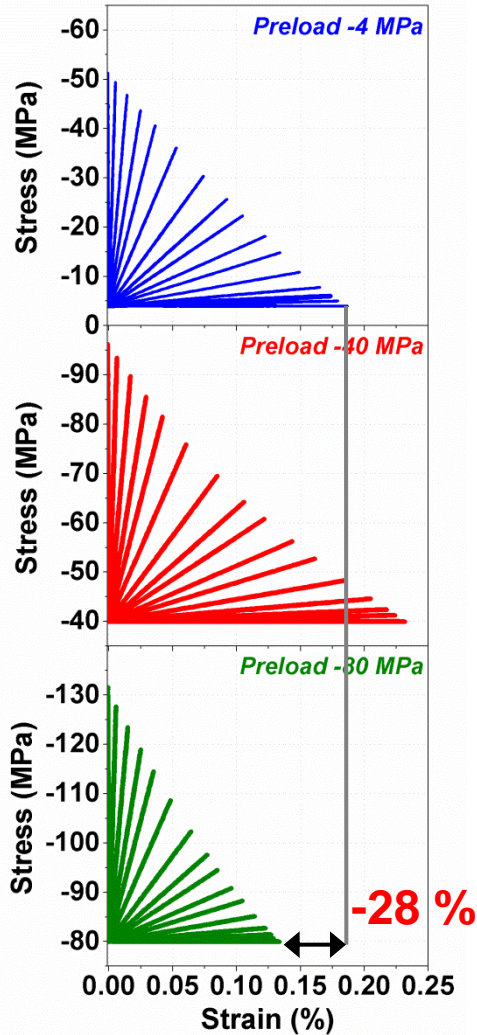
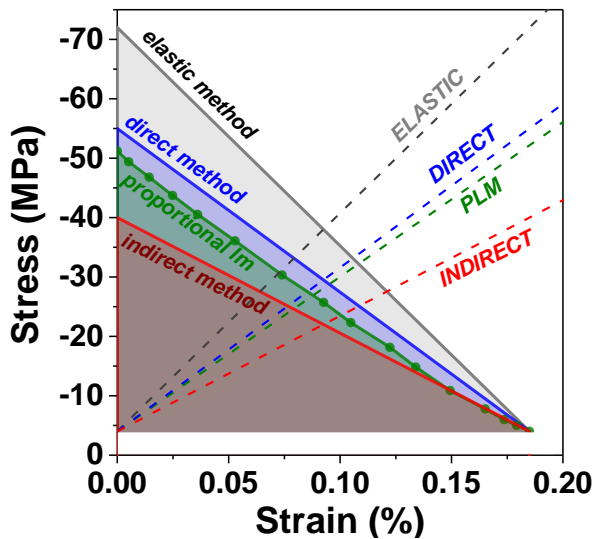
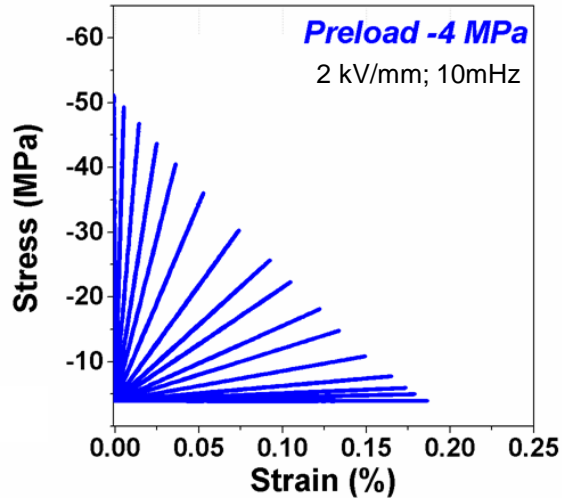
Measurement setup





Soft lead zirconate titanate (PZT)

Operational range of soft PZT



Alternatives for PZT?

Unipolar strain

Lead-based FE
(soft type PZT)

PIC151; PI Ceramics

Lead-free FE

$\text{Ba}(\text{Zr}_{0.2}\text{Ti}_{0.8})\text{O}_3\text{-}0.5(\text{Ba}_{0.7}\text{Ca}_{0.3})\text{TiO}_3$

Brandt et al., JAP 2014

Relaxor FE

$0.93(\text{Bi}_{0.5}\text{Na}_{0.5})\text{TiO}_3\text{-}0.07\text{SrTiO}_3$

Takenaka et al., JJAP 1991

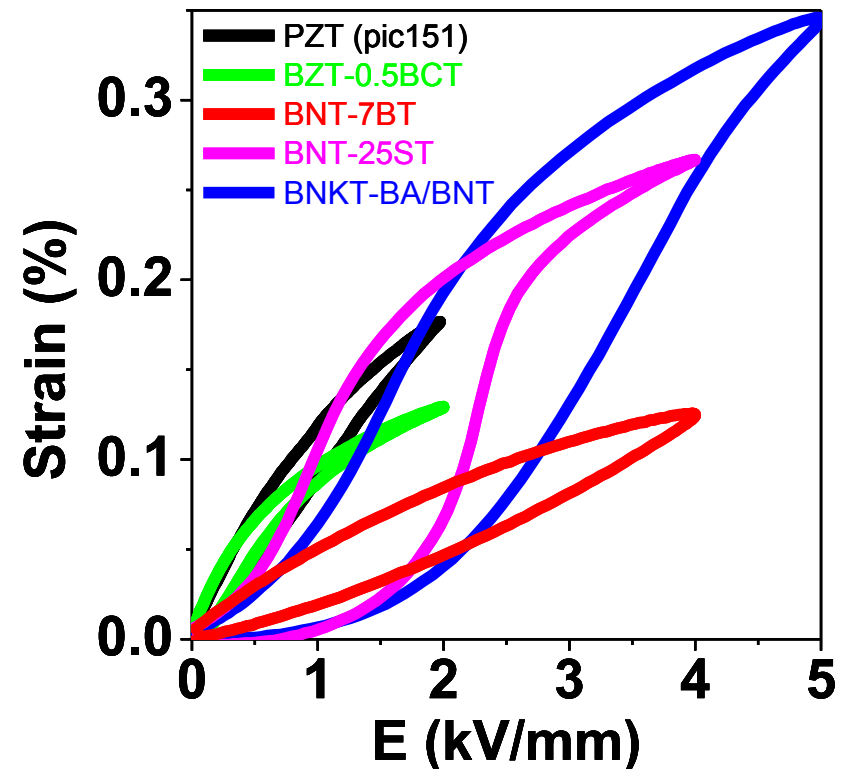
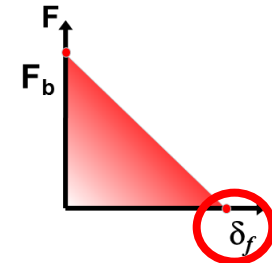
Relaxor FE

$0.75(\text{Bi}_{0.5}\text{Na}_{0.5})\text{TiO}_3\text{-}0.25\text{SrTiO}_3$

Acosta et al., JACerS 2014

Relaxor/FE composites
(BNKT-BA/20%BNT)

Lee et al., APL 2014; Groh et al. 2013



Blocking stress

Lead-based FE
(soft type PZT)

PIC151; PI Ceramics

Lead-free FE

$\text{Ba}(\text{Zr}_{0.2}\text{Ti}_{0.8})\text{O}_3\text{-}0.5(\text{Ba}_{0.7}\text{Ca}_{0.3})\text{TiO}_3$

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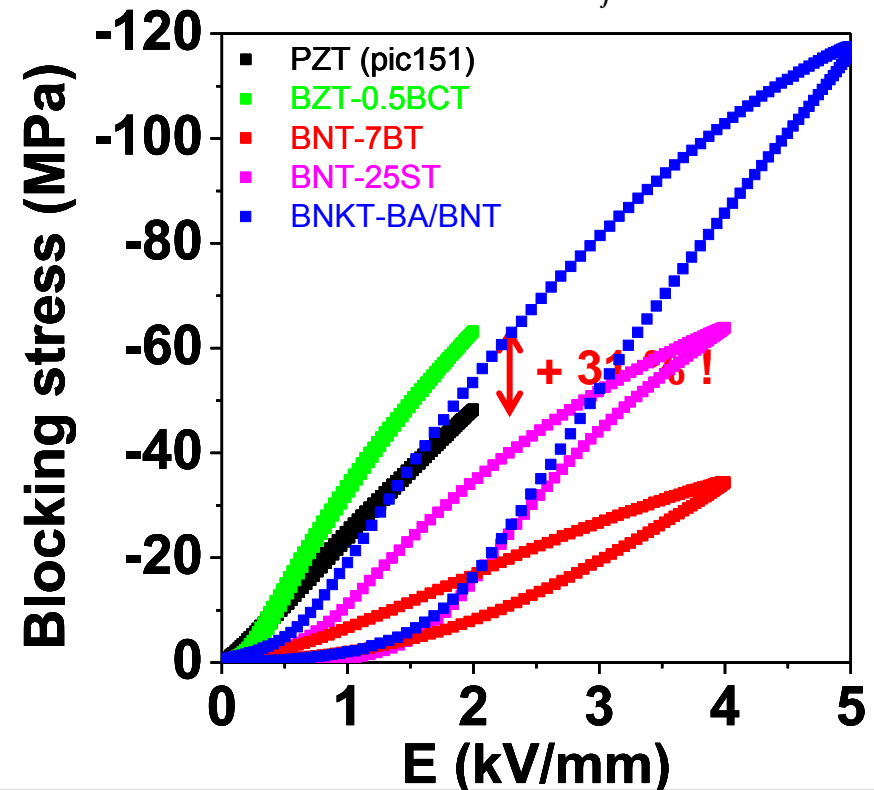
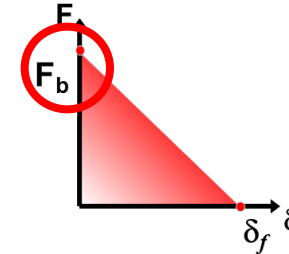
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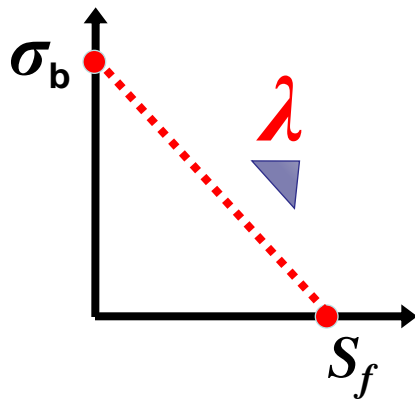
Acosta et al., JACerS 2014

Relaxor/FE composites
(BNKT-BA/20%BNT)

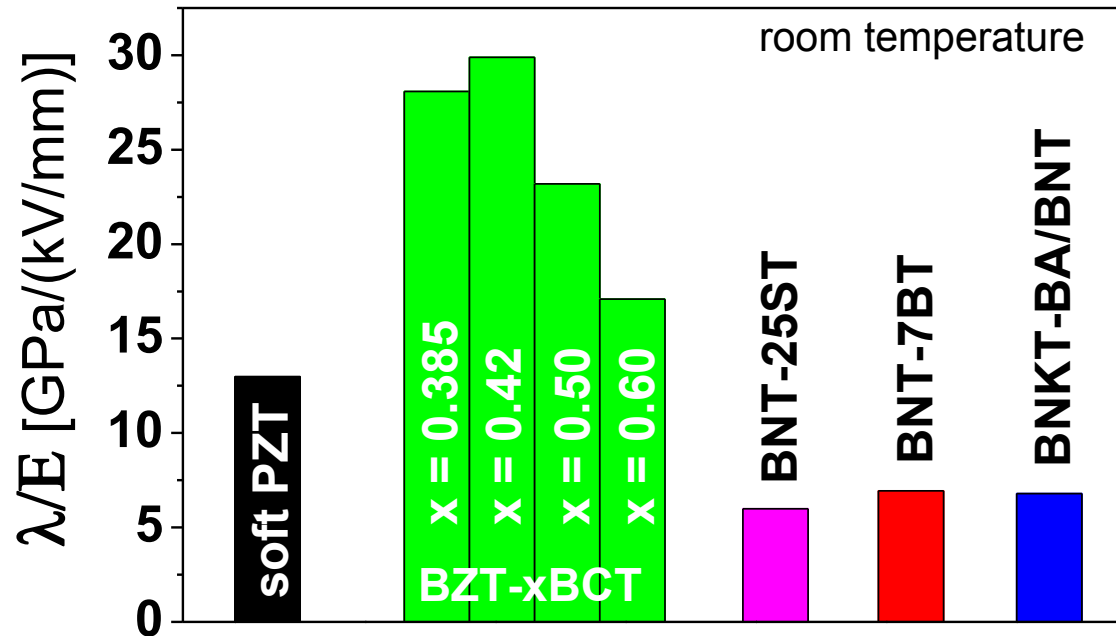
Lee et al., APL 2014; Groh et al. 2013



Electromechanical Conversion Efficiency (λ)

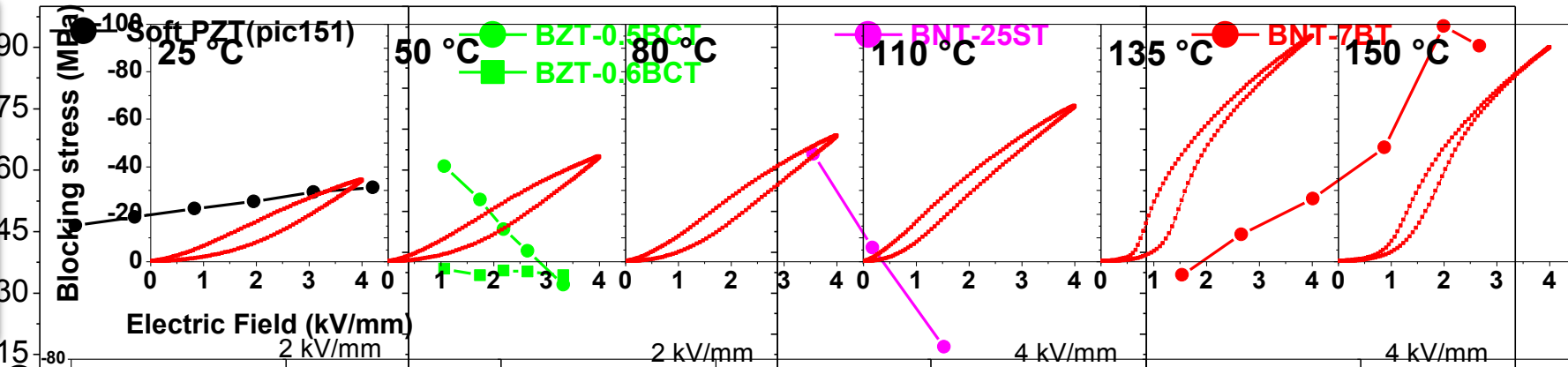


$$\lambda = \frac{|\sigma_b|}{S_f}$$

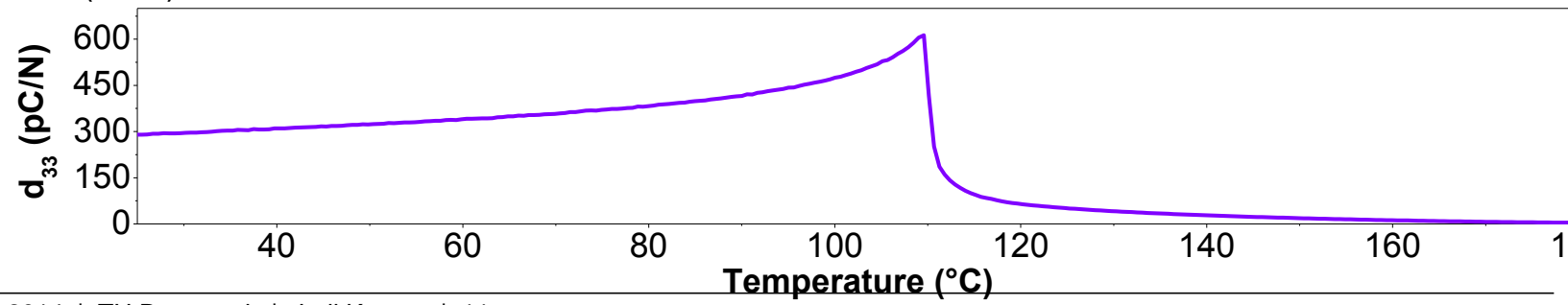
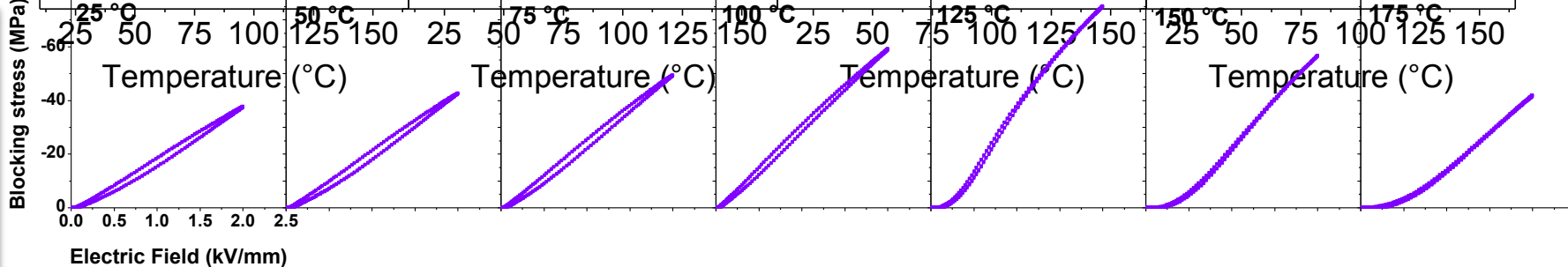


Temperature stability

BNT - 7BT

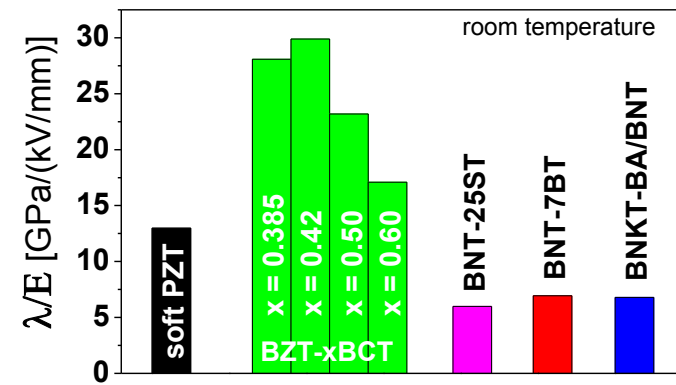
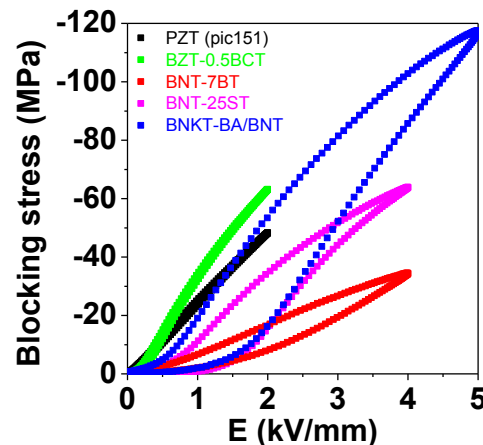
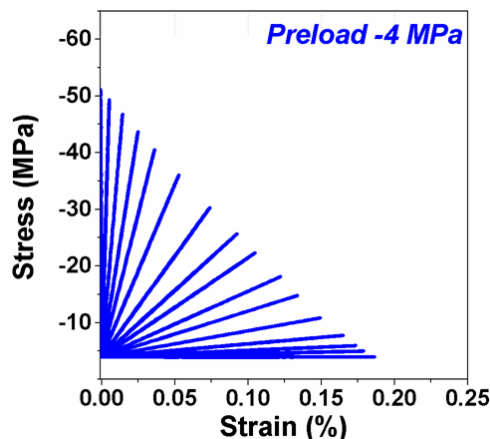


PLZT 9/53/47



Summary and ongoing work

- Investigation of different **strain mechanisms** and their influence?
 - **Stability** of properties in lead-free compositions?
 - Stress-strain behavior of **multilayer actuators**?
 - Simulating **non-linear springs**?





Acknowledgements:

- Colleagues from the NAW group (TU Darmstadt).
- Dr. Soon-Jong Jeong (KERI, Korea).

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