

# **On The Use of Multiple Linear Models for the Control of Nonlinear Piezoelectric Actuators**

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Presented by

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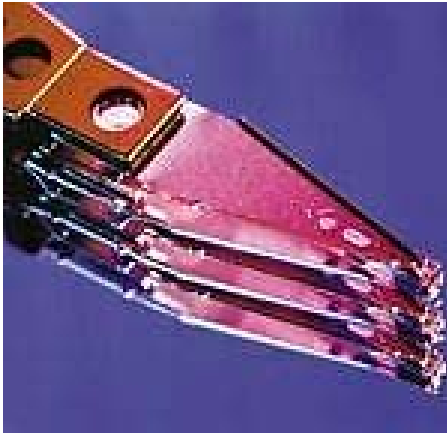
McMaster University

**The 14th International Conference on Flexible Automation and  
Intelligent Manufacturing (FAIM2004)**

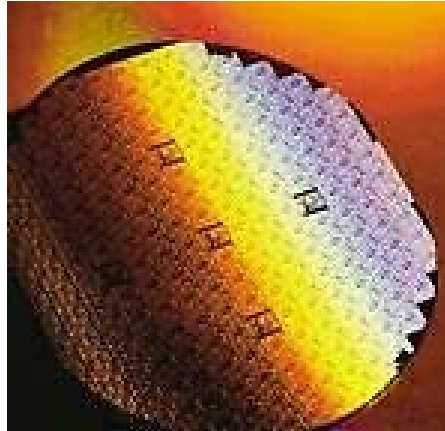
# Overview

- Background
  - Applications of Micropositioners
  - Piezoelectric Actuators (PAs) as an Example of Micropositioners
- Nonlinear Dynamics of PAs
- Linear Modeling of Nonlinear PAs
- Model-based Switching Control of PAs
- Machining Applications of PAs
  - Asymmetric Face Turning Using Fast Tool Servos
  - Misalignment Compensation in Turning
- Summary

# Applications of Micropositioners



**Data storage**



**LCD and flat panel Semiconductors**



**Microscopy**



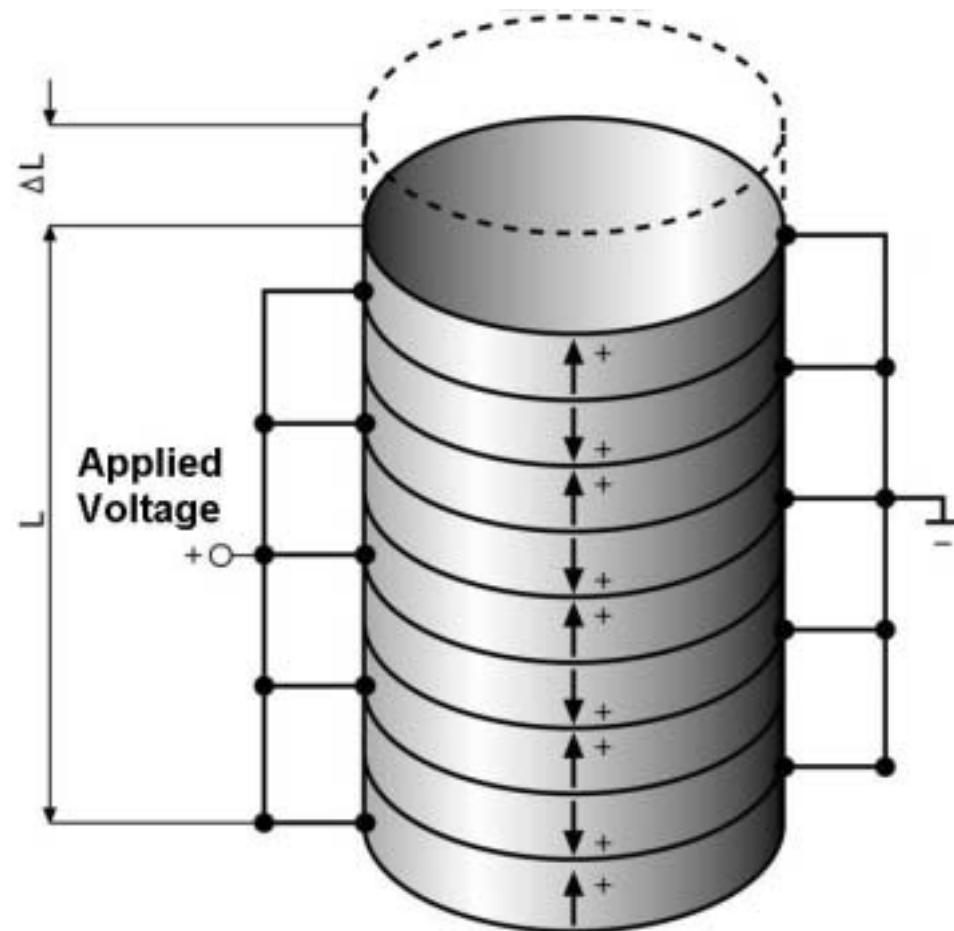
**Micro-assembly**



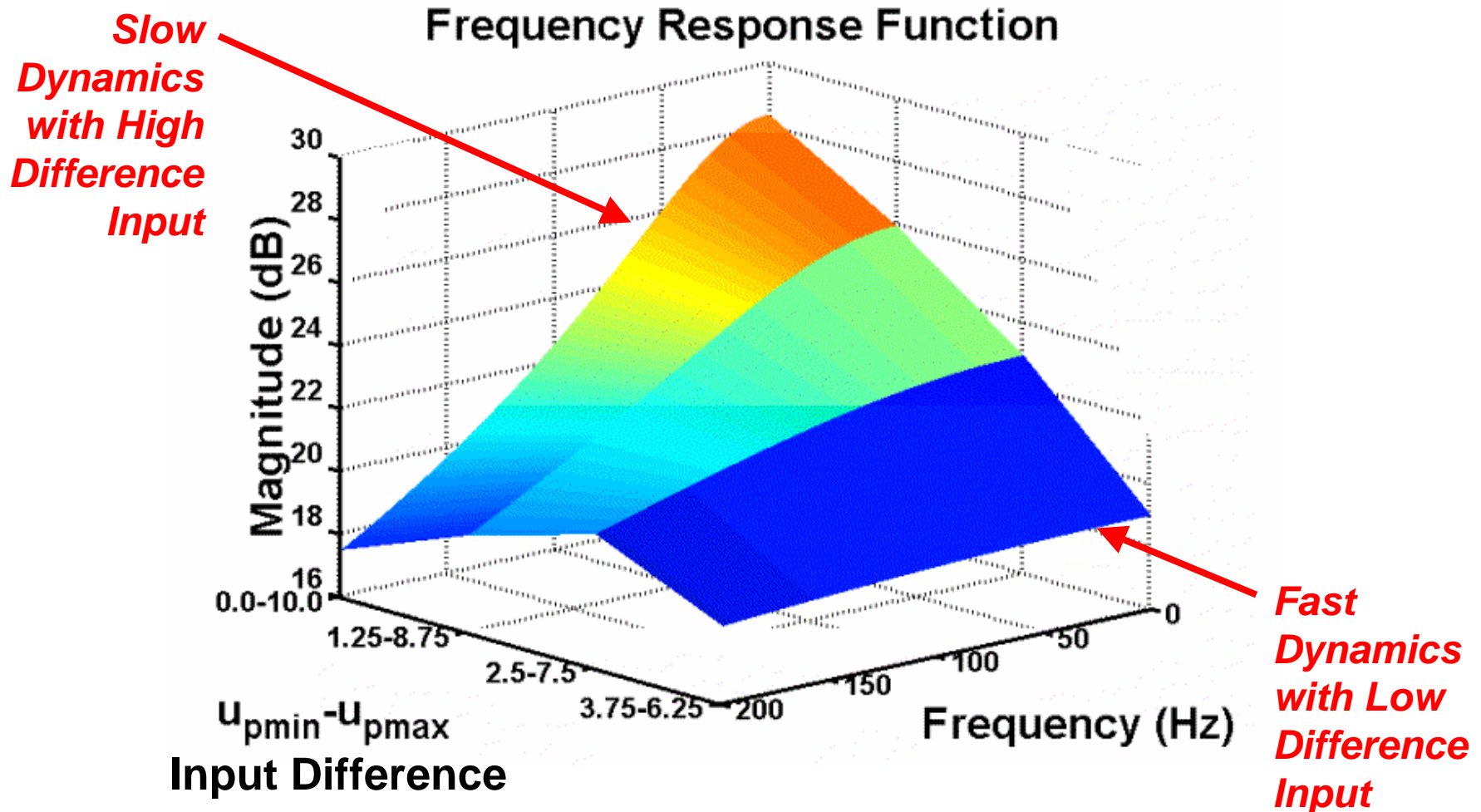
**Medical technology**

# Examples of Micropositioners

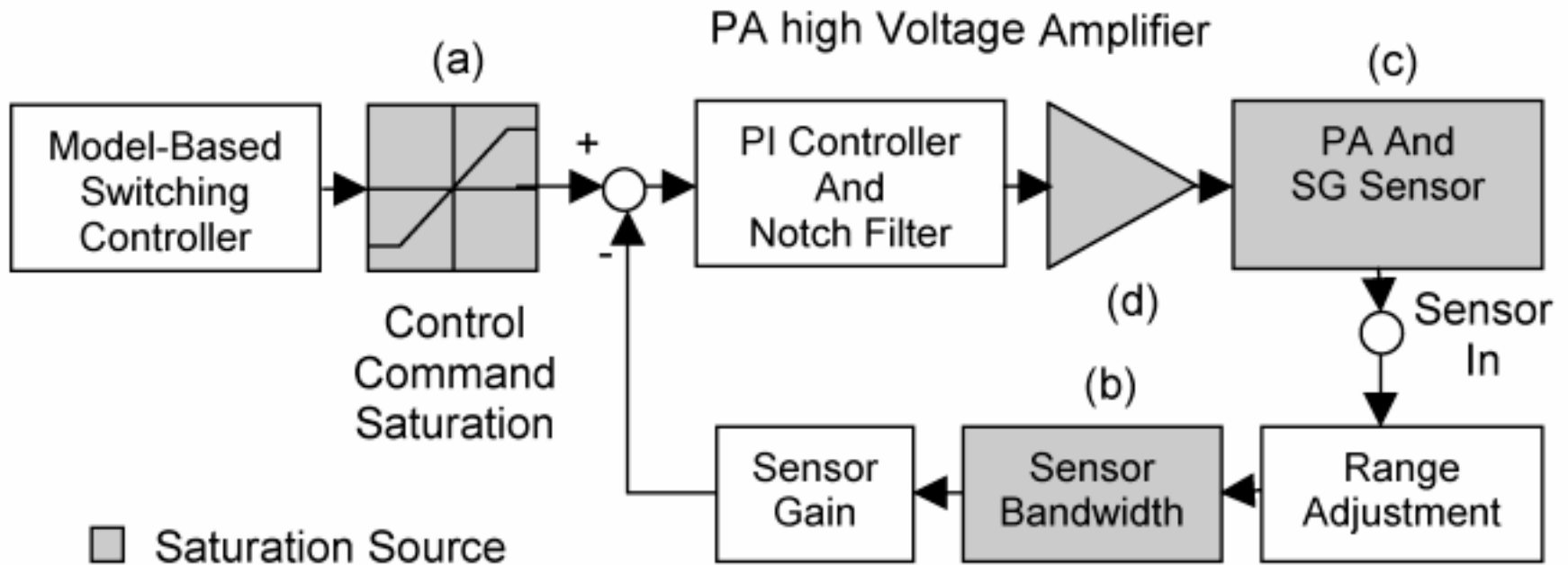
## Piezoelectric Actuators (PAs)



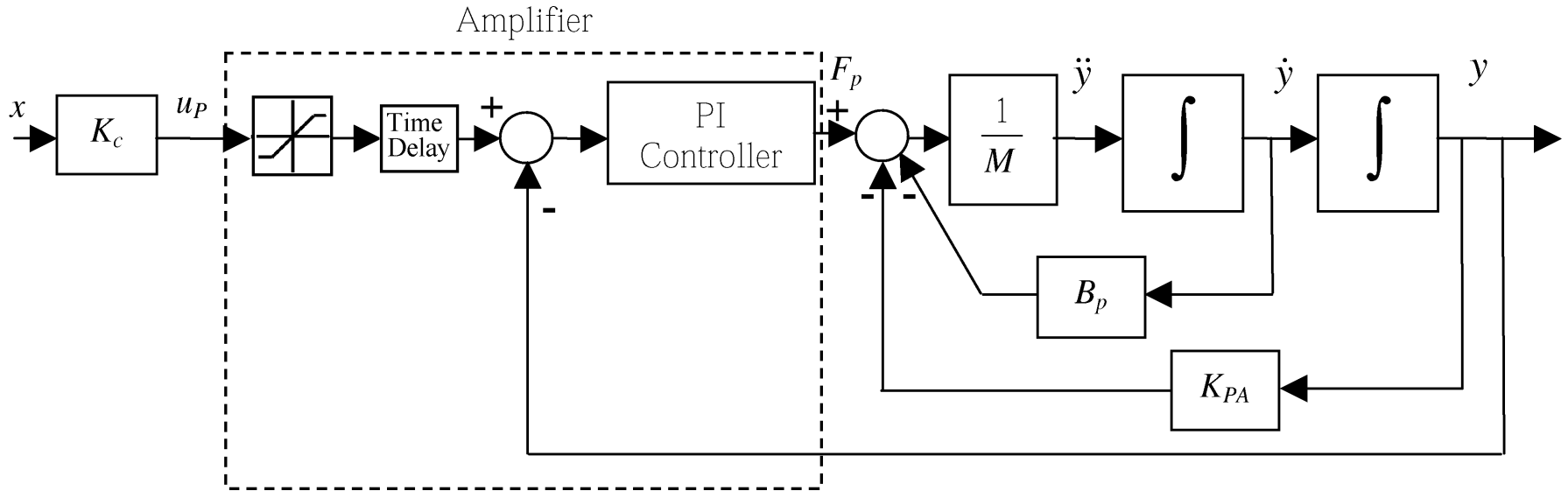
# Nonlinear Dynamics of PAs



# Nonlinear Dynamics of PAs



# Linear Modeling of Nonlinear PAs



## PA General model

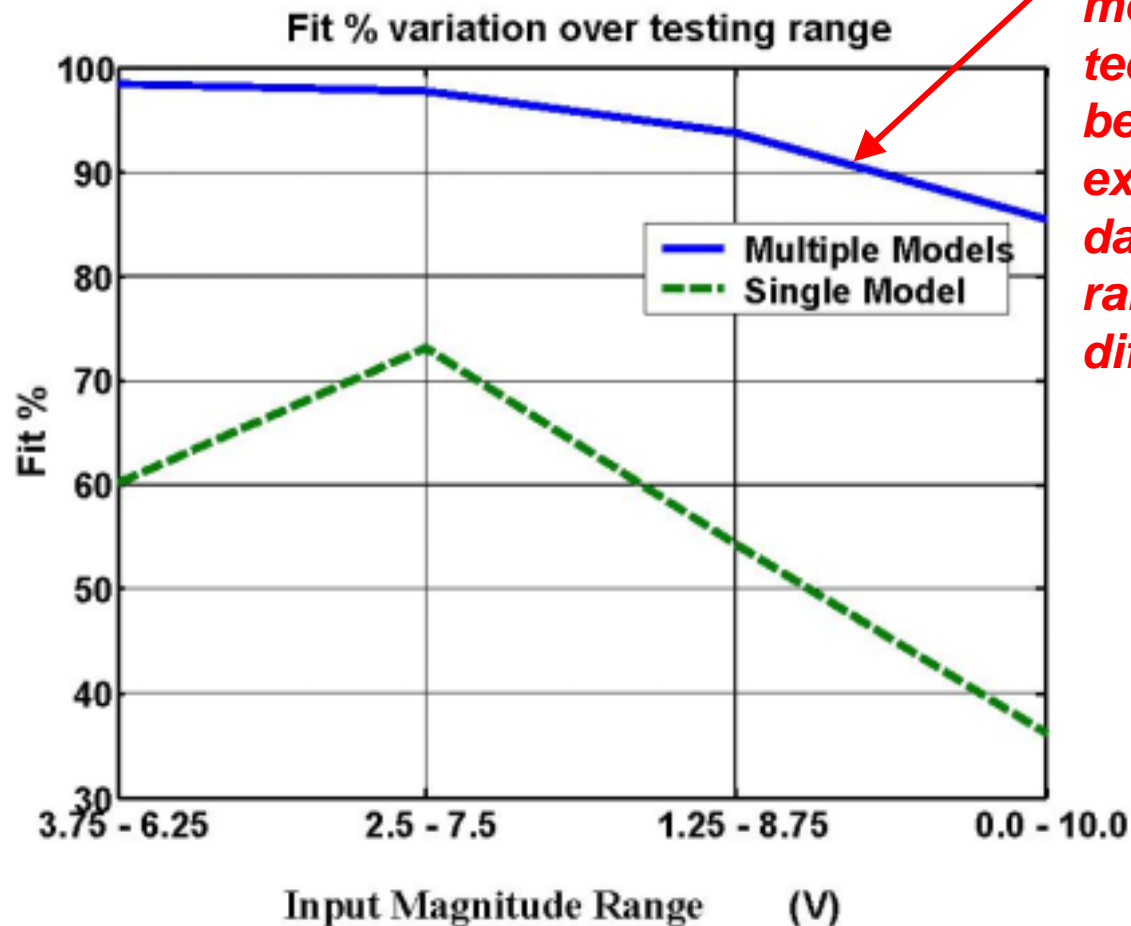
**PA  
Transfer  
Function**

$$G_{Pn}(z) = \frac{a_{n1}z + a_{n0}}{b_{n4}z^4 + b_{n3}z^3 + b_{n2}z^2 + b_{n1}z}$$

**Forward-Shift  
Operator**

**Model Coefficients**

# Linear Modeling of Nonlinear PAs



*Multiple linear models technique gives better fit for the experimental data over the full range of input difference*

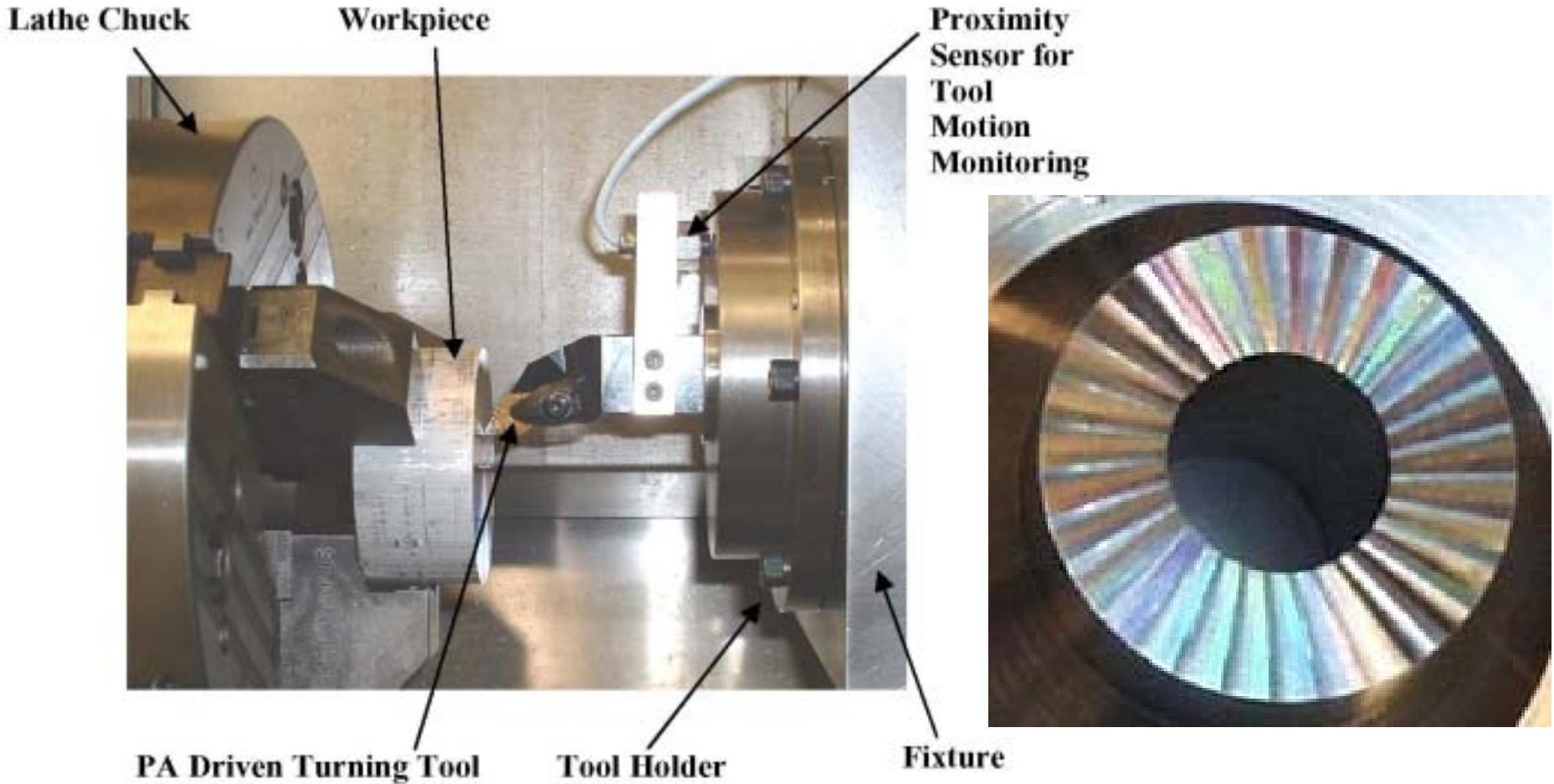




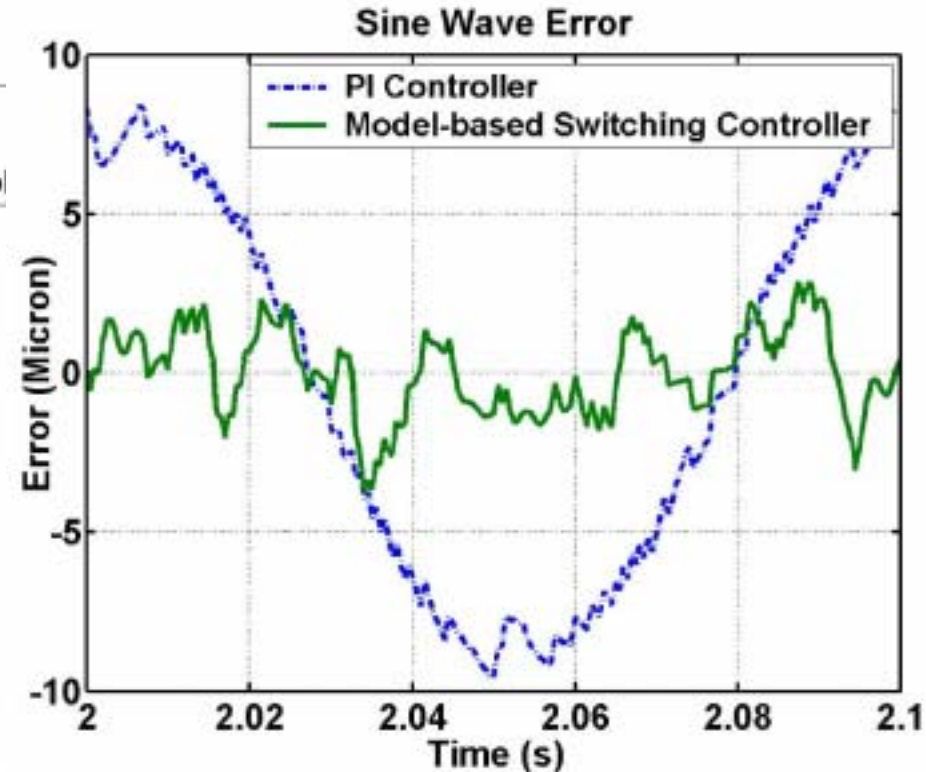
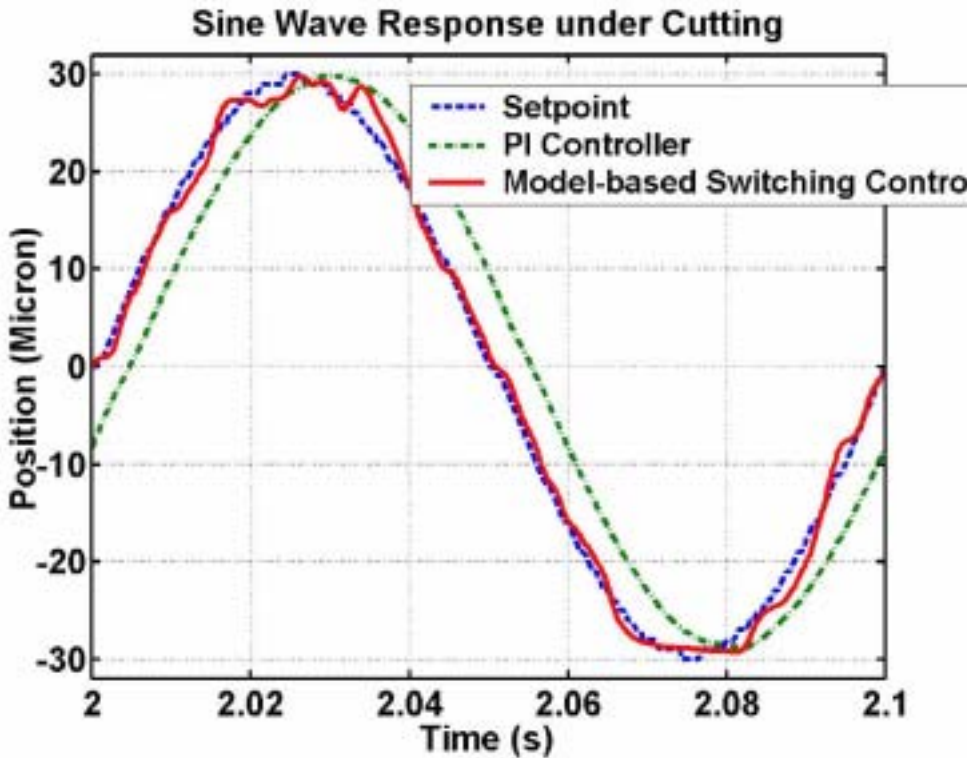
# Piezoelectric Actuators as Fast Tool Servos



# Asymmetric Face Turning

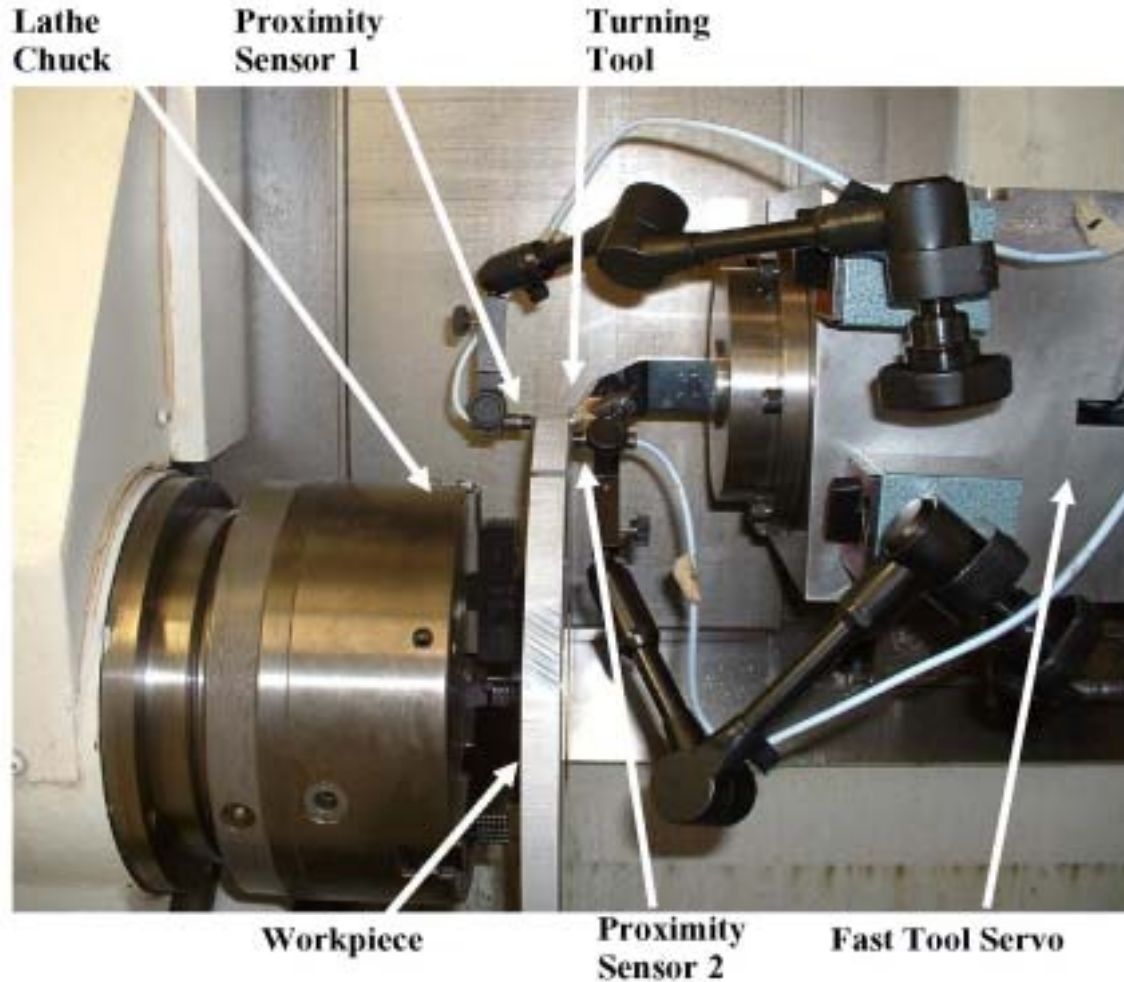
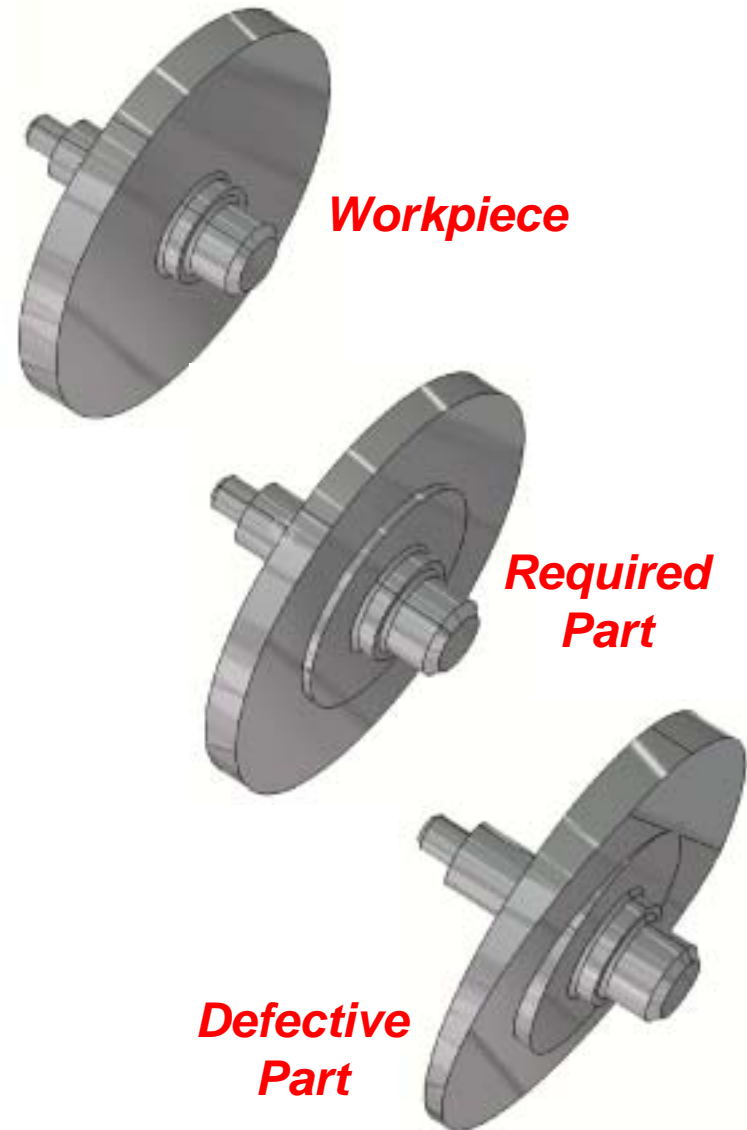


# Asymmetric Face Turning



***The model-based switching controller was able to reduce the tracking error from about  $\pm 8$  micron to about  $\pm 3$  micron***

# Misalignment Compensation In Turning



***A uniform thickness could be obtained within  $\pm 5$  micron at 600 rpm without a time consuming setup procedure***





# Summary

- Multiple linear modeling technique was effective in representing nonlinear dynamics of the PA without the need for a nonlinear model
- The developed technique was able to improve the performance of a PA
- This technique simplifies the controller design procedure but it requires a switching strategy between controllers to be implemented