Linear Piezo Motor Actuator Combining Long Travel, Picometer Resolution and High Forces

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The Problem: Moore’s Law

Moore's Law graph showing the exponential growth in the number of transistors in Intel processors from 1970 to 2005.
The Problem: Moore’s Law

- Moore’s Law compresses IC linewidths and feature-sizes.
- Nanopositioning mechanisms embedded in front-end production and metrology tools have difficulties keeping up; they must provide 10 to 1000x higher precision than feature size.
- Vibrations, position errors, drift need to be controlled to <0.1 nm (~atom diameter).
- Conventional nanopositioning systems have either high accuracy and short travel or do not provide the required stability and precision.
Requirements from Semiconductor Industry for Next Generation Actuators

• Resolution <0.1 nm + travel of several mm
• Keep position stable to nanometer level for a long time
• Lifetime several years minimum
• Stiff with high resonant frequency for fast response and low vibrations
• Must work in Vacuum, Helium, Magnetic Fields

Requirements can only be met with solid state piezoceramic actuators!

But How?
Piezo Technology Before NEXLINE®:

Piezo = Mission-critical Technology
Deployed throughout semiconductor fabrication, packaging & test

- **Actuators**
  - High Force, Speed, Resolution
  - NEW: Ceramic Encapsulation (+Lifetime)
- **Flexure Positioners/Scanners**
  - <1 nm Resolution/Trajectory Accuracy
  - High-Speed Positioning and Scanning
- **Capacitive Position Feedback**
  - Sub-nm Resolution & Stability

Limitations (for some applications):
- Either small travel range
- OR low stiffness
- No position hold with power off
NEXLINE®: Solves the Problem

• NEXLINE® Addresses the Drawbacks of Existing Nanopositioning Systems

• Unique Combination
  – Long Travel (No Basic Limitation)
  – <0.1 Nanometer Resolution
  – High Bandwidth, High Force (to 500 N)
  – Very Compact & Stiff
  – Vacuum, Helium, UV compatible, Wide Temp. Range
  – Non-Magnetic Option (Electron Beam Compatible)
  – Auto Lock: nm-position hold @ 0V operating voltage:
    No Leakage Currents => no wear => 10 Year Lifetime
NEXLINE® Innovative Linear Actuators

Piezoelectric Hybrid Drive

- Flexible
  - Geometry, Size, Force, Travel
- Three Integration Levels
  - OEM Motor, Actuator, Multi-Axis Stage
- Applications:
  - Nanofabrication
  - Lithography
  - Alignment and Nanopositioning
  - Metrology / Testing
  - Repair Systems
NEXLINE® Working Principle

- Combination of Shear and Linear Piezo Actuators
- Flexures for high guiding precision and zero friction
- **Smart Digital Controller** combines high resolution analog mode and long range step mode
- Compatible with different high resolution sensors
NEXLINE® Working Principle

- analog
- step
- mixed
- const. speed
NEXLINE® – Actuator Characteristics

N-215.00

- **Stroke**: 20 mm
- **Continuous Analog Mode**:
  - Resolution < 0.05 nm
  - Range: to 4 µm
- **Step Mode**:
  - Step size: 5nm - 8µm
- **Blocking force**: >500N
- **Slipping force**: >600N
NEXLINE® – Actuator Characteristics

- A) Long range step mode
- B) <0.05 nm steps in analog mode

0.05 Nanometers = Big Safety Margin for Next Generation Systems
Value for Semiconductor Industry

- NEXLINE® helps to increase resolution of steppers or scanners
- Improves the precision of projection systems by correcting errors caused by vibrations, mechanical or thermal problems or other deficiencies
- Was specifically developed for the semiconductor industry and combines high resolution, compact design, high force, stiffness and lifetime
NEXLINE® Systems: What’s next?

• NEXLINE® can be Integrated in Complex Multi-axis Positioning Systems

• Applications:
  – Wafer Chuck: Z/Tip/Tilt Stages
  – Positioning systems for nanoimprint lithography
  – Nanometrology systems
High Load Z-Tip/Tilt Wafer Stage

- Z-stroke: 1.3 mm
- Tip/Tilt: +/- 4 mrad
- Max. Load >50 kg
- Closed loop with internal incremental sensor
Nonmagnetic 6-DOF Hexapod

Low Profile, Six-Axis Nanopositioning System

- 8” Aperture
- Load 50kg
- Low Profile: 140mm
- Translation XYZ: 10mm
- Rotation all axes: 6 °
NEXLINE® Technology Summary

- Increases performance of production and metrology tools
- Proven, novel technology
- Has been successfully used in semiconductor applications
- Addresses challenges of emerging lithographies (e.g., EUV, immersion, nanoimprint)
- Overcomes limitations of classical nanopositioning systems
- Very flexible: from OEM-actuators to 6 DOF systems