Precision Positioning Table Employing Parallel Mechanism for Scanning Probe Microscope

URL: http://www.toyota-ti.ac.jp/Lab/Kikai/5k60/

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Background and Problem

- Cutting machine for nanometer depth of cut
- unavoidable tilt of tube type piezoelectric actuator in general scanning probe microscope (SPM)

Solution

- Stewart platform type parallel mechanism controlled by induced charge feedback method

Advantages

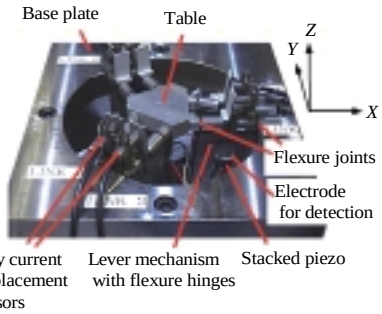
- 6 degrees of freedom
- High resolution in *z* because of small elevation angle
- Flexible tool path
- Enable to use in vacuum because of no slipping element

Results

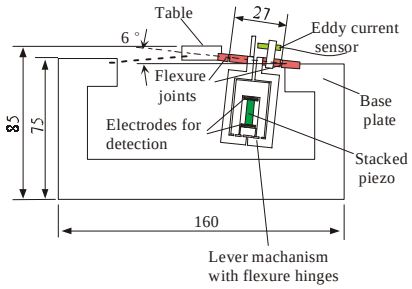
- Smaller tilt (1/10 to tube type)
- High positioning accuracy (16 nm in *z*)
- Linearity within 20×20 μm by semi-closed loop control

Applicable fields

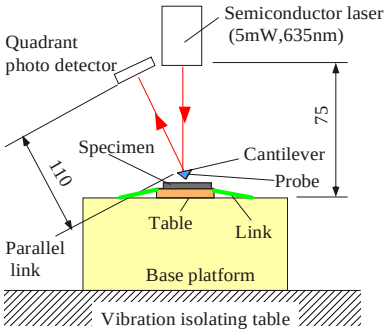
- Ductile mode cutting of brittle materials
- Micromachininig
- Fine motion stage for SPM



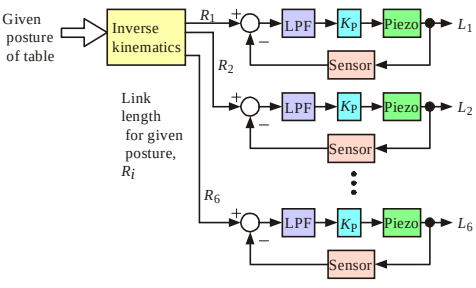
Appearance of device



Sectional view



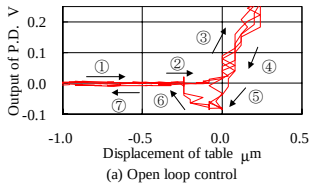
Setup for atomic force microscope



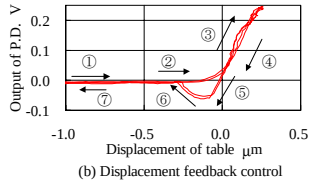
Block diagram of control system

Specifications

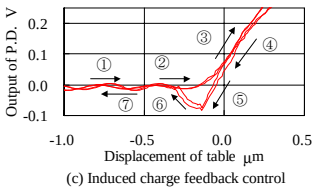
Size: 160×160×85 mm
Mass of table: 24 g
Movable range:
100 μm in *xy*, 20 μm in *z*
Resonance frequency:
100 Hz in *xy*, 75 Hz in *z*
Degrees of freedom: 6
Actuators: Piezoelectric actuators
Magnification: 12.5



(a) Open loop control



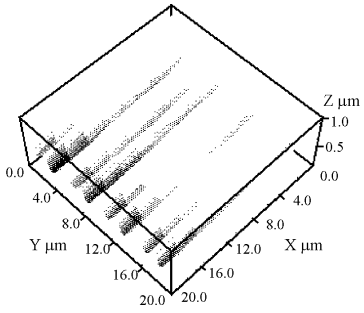
(b) Displacement feedback control



(c) Induced charge feedback control

Cross-talk ratio

Feedback	Cross talk ratio % x/y	z/y	Pitching error μrad
None	19.6	8.2	12
Displacement	11.7	3.9	17
Induced charge	3.5	4.7	17



AFM image of diffraction gratings

Force curve on Silicon

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