



Ministry of Science and Technology
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Development of Nano Movement System

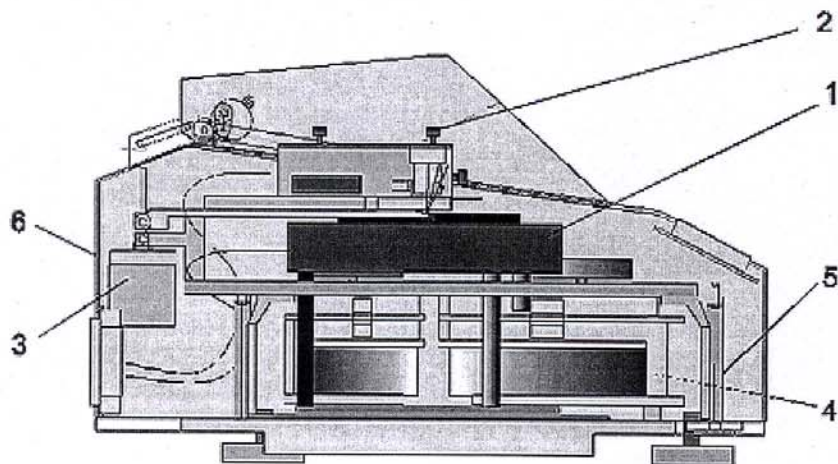
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Technology progress was always inextricably connected with miniaturization of devices and machines from centi to micro and now to nano scale sizes. Nowadays nanotechnology is the field, which integrates most valuable achievements of current science and it promises to be the main trend of 21st century technology.

Nanomanipulation is a basic part of nanotechnology, which enables to change, interact and control nano scale phenomena precisely. By the nanomanipulators the nanoobjects are pushed, pulled, picked, oriented and positioned forming working structures of corresponding nanomachines.

In the work are presented results of development of a nano movement system intended for manipulation of objects with a few tens of nanometers. The system is a specially designed device which supports manipulation mode (particles movement and surface scratching), 3D imaging of the manipulation field in AFM mode, and a cantilever-type nanoforce sensor. The working part of the manipulator is a silicon tip having 6 DOF relative to its contact point. On the figure below is shown the main view of the nano movement system.



Stage 1 is used for changing the probe-sample relative position during surface scanning or particles manipulation. Manipulator 2 realizes roll, pitch and yaw motions of the probe. Approaching system 3 provides vertical movements of the sample. Draft positioning system 4 is used for selection of the area of interest which can be viewed by an optical system based on a CCD camera. The nano movement system is placed on vibration isolation suspension 5. The case 6 is used for protecting the system from acoustical noise and air flow affecting the manipulation process.

The operation cycle of the nano movement and manipulation system is divided into two main steps: scanning a selected area in AFM mode to determine initial positions of the particles (imaging mode) and the particles manipulation (manipulation mode).

Development of Nano Movement System

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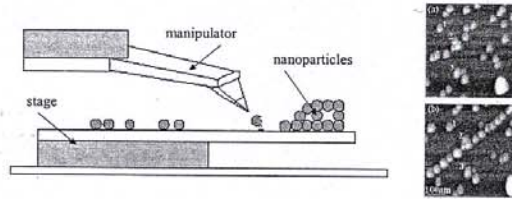
Background

Technology progress was always inextricably connected with miniaturization of devices and machines from centi to micro and now to nano scale sizes. Nowadays nanotechnology is the field, which integrates most valuable achievements of current science and it promises to be the main trend of 21st century technology.

Nanomanipulation is a basic part of nanotechnology, which enables to change, interact and control nano scale phenomena precisely. By the nanomanipulators the nanoobjects are pushed, pulled, picked, oriented and positioned forming working structures of corresponding nanomachines.

Project Aim

The purpose of the project is development nano movement system with six degree of freedom for manipulation of nano scale objects.



Basic structure of nanomanipulation system and result of manipulation

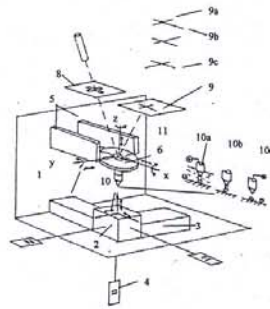
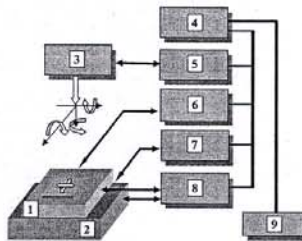
Specification of Nano Measurement and Positioning System

XYZ movement range	100 μm
Z resolution	0.1 nm
XY repeatability	1 nm
Resolution in θ, ϕ, ψ	0.1 $^\circ$
Repeatability in θ, ϕ, ψ	1 $^\circ$
Range of rotation	10 $^\circ$
Near field position measurement	Capacitive sensor
Stage working area	3x3 cm
Max sample weight	100 g
Resonant frequency of stage	600 Hz
Working environment	760 mmHg, 50 RH, +20 $^\circ\text{C}$

Project Schedule (2001–2004)

- 1st year:**
- 3 degree of freedom XYZ stage
 - working in AFM mode
- 2nd year**
- XYZ stage long/small distance
 - Close loop control of displacements
 - Pushing nanoparticles
- 3rd year**
- 6 degree of freedom manipulator
 - Roll, Pitch, Yaw manipulator
 - 1nm resolution

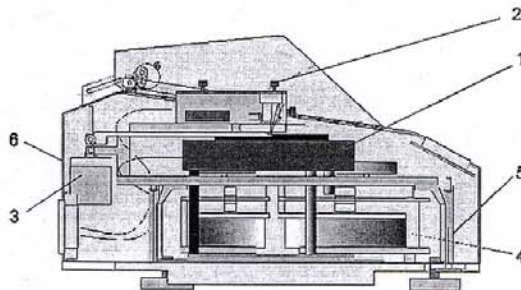
Principal Scheme of Nano Movement System



1 – Nanopositioner; 2 – Draft positioning system;
 3 – Nano manipulator; 4 – PC-Interface board;
 5 – Nanomanipulator Control; 6 – Close loop
 control; 7 – Close loop motor control; 8 – Far/Near
 field measurement system; 9 – Host computer /⁴

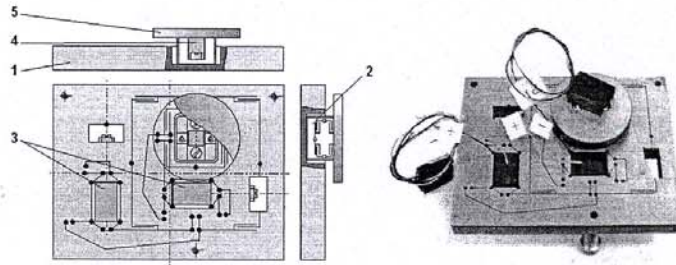
1-3 – PZS for XYZ movement;
 4 – capacitive sensors; 5 – bimorph plates;
 6 – rotating diaphragm; 7-9 – shape masked
 laser system; 10 – manipulator.

Design of the System



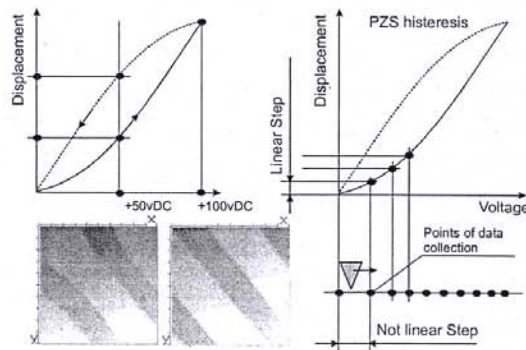
1 – XYZ stage; 2 – nanomanipulator; 3 – approaching system;
 4 – draft positioning system; 5 – vibration isolation suspension; 6 – case.

XYZ Positioning System

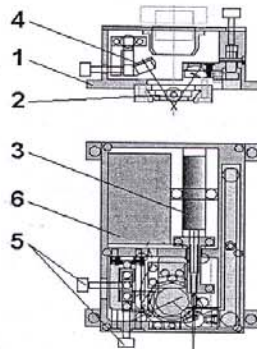


- 1 - Base plate with EDM made flextures;
- 2 - Z scanner; 3 - XY axes actuators;
- 4 - Z axis actuator; 5 - specimen stage

XY Stage Nonlinearity Compensation



Nanomanipulator



1 - base; 2 - tip holder; 3 - laser;
4 - photodetector; 5 - tuning knobs;
6 - circuit board

200kHz

Nanomanipulation Diagram

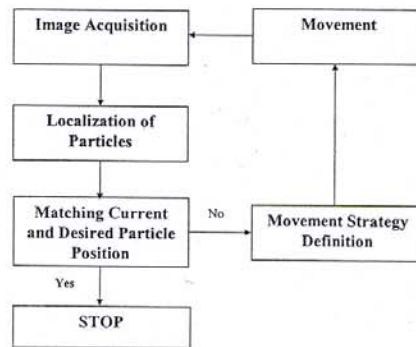
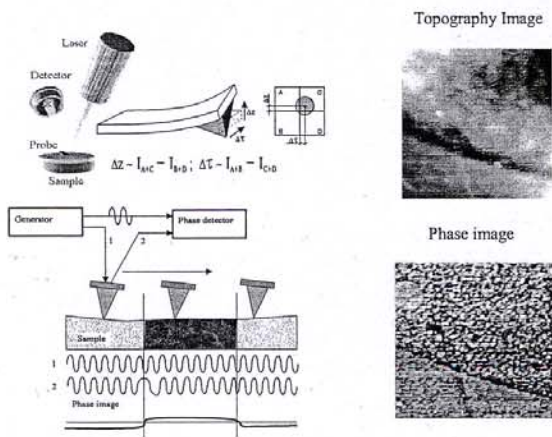
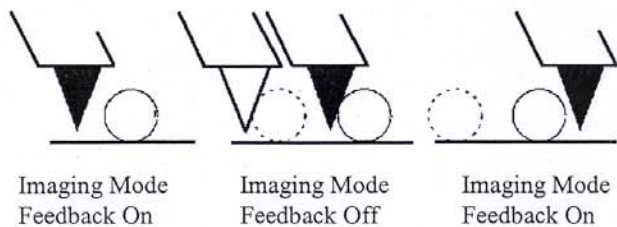


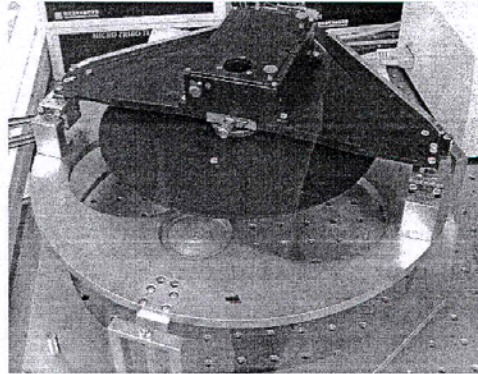
Image Acquisition Mode



Manipulation Mode



Main View of Developed System



RESULTS

The following components of the Nano Movement System are developed and produced:

- 3 degree of freedom XYZ stage
 - Range 100 μm ,
 - XY resolution 1 nm
 - Z resolution 0.2 nm
- Close loop control of XY displacement
- Manipulator with nano force feedback
- AFM topography/phase image acquisition mode support