PRONANO

Contract NMP2-CT-2005-515739

PRONANO

Technology for the Production of Massively Parallel Intelligent
Cantilever - Probe Platforms for Nanoscale Analysis and Synthesis

Instrument:	Integrated Project
Thematic Priority:	NMP

12 Month Periodic Activity Report

Public Summary

Period covered:	from 01-04-2005 to 31-03-2006	Date of preparation:	12-05-2006
Start date of project:	01-04-2005	Duration:	5 years
Project coordinator:		Thomas Sulzbach	
Project coordinator organisation:		Nanoworld Services GmbH	
Revision:		20060512	

Publishable executive summary

During the first period a remarkable progress towards the overall aim of massively parallel addressable cantilever arrays have been achieved. First working arrays of up to 4x32 cantilevers have been realized (Uni Kassel) enabling experiments focussing on the fundamental understanding of parallel operation of cantilevers with integrated actuation and readout and the interaction of the probes with the control and data acquisition on the on the one hand and the scanning mechanism on the other hand (WP3). The realization of shallow junction piezoresistive deflection sensors has been addressed by the development of sophisticated implantation techniques (FZR) which has already been used for the fabrication of the first generation of probes. High dose ion implantation has been used for the creation of heater elements (FZR) of the thermal bimorph actuator.

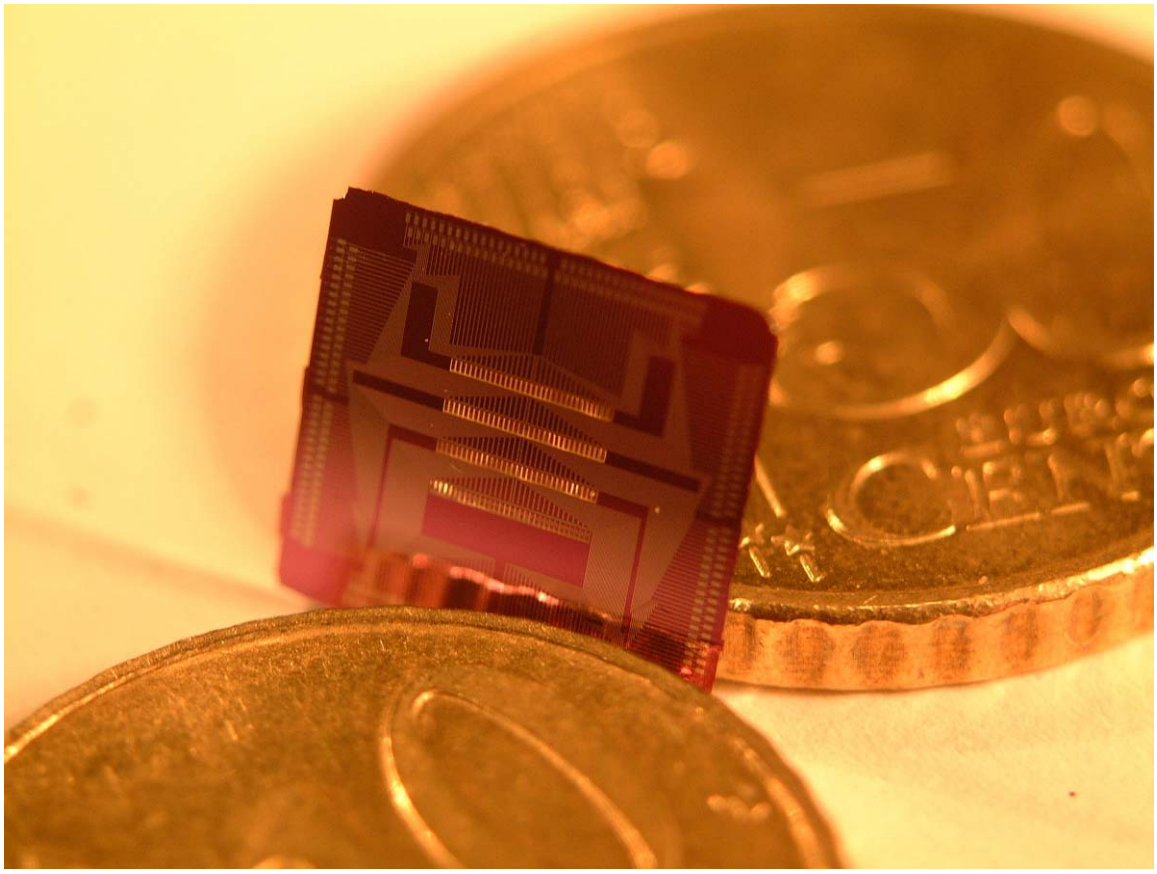

Fig. 0.1: First generation of cantilever array probes with 4x32 fully addressable cantilevers

For the realization of the first generation of probes dedicated mask layouts have been designed (Uni Kassel, UISAV) and the processing sequences have been developed. Especially tailored analysis methods are accompanying the process development for understanding the detailed composition of deposited layers and gaining insight into the implanted doping profiles (INPL). The integration of ultrasharp tips into the process flow of the addressable cantilever arrays is particularly investigated and special process sequences ensuring the protection of the fragile tip during subsequent processing are developed (Nanoworld).

A dedicated packaging for the first generation of probe array has been evaluated and realized (ARCS). Parallel to that, the concept and technology development for customized packaging

of the massively parallel second generation of probe arrays with vertical interconnections have been started. A preliminary technology for the realisation of vertical interconnections through the wafer has been established as basis for the fabrication of the second generation of probe arrays with higher integration density (UU).

As an alternative to the silicon technology with the potential of cheaper mass manufacturing and high actuation efficiency polymer based cantilever arrays are developed and first demonstrators have been realized during the reporting period (RAL).

The nano-measurement machine has been improved and adapted to the requirements of a scanning stage for the addressable cantilever arrays (SIOS). Especially tailored probe mounting adaptors have been developed and integrated.

The aim of the work package 2 is to design, develop and test precise, wide band and low noise control and measurement electronics which will enable application and characterization of the fabricated PRONANO single cantilever as well as 1D and 2D sensor arrays.

In our experiments it is proposed to excite the resonance cantilever vibrations using the thermal heater (actuator) integrated with the spring beam. Simultaneously the cantilever oscillation will be detected by monitoring the output signal of the cantilever piezoresistor. The change of the cantilever vibration, which occurs under the influence of the force acting at the microcantilever tip, is a measure of distance between the microtip and the surface.

Therefore developing of the discrete (hybrid) electronics (for the single cantilever systems and up to 32 beam 1D sensor arrays) is foreseen which will detect the cantilever vibration and control the resonance and static beam deflection (WRUT, Microsystems). Based on these experiments we will design, fabricate, test and apply ASIC systems for the 2D sensor arrays (ID-MOS, ELMOS, WRUT). The designed hybrid and ASIC measurement and control systems will include selective preamplifier stage, detector of the cantilever oscillation amplitude, tip-surface distance controller and high resolution system for the excitation of the cantilever vibration. Additionally we propose to develop systems which will enable the operation of the PRONANO cantilevers in the self oscillation mode and the detection of the resonance frequency of the spring beam.

Fig. 0.2: Analogue PID controller (left) and high-speed RMS/DC converter (right)

A Phase Locked Loop circuitry is developed which enables application of the PRONANO cantilevers as self oscillating devices (Microsystems). Design, fabrication and testing of ASIC's electronics for the PRONANO cantilevers from 1D and 2D sensor arrays is investigated.

During the last 12 month specifications for the subcomponents were defined to ensure their compatibility with the test-bench system built at SIOS as well as other customized application tools to be built by the industrial partners (NaWoTec, Leica, Infinion) at the second stage of the project. The specifications were given in table 0.1.

	Mask repair (NaWoTec)	**CD metrology (Leica)**	**Inspection**	**Pressure sensor (Infineon)**
Spatial resolution	< 5 nm	2 nm	10 nm	1 µm
Z-resolution	1 nm	< 1nm	5 nm	10 nm
Scan area	20 x 20 µm	< 2 x 2 µm	25 x 25 mm - 14 x 14 cm	100 mm^2 - 3000 mm^2
Throughput	< 2 min	< 10 sec	< 5 h	< 100 mm^2/h
	Single cantilever		Cantilever array	

Table 0.1: Top level specification for the intended pilot applications

According to the workplan SIOS has developed a test bench based on the NMM system.

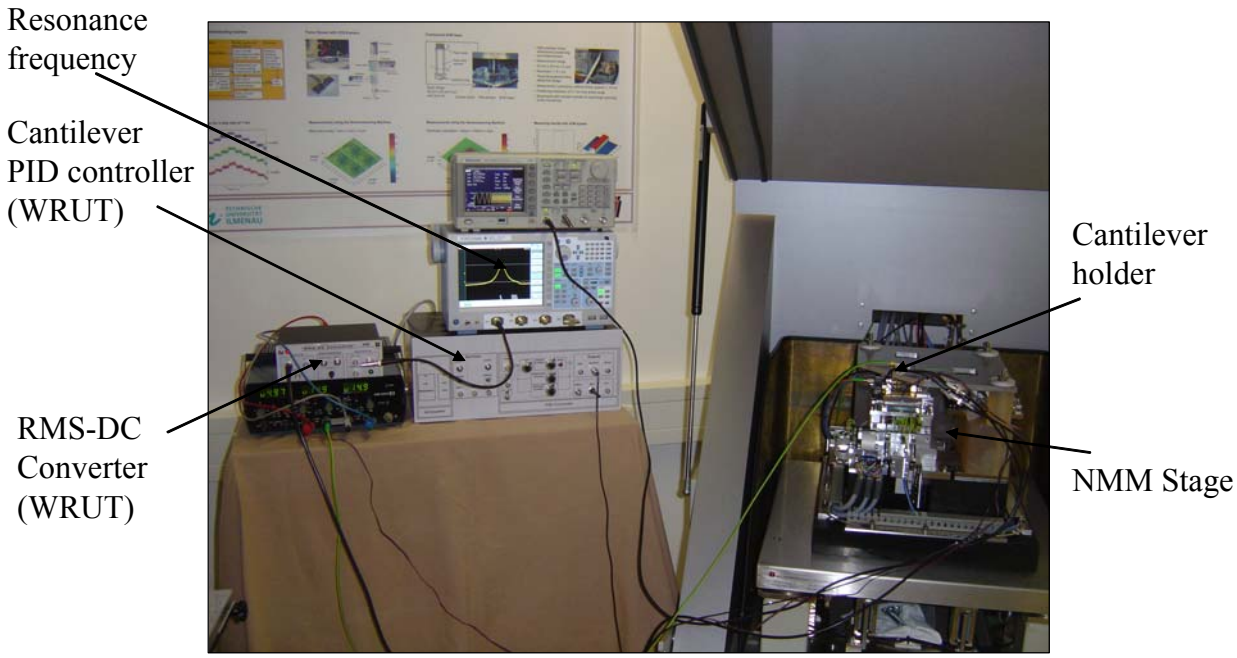

Fig. 0.3 Test-bench setup comprising nano-measurement machine, probe and cantilever control electronics.

In the next phase of the project an in-situ, vacuum compatible, xy scanning head with integrated cantilever transfer is planned for the mask repair tool at NaWoTec.

In Work package 4 the provision of efficient training, communication tools and dissemination of knowledge are adressed. For this, different activities are organized.

The public website of the project http://www.pronano.org/ gives a short introduction to the project goals, includes a News section and presents the project partners with their contact details.

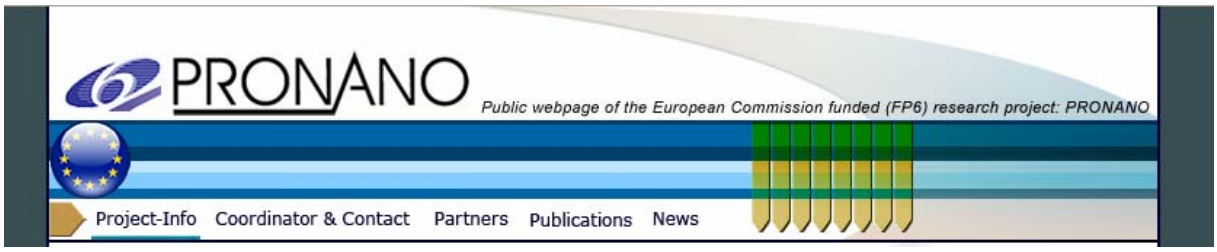

Fig. 0.4 Header of the public PRONANO web page (http://www.pronano.org)

Within the project, **different Workshops** are realized which are also open to external auditors. The first one takes place on April 24, 2006 at Technical University of Ilmenau. Topic: *Scanning Probe Arrays*. Currently scheduled courses are published on the Pronano Website http://www.pronano.org/.

A web-based course module will be available in the end of 2006. It will allow the users to train themselves at their personal computer and thus avoide time consuming traveling to external course locations. The topic of the first module will be "*Sensing Techniques and Actuation Principles for Cantilever Deflection*".

Encouragement of **mobility of researchers and the appointment of PhD** students is also an activity of this Work Package. In the end of the first year, 19 students and young researchers are participating in the activities of the project and numerous working visits and meetings between the project partners took place.

Different **dissemination activities** include for example articles in magazines and newsletters as well as talks at conferences and publications. The aim is to inform a wider public about the activities of the network and to publish concrete results.