

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

Month 36 Periodic Activity Report

Public Summary

Period covered: from 01-04-2007 to 31-03-2008

Start date of project: 01-04-2005

Date of preparation: 14-05-2008

Duration: 5 years

Project coordinator:

Project coordinator organisation:

Revision:

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Publishable executive summary

During the reporting period piezoresistive cantilevers arrays have been studied, modelled, developed, realized and characterized as required in WP3. To fulfil the project targets, the fabricated devices have been analysed and characterized immediately after fabrication, closing the feedback loop from design to fabrication to optimization.

Parallel scanning/imaging using self-actuated piezoresistive cantilever arrays fabricated in WP1 was successfully demonstrated in WP2/WP3. “Shallow Junction” technology for piezoresistive read-out sensor was established. The first generation parallel SPP chips have been integrated into the SIOS measurement machine and first test measurement has been performed.

The fabrication of the 1st generation of probes with integrated thermal bimorph actuator and piezoresistive sensor was further optimized and repeated by both, Nanoworld and TU Ilmenau to supply probes for the characterization and demonstration activities. At this, the TU Ilmenau group realized the process integration of controlled cantilever deflection and implemented further improvements of layout for probes with implanted and metallic heaters. In this time TUI presents a SPICE circuit model for investigation and quantification of electrical cross talking effects in self-actuated cantilevers with implanted heater and piezoresistor structures. The problem of current crosstalk is described and a solution is pointed out. For better understanding and design optimization of PRONANO devices and also parasitic effects the modelling and the simulation are important and necessary instruments. With the developed equivalent circuit model of the self-actuated cantilever with implanted heater and deflection sensor TUI could describe and quantify electrical crosstalk effects. The problem of the current crosstalk was detected and a way of solving was deduced. This effect can be significantly suppressed by substrate biasing and corresponding further design optimisation. Realised by TUI new-design PRONANO cantilever arrays including galvanic separation by air trench and additional shielding are under investigation.

Nanoworld focused at the improvement of tip quality and reduction of the cross-talk between the neighbouring cantilevers. In both groups an in-house experimental setups for characterization of the produced probes have been established.

A major issue of the reporting period was the development of a dedicated concept and layout for the second generation of probes. On the one hand, the setbacks of vertical interconnection technology with metal filled through wafer via holes had to be compensated and, on the other hand, the unforeseen limitations of state-of-the-art packaging technologies required a time-consuming discussion about a compromise. At the second part of the reporting period, this compromise was found and agreed among the involved partners, the SOI wafers with via-holes was ordered by IceMOS, Ireland and the lithographic masks were produced by UISAV, Slovakia. All these achievements enable the start of demonstrator realization, now.

In the Workpackage 2 the team of 4 groups (Microsystems, WRUT, IDMOS, SIOS) developed, tested and applied the components needed for the surface scanning using the PRONANO cantilever arrays. Additionally in collaboration with WP3 and WP1 groups we developed and applied experimental methods for the determination of the deflection sensitivity of the piezoresistive strain sensors integrated with the PRONANO cantilever. Our activities included the following research conducted in three main research fields:

I. Hybride electronics

- design, fabrication and application of the PRONANO 2D cantilever array measurement head,
- design of the 32 channel DSP based controller for acquisition of data corresponding with the operation of the PRONANO cantilever arrays,
- high resolution surface measurement using PRONANO cantilever arrays,
- continuous modification and optimization of the PRONANO hybrid measurement-control electronics and software (including preamplifiers, multichannel PID controllers and selective RMS/DC converters, multichannel DDS generators), which enabled us to record surface topography images using 1D and 2D PRONANO cantilever arrays,
- application of the already designed and fabricated ASIC based electronics and software in the surface measurements and PRONANO sensor characterization.

II. ASIC based electronics

- design, development and testing of the ASIC FPGA based DDS generator core, we tested its performance and our goal is to integrate this component in surface measurements,
- design, development and testing of the ASIC FPGA based PI controller core, we tested its performance and implemented it in our laboratory FPGA test benches,

The idea of the above described activities is to replace hybride blocks of the measurement and control electronics with the designed and already fabricated ASIC components. It this way the reliability and the performance of the measurement and control system will be significantly improved. In addition

- design, development of the analogue front-end ASIC based system (8 cantilever version), which will enable signal acquisition and deflection control of 8 PRONANO cantilevers; this device

III. Development of advanced FM detection circuits for PRONANO cantilevers

- design and preliminary tests of the FM demodulators and selfoscillation circuitry for 1D cantilever array; we tested this electronics with single PRONANO cantilevers and with the sensors from the PRONANO cantilever arrays,
- high resolution surface measurements using PRONANO single cantilevers and sesnors from 1D PRONANO cantilever arrays.

Work of this reporting period focused on testing and characterizing single and multi cantilever probes. Project partners from the industry determined preliminary specifications which were derived from the pilot applications and are also consistent with limitations and other probe characteristics.

Test and measurement setups created during the previous reporting period were used to diligently characterize single cantilever probes including their thermal bimorph actuators, piezoresistive deflection sensors and the sharp probe tip. Actuator efficiency, force sensitivity, resonant behaviour and the signal to noise ration of several probe types (e.g. single / multiple piezo resistors) have been determined.

The single probe electrical measurement setups were extended by means of multiplexers and cross switches to enable measurements on cantilever arrays. Sensor arrays also demand a very precise

angular alignment for some of the measurements and a test fixture with high precision angular adjustment capabilities was developed.

In addition to the properties mentioned above, variations of the probes within an array and unwanted interactions between neighbouring probes, such as cross talk were evaluated. Since cross talk was found to be too large for most applications guidance and feedback to work package one partners was provided to aid in the development of probes with features minimizing cross talk.

Comparing these probe characteristics to state of the art single cantilever systems, advantages and limitations of multi probe devices can be established. Thus, usability and economic viability for specific industrial applications can be roughly estimated. Furthermore deviations from performance specifications which can be derived from the application can be addressed early on.

The integration of an AFM into a scanned electron beam apparatus for the repair of photomasks, which are used by the semiconductor industry, is one of the demonstration applications. It was found that some influences of the tool's environment on AFM performance is very difficult to predict and a dedicated test setup was created to measure the effect of mechanical vibrations on the AFM measurements. Vibrations were found to be slightly too large and modifications to some tools components reducing vibration levels were implemented. This clearly illustrates the importance of concrete pilot applications to verify the economic viability of novel technologies.

Other pilot applications suffered from delays with probe array fabrication and will commence as soon as packaged probe arrays are available.

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The major achievements in WP4 during the reporting period are:

1) **Workshops**

In collaboration with Wroclaw University and Microsystems Ltd., FSRM organized the 3rd public PRONANO workshop.

The workshop took place on April 23, 2007 at University of Wroclaw, Poland.

Totally 19 people participated in this event.

This practical workshop was organised in the laboratories of WRUT and mainly tailored to give the collaborators from inside the project the possibility of seeing measurements and lab demonstrations. Topics:

- Resonance behavior of the PRONANO cantilever systems
- Thermal actuation of the PRONANO cantilever systems
- Testing of the static deflection sensitivity of the PRONANO cantilever systems
- Performance of the PRONANO ASIC PREAMP
- Control behavior of the PRONANO feedback loop
- DDS signal systems

2) **Web-based courses**

The first web-based course “Introduction to Microcantilever Applications” was ready in the beginning of 2007.

During the reporting period, this module has been announced to potentially interested candidates.

Result: over 180 registrations.

An on-line survey has been made to analyze the expectations and opinions of the people who worked on the module. According to the results, it has been decided to work out a second web-based course, going more into the details: “The Mechanics of Microcantilevers”.

3) **Articles, conferences, publications**

- 4 presentations at conferences and 3 scientific publications by the project partners.