

MEMS manufacturing in company of Nano ToolShop Ltd.

Nano ToolShop (NTS) is a developer of *novel MEMS (Micro Electro-Mechanical Systems)* devices along with corresponding operating methods and technologies. NTS's goal is to develop a viable technology for multi-probe nano-scale devices and assist the design and development process of relevant equipment, based on such devices.

Two most promising applications are:

- **high-throughput/high-complexity Scanning Probe Microscopy (SPM) and**
- **sensors for chemical and bio-chemical recognition (e-NOSE, etc.).**

NTS focuses on being:

- a high-tech subcontractor to SPM system OEMs
- a supplier of high-tech consumables (nano-probes) to end users of SPM systems

NTS does not a high-volume manufacturer but rather focuses on custom development, rapid prototyping and small-to-medium production runs.

Strategic approach: The company has three key strengths:

- Access to highly trained and experienced personnel
- Manufacturing facilities that are specifically optimized for producing nano-probes.
- Since the area of needed expertise is quite wide, a very close and trustable co-operation with different companies and Institutes of Bulgarian Academy of Science, having similar or complimentary know-how, was set up for years. As a result, this is a prerequisite permitting NTS to focus on emerging applications.

Products:

- **SPM probes: An integrated cantilever sensor** (see the front cover, picture on the right) is an example, demonstrating company capability to design and manufacture various kinds

Integrated MEMS sensor for chemical and bio-chemical applications

Future of analytical and manufacturing methods based on micro-mechanical cantilevers, depends critically on the ability to implement parallel operation and fast signal processing. There are two main reasons: high throughput requirement and complexity (multidimensionality) of analyzed value. In order to get parallel function, any single device should be simultaneously: recognizable, autonomously actuated and independently accessible for readout. Devices, fulfilling these requirements, are suffering from a substantial increase in complexity of both: layout and manufacturing technology.

As a part of e-NOSE (Nanotechnology Olfactory Sensor) application project, a novel piezoresistive cell, shown in Fig. 2 was developed and manufactured. It consists of four cantilevers of different length and each of them is having a single piezoresistor for displacement detection. Each cantilever is, in fact, microbalance made of silicon beam coated with specific analyte-sensitive layer. When the cantilever along with the deposited active layer vibrates, its resonance frequency f depends on effective mass of the system: cantilever with active layer. If molecules from the environment adsorb on the cantilever surface, the mass changes involved can be detected by recording the shift in resonance frequency. Cantilevers of different length and resonance frequency allow identification of the individual cantilevers during measurements and minimization of the mechanical cross talk. In order to get an autonomously

of advanced custom-tailored MEMS devices. This particular sensor, consisting of thin silicon cantilever with piezoresistor and bimorph actuator, provides nano-Newton / nano-meter resolution. Different-in-shape tips or other sensing elements, could be integrated on the cantilever.

- Sensors for bio-chemical recognition and life science

Since November 2005 NTS company is a **coordinator** of R&D project (NIF No IF-02-20/24.10.2005) aimed to develop **e-NOSE**. Within the project, a novel piezoresistive MEMS cell (see the front cover, picture on the left) was developed. According to specific application requirements, the cell could be modified and/or multiplied as many times, as required. Additionally, because of the integrated bimorph thermo actuator, this device could operate without any extra components. Mirror-smooth cantilever back side allows dual kind of detection, laser and/or piezo resistive used, simultaneously/ complimentary.

History: Nano ToolShop Ltd. was established in 2003 as a JV between Bulgarian and EU partners.



Fig. 1. High temperature furnace.



Fig. 2. Photo-lithography aligner.

operating device, bimorph thermo-actuator was integrated on the cantilever, additionally.

The new micro-machined cell, as a micro-balance, is suitable for chemical and biological recognition. Sensor's pads are wire-bonded on sensor-carriers, made of standard double-side PCB with metallized vias. Sensor-to-carrier wires are epoxy coated, in order to protect them and prevent leakages.

A dedicated electronic modules, one of them shown in Fig. 3, have been developed by our partner from Bulgarian Academy of Science - Institute of Solid State Physics. Using advanced hardware and software solutions, systems with embedded four-cantilever sensors, demonstrate picogram/ sub-picogram resolution.

Every single cantilever cell is fully characterized at manufacturer fab. Measured parameters, application specific data and dedicated hardware are available, at request - see contact data.



Fig. 3. Optical photo of cantilever cell measuring amplifier.

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