Technical Subject: Thermal Manipulation and Diagnostics of Molecular and Cellular Structures

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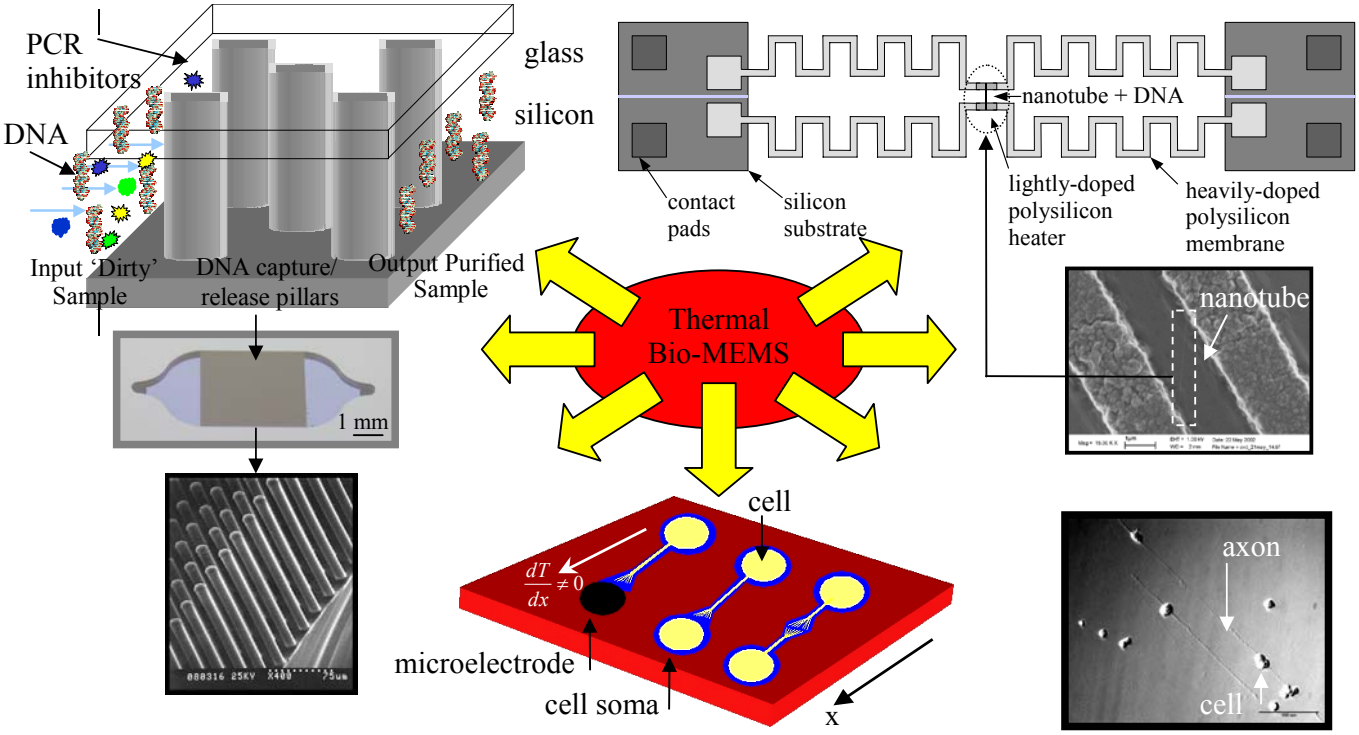

Figure 1 : Overview of thermal Bio-NEMS

Counter-clockwise from top-left (a) High-surface-area MEMS nucleic acid or protein purification system, (b) Image of the actual device, (c) SEM of micro-pillars, (d) Thermal surface for controlling nerve cell growth using high spatial thermal gradients, (e) Microcontact printing of retinal ganglion cells, (f) SEM of MEMS device for thermophysical property measurement (Nanotube shown), (g) Schematic of the device shown in (f)

Objectives of Research:

While temperature strongly influences the physical and chemical behavior of cells and molecules, the use of temperature gradients for controlling and characterizing these biological systems is virtually unexplored. We are using nanomachined silicon structures (NEMS) to produce large gradients (exceeding 10^6 K/s and 10^6 K/m) and to measure temperature with high precision (< 1 mK). This project achieves unprecedented thermal control and establishes a new class of diagnostic, manipulation, and detection techniques.

Proposed Thermal Bio/NEMS Experimental Areas:

- Thermal control of nerve cell regeneration for improving neural prosthetic interfaces
- Thermal manipulation and release of proteins and DNA for highly specific biomolecular detection
- Temperature assisted ultra-small volume cell purification for stem cell transplantation
- High temporal resolution thermal control to interrogate biomolecular reaction mechanisms
- Thermophysical property measurements of molecular/cellular structures to design thermal based detection

Methods of Realization:

- Nanomachined silicon structures with dedicated heaters and thermometers
- Micro contact printing for surface functionalization
- Techniques in Ophthalmic Tissue Engineering including fluorescence and electron microscopy, polymer synthesis, primary cell cultures, and small animal surgery for transplantation.

Call for Collaboration:

The researchers welcome collaborations in the fields of molecular and cellular biology. Specifically, those working on biological systems that could benefit from access to temperature sensitivity better than 1 mK and temperature gradients higher than 10^6 K/m and 10^6 K/s.

Relationship to Nano-Biotechnology:

The past decade has brought many nano-biotech devices that use electrical potential gradients (electric fields) and nanoscale obstructions to separate and otherwise control the motion of biomolecules and cells. The present work makes the first progress on devices that use nanoscale temperature gradients together with nanoscale features for similar purposes, thereby leveraging the close coupling between temperature and the physical and chemical behavior of molecules and cells.

Potential Contribution to Human Well-Being:

This work generates new fundamental information about cells and molecules, and is expected to enable new classes of consumer and biomedical products for health monitoring, virus and bacteria detection and therapeutic use.