



Nanofluidic Biochip

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BioChip : Definition

- **Biochips** are miniaturized devices incorporating some combination of massive parallelism, microfluidics, and functional integration in support of bio-analytical goals.
- **Microarray Biochips** are usually two-dimensional surfaces contains multiple copies of a biomolecules that is capable of interacting with a complementary molecules for the purpose of determining which of the latter are present in a specimen.
- **Microfluidic Biochips** are miniaturized devices designed to move fluids through networks of channels where they are subject to the various processes required to achieve a bio-analytical results.



Microfluidic Lab-on-a-Chip

- Possible Alternatives for Diagnosis?
 - “Simple” Microfluidic Biochips (Lab-on-a-Chips: LOC) for diagnosis
 - Stand-alone LOC system for Point-of-Care (POC) application
 - Cell Chip : Single cell-level detection, physiology, pathology
 - Simple/reproducible microfluidics scheme
- Key Fabrication Technologies for Microfluidic Biochips
 - Microfluidics, Nanofluidics
 - Plastic Micromachining : Soft-lithography, Rapid prototyping



Trends in LOC Development

- **Simplicity**
- **Versatility**
- **Portability**
- **Low cost**

- **Key Fabrication Technologies for LOCs**
 - **Microfluidics, Nanofluidics : Simple & reliable protocols**
 - **Plastic Micromachining**



Micro/Nanofluidics

- **Miniaturized Channels and Reservoirs**
 - High surface to volume ration/low Reynolds number flow
 - Increased speed of reaction
 - Reduce cost of reagent
 - Reduce power consumption
 - Precise mixing/dosage and heating
- **Integration and Industrialization**
 - Reduce cost of manufacturing
 - Minimize dead space, void volume
 - Minimize sample carryover
 - Multiplex capability :

Increased number of parameters monitored per assay



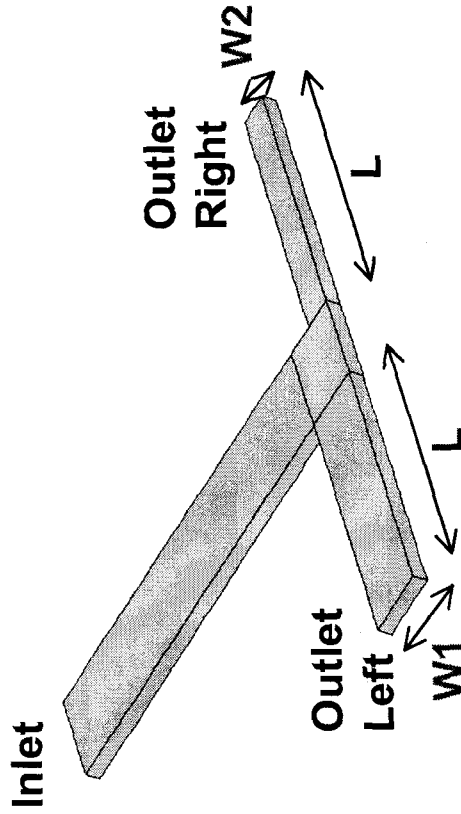
Key Challenges in Micro/Nanofluidics

- **Integration of different elements** such as pumps, valves, and reservoirs in device
- **Design of efficient liquid pumping strategies** that do not expose analytes to high electrical charge/overheating and can be used in nonorganic media
- **Problems arising from surface tension, avoiding vapor bubbles, and evaporation in microchannels**
- **Lack of technologies suitable for monitoring fluid flow**
- **Clogging of microchannels** with trapped small particles or precipitates



Microfluidics : Modeling

- Design Rules for Microfluidic Pathways



$$(Ratio)_{Left} = \frac{Q_1}{Q_1 + Q_2} = \frac{1}{1 + \left(\frac{\gamma_1}{\gamma_2}\right) \left(\frac{1 + \gamma_1}{1 + \gamma_2}\right)^2} \left(\frac{Po_1}{Po_2}\right)$$

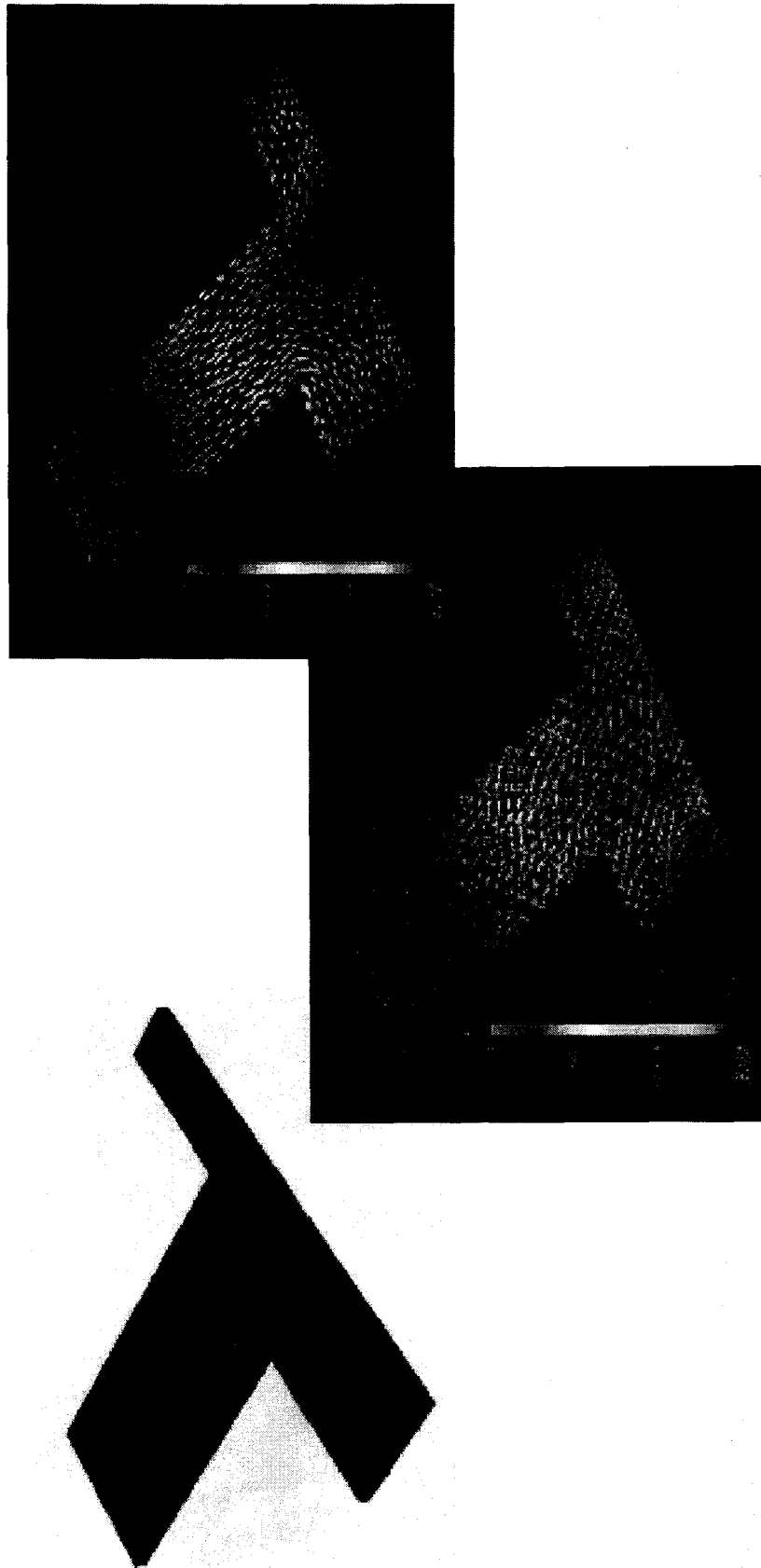
	Outlet Left	Outlet Right
width	W1	W2
Length	L	L
Height	h	h
Viscosity	μ	μ
Po	Po1	Po2
P	P	P
g (aspect ratio)	γ_1	γ_2
Q	Q1	Q2



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Simulations of Microfluidics

- Pressure and Velocity Analysis in the Micro Channel with CFD

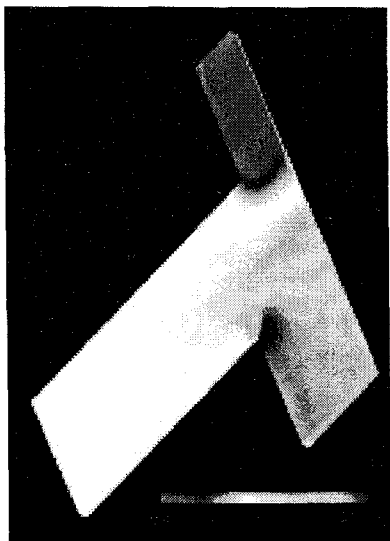


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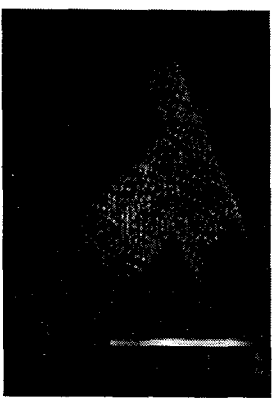
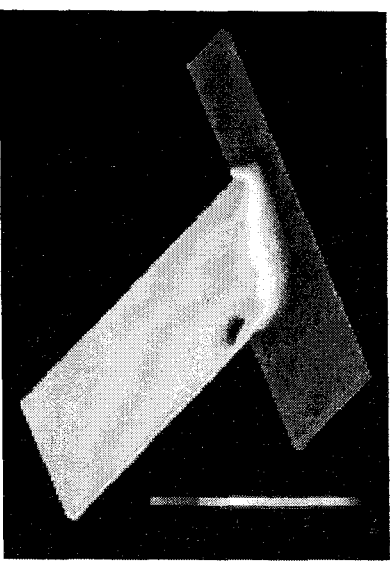


Simulations of Microfluidics

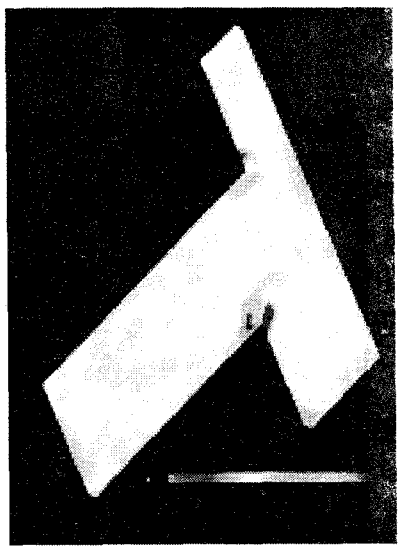
Velocity in X Direction



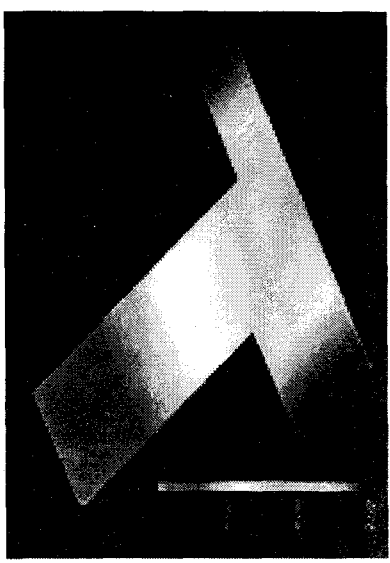
Velocity in Y Direction



Velocity in Z Direction



Pressure





Plastic Micromachining : Why?

- Silicon
- Glass
- Quartz
- Plastic (PDMS) **➔**
poly(dimethylsiloxane)
- Plastic (PMMA)

Low weight, but high strength

No crack formation (c.f. silicon & glass)

Variable characteristics

Easy & cheap fabrication

Optical transparency

for Optical, laser, fluorescence analysis

Biocompatibility, Blood-compatibility

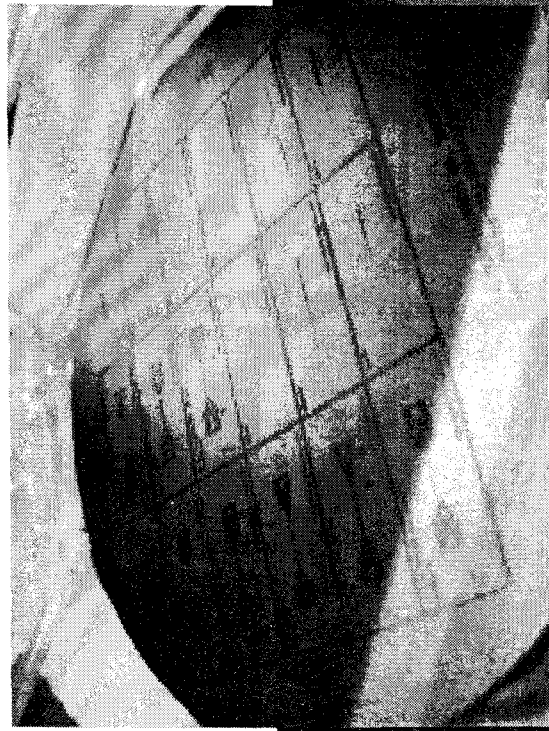
Good Solution for the mass production of

disposable devices

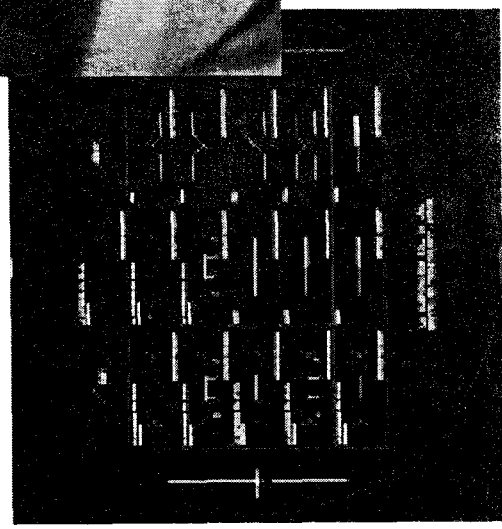


Plastic Micromachining

- Plastic (PDMS) Micromachining Schemes

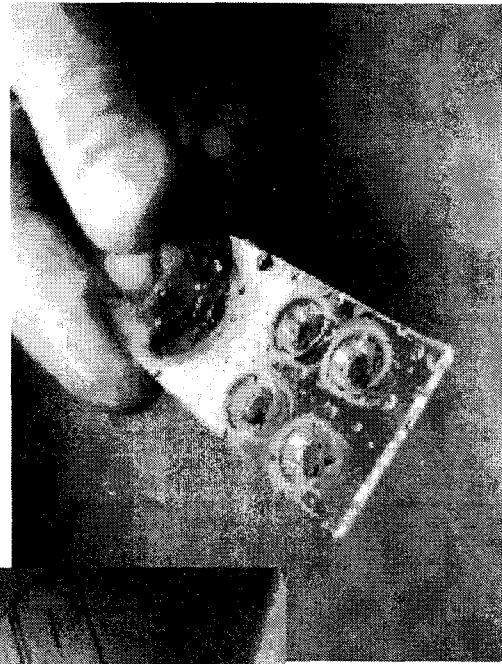


mold fabrication



design

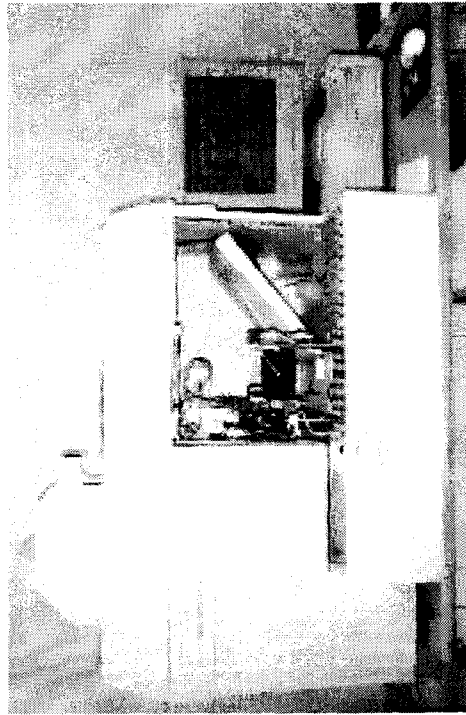
chip fabrication





Nanofluidic Cell Counter/Sorter

- Technical Breakthrough
 - Analyzer with plastic disposable LOC with Micro/Nanofluidics



Conventional blood cell counter

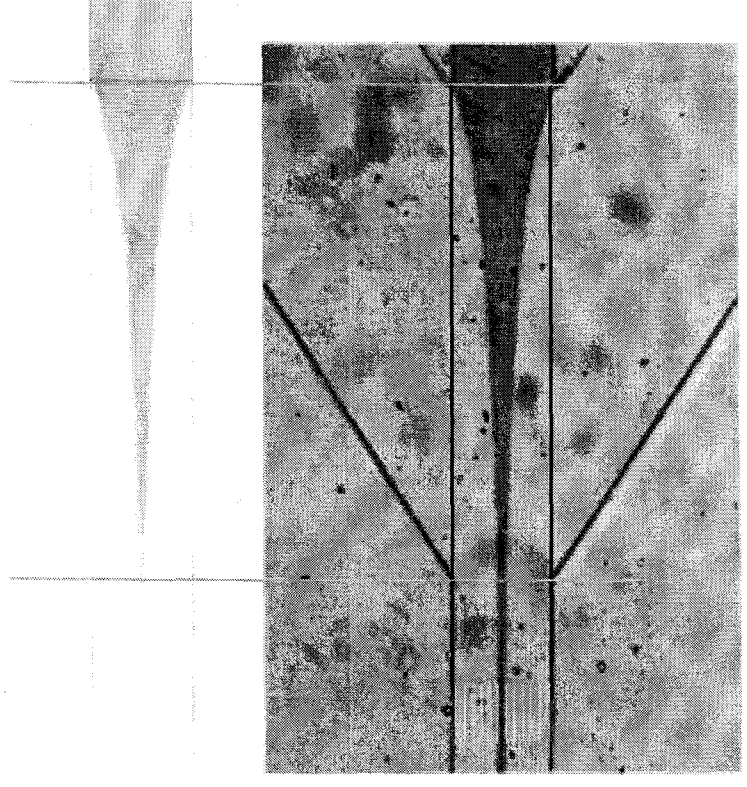


Microchip cell counter



Cell Counter Technique : Micro/Nanofluidics

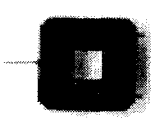
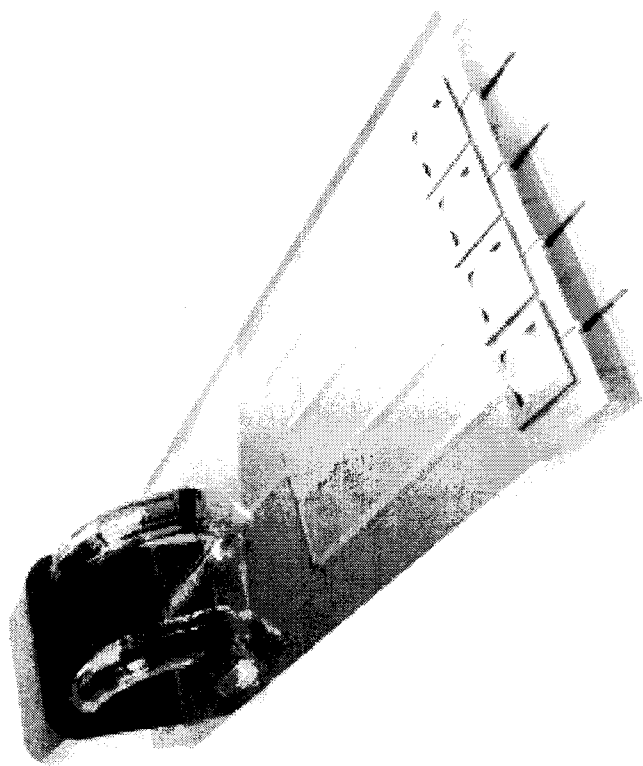
- **Hydrodynamic Focusing Technique**
 - Nanoscale flow control
 - Minimum control volume : 50 pl
 - Fast reaction with nanosecond mixing time





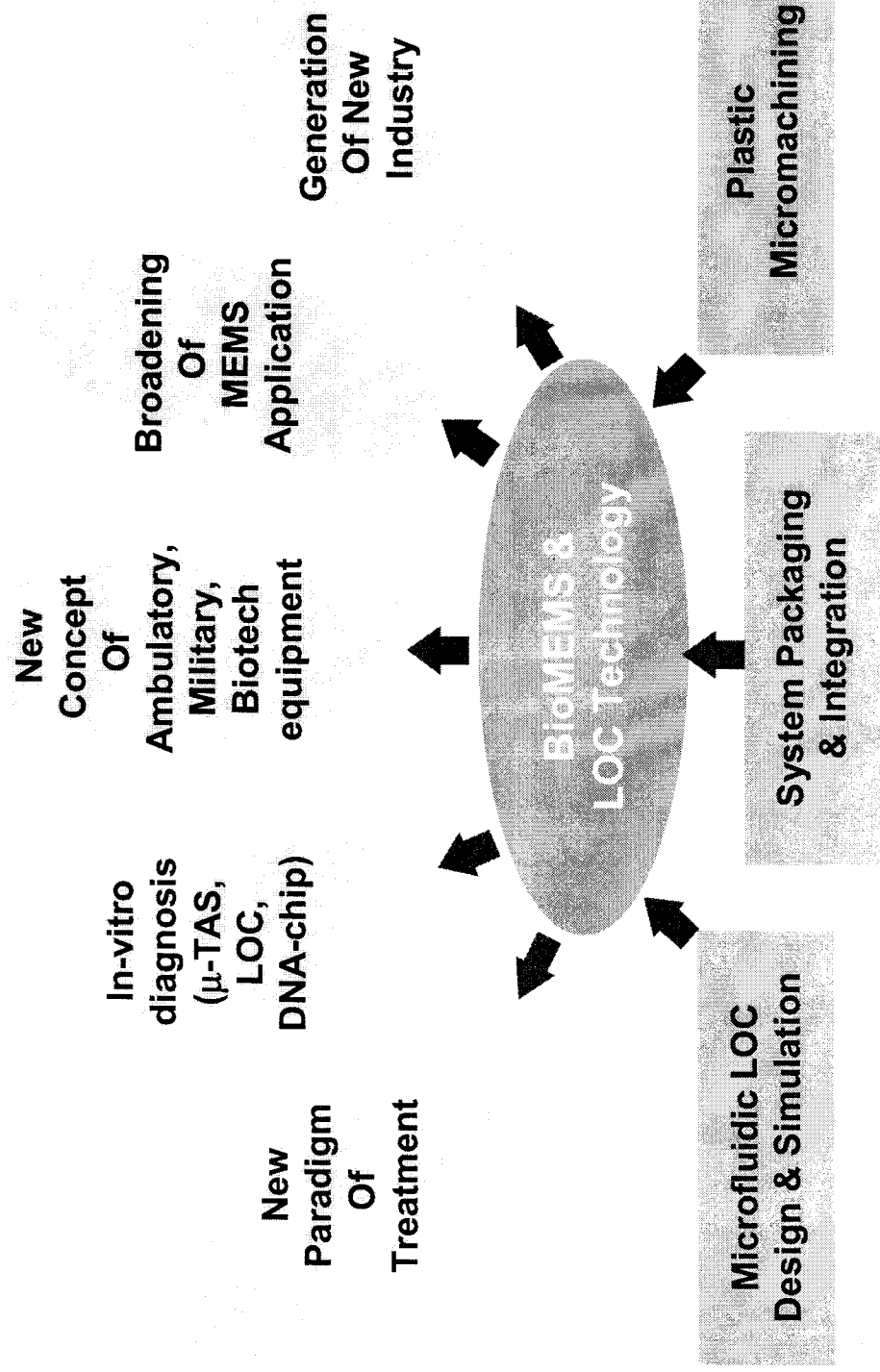
Micro Dispensing Syringe

- Micro dispensing syringe unit with built-in dilution feature





Effect of New Technology





Conclusion

- **Automated Simple LOC Micro Systems**
 - Micro/Nanofluidic application with disposable plastic chip

- **Point-of-Care (POC) Micro Systems**
 - Disposable/Non-disposable part separation
 - Integration of Hard-Wet-Soft ware

- **BioMEMS(BioNEMS) & LOC Technology**
 - Key Technology for 21st Century
 - Complex Huddle & Challenge
 - Interdisciplinary Collaboration
 - Biz Model for New Venture Business