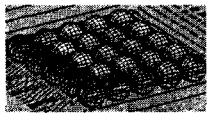
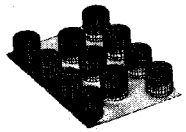




BioMEMS/BioNEMS applications in CFD-ACE+

Kyung Won Tech.
2004.12

On the Leading Edge of CFD Technology

BioMEMS Applications/Customers

- Integrated BioDevices/Systems
  - Lab-On-A-Chip
  - Microanalytical Systems
  - Microarray Platforms
  - DNA Chips
  - Protein Chips
  - Biosensors
  - Cell Based Devices
- Application Areas
  - Genomics/Proteomics
  - Diagnostics/Theranostics
  - Drug discovery/HTS
- Underlying Technologies
  - Microfabrication/MEMS
  - Microfluidics
  - Electrokinetics
  - Biochemistry

- **Abbott Labs**
- **Agilent**
- **Aiza**
- ***Applied Biosystems***
- **Caliper Life Sciences**
- **Diagnostic Products**
- **Doheny Eye Inst.**
- **ETRI**
- **HP**
- **Hitachi**
- ***Johnson & Johnson***
- **Kodak**
- **Lifescan**
- **LG Electronics**
- **Meso Systems**
- **Medisense**
- **Micronics**
- ***Motorola***

(partial list)

- **NanoCoolers**
- **Nanolnk**
- **Nanogen**
- **Samsung**
- **Sandia N. Labs**
- **Sequenom**
- **Scandin. Micro Devices**
- **Thomsen Biosciences**
- **Unipath**
- **Western Digital**
- **Zyvex**
- **NASA Glenn**
- **NASA Marshall**
- **MIT Lincoln Labs**
- **Stanford**
- **UC Berkeley**
- **UC Santa Barbara**
- **Univ. of Cincinnati**

On the Leading Edge of CFD Technology

CFD-ACE+

Microfluidics
- Hydrophobic/Hydrophilic Filling and Dispensing with Chemistry
- Fluid-Structure Interaction
- Pressure Driven Flow
- Heat Transfer
- *Electric Field*
- Dynamic Contact Angle
- Hele-Shaw Models
- CD – Based μFluidic Devices

Biochemistry
- Mass Transport or Kinetics-Limited
- Antigen-Antibody Ligand-Receptor Binding
- Surface & Bulk Flow Reactions
- Multi-Protein, Multi-Receptor, Competitive Binding
- DNA Hybridization
- Surface or Volume-Immobilized Enzyme Catalysis (Michaelis-Menten)
- Microsphere-based Detection (Immunoassays)

Electrokinetics/Chemistry
- Electroosmosis/Electrophoresis
- Ionization Involving Acid/Base Reactions, Ampholyte Chemistry
- Modes of Focusing/Separation-Isoelectric, Focusing, Isotachophoresis, *pH Gradients, CE-ITP, Etc.*
- Sample Stacking
- Electrochemical Sensing
- Conventional & Traveling Wave Dielectrophoresis
- Dispersion
- Electromagnetics
- AC/DC Electric Fields
- Joule Heating

The complete solution!

On the Leading Edge of CFD Technology

CFD-ACE+

Multi-physics Phenomena

- **Complex, Interacting Physicochemical Processes:**
  - **Fluid Flow**
  - **Hydrophobic/Hydrophilic Surface Interactions**
  - **Electrokinetic Transport**
  - **Thermal Effects**
  - **AC/DC Fields**
  - **Multi-Species Biomolecular Reactions, etc.**
- ***GREATER NEED FOR A FUNDAMENTAL UNDERSTANDING OF THESE "MULTIPHYSICS" PHENOMENA TO ENABLE OPTIMAL BIOCHIP DESIGN***

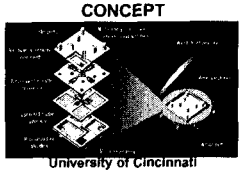
On the Leading Edge of CFD Technology

CFD-ACE+

KW tech

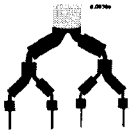
Simulation-based Design

CONCEPT

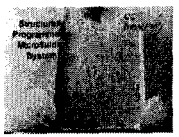


University of Cincinnati

COMPONENT LEVEL ANALYSIS

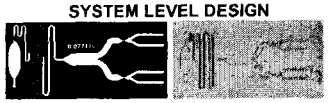


Simulation

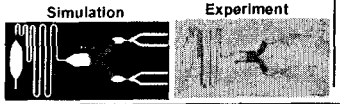


Experiment

SYSTEM LEVEL DESIGN



Simulation



Experiment

CFD-ACE+

Modeling and Simulation Software

for Microfluidic and BioMEMS Design

Fluid transport	Electrokinetics
Mixing	Biochemical Reactions
Separation	Detection

On the Leading Edge of CFD Technology

Success Case

KW tech

thomsen BIOSCIENCE

" Our collaboration with CFDRC has been very successful from our joint of view and it is actually the first time in my scientific career that I have seen modeling come close to reality. CFDRC not only solved the task at an impressive speed within the deadlines of our compressed schedule, but they also added a great deal of innovation and creativity to the process. Thomsen Bioscience has successfully created biochip prototypes based on modeled results by CFDRC and we are now expanding our collaboration with CFDRC to exploit this source of scientific engineering to its fullest potential."

Kodak Research Scientist

I am Antonio Cabal, a research scientist in the Electronic Imaging Products R&D, Eastman Kodak Company. Our work with CFD Research Corporation has been very successful. Due to the multiphysics nature of the inkjet problem we modeled (structural dynamics coupled with electrostatics, heat transfer, and fluid dynamics including free surfaces) in the year 2002, CFD-ACE+ was the only commercial code solver capable of dealing with the complexity in terms of coupling and grid deformation of our 3D problem. We found CFDRC python scripting capabilities to be a very useful tool in the parametric optimization of our designs.

Antonio Cabal, Ph.D.
Electronic Imaging Products
Eastman Kodak Company

On the Leading Edge of CFD Technology

Success Case

KW tech

micronics

"We find CFD analyses are very helpful in understanding experimental data, and especially useful in modeling micro-scale effects that sensors are too large or obtrusive to measure. We view the CFD-ACE+ tool as a predictive modeling system, allowing us to save both man-hours and prototype production cost, as well as, ensuring that projects are completed on time."

MOTOROLA LABS

2002 Inter Society Conference on Thermal Phenomena
"Thermal Management of BioMEMS"

"A thermal-fluidic system model, developed using CFDRC-ACE+ software, was an invaluable aid to the design of this system."

"In addition, extensive thermal-fluidic modeling was done on both systems in order to virtually prototype and optimize the designs. This enabled several designs iterations to be performed without requiring costly and time-consuming device fabrication at each change. The system models proved to quite accurate as good correlation with measured data was also shown"

On the Leading Edge of CFD Technology

Summary

KW tech

- CFD-ACE+ Multiphysics, Multiscale Software
  - Enables high-fidelity simulation and analysis of complex Interacting Physico-Chemical Processes in Microfluidics and BioMEMS devices & integrated systems
- Benefits of CFD-ACE+ oriented development process
  - Rapid screening of innovative Microsystem Concepts
  - Fast virtual design, testing and optimization
  - Shorter design cycle (T-T-M ↓: Capital Burn Rate ↓)
  - Improved understanding of device function/failure

Modeling should be a critical component of every Microfluidic and BioMEMS Design

On the Leading Edge of CFD Technology