Probing Beyond 100nm: Electrical, Mechanical and Biological

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Business Development (Asia Pacific)

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Founded by Mr James Von Ehr who invested USD50M in nanotech

Zyvex is the world’s first molecular nanotechnology company.

Our vision is to be the leading worldwide supplier of tools, products, and services that enable adaptable, affordable, and molecularly precise manufacturing.
Corporate Introduction

- Privately held company; Founded in 1997
- Located in Richardson, Texas
- Detailed Five-Year Strategic Business and Marketing plans
- Detailed Technology Roadmap
- Aggressive IP strategy
- Extensive list of scientific and business publications

Resources

- Headcount: 64 and increasing
  - 14 Ph.D.s
  - Engineers, scientists, technical management
- 44,000 sq. ft. facility
- Class 1000 clean room
- Several fully equipped laboratories
- CNC-equipped machine shop
- Equipment: SEM, TEM, AFM, SPM, UHV-STM, numerous lasers, MEMS motion analyzer, electrical testing station

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Zyvex patents
• 26 U.S. patents issued
• 37 patents pending
• 5 notifications of allowance
• 57 International patents pending

Categories
• Molecular nanotechnology
• Microassembly technology
• Nanostructure process techniques
• Micro- and nanodevices
• Microconnector technology
• Nanomaterials
Zyvex Technologies

- Nanomaterials
  - CNT functionalization
  - CNT processing

- Structures
  - Assembly of microcomponents (MEMS-based) for integrated Microsystems

- Tools (S100, F100, A100, L100)
  - Nanomanipulators for characterization and manipulation of nanostuctures in SEM, FIB, optical microscopes
The Zyvex Approach:
NanoSolve™ Materials

Commerciably Available Applications

NEW Carbon Nanotubes from Aldila
- 100x stronger than steel & 1/38th the weight
- Defect free carbon structure

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The Zyvex Approach: MicroAssembly Program

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Small-scale assembly

Assemblies (structures)

Systems (Tools)

End-effector (Tools)

MEMS / NEMS / micro assembly

Nanoassembly

Future atomically precise manufacturing
The Zyvex Approach: NanoWorks™ Tools

Zyvex NanoWorks™ Tools

- Technology Platform with several configurations
  - S100 Nanomanipulator System
  - F100 Nanomanipulator System
  - L100 Nanomanipulator System
  - A100 Assembly System
  - KZ100 Probing System
  - IC Nanoprobing System
- Subcomponents
  - NanoEffector™ Probes
  - NanoEffector™ Microgrippers
  - mDriver™ 1000 MEMS Driving System
  - tDriver™ 1600 MEMS Driving Station
  - pDriver™ Piezo Motor Driver
Zyvex NanoWorks™ Tools

- 3-Dimensional control
- Illuminated keypad
- Control software runs on Windows

Zyvex NanoWorks™ Tools

- Complete Solution
  - Includes:
    - Prober
    - Zyvex Proprietary Probe Tips
    - Exclusive Anti-Contamination Module
    - Keithley 4200
    - Zyvex Control Software (Full system integration)
    - Zyvex DataViewer Software
    - Installation/Training and Service from Zyvex

- Future Advancements/Roadmap
  - Closed loop control system
  - Re-positional modular robots
  - Step and repeat capability
Zyvex NanoWorks™ Tools

- **Current Technology:**
  - Successfully probing 65nm contacts
  - 5 nm positional accuracy
  - Linear x,y,z motion
  - Single robot provides both coarse and fine motion

- **Keithley Partner**
  - IC characterization in conjunction with Keithley 4200
  - 1 pA measurement resolution

- **Exclusive Anti-Contamination Unit from XEI Scientific**
  - Reduces SEM/FIB pump-down time
  - Insures clean SEM/FIB environment for ohmic contact

- **Zyvex software seamlessly integrates entire system**
  - Windows based software with precision joystick
  - SEM/FIB control if desired
  - DataView software collects and archives data automatically and remotely if desired

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XEI Scientific Anti-Contamination System

No Cleaning Done 10 minutes of ACU Cleaning

\[
\begin{align*}
O_2 + O^+ & \rightarrow O_2^+ + O \\
O_2^+ + e^- & \rightarrow O + O
\end{align*}
\]

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Probes and IC at 0 deg. Tilt

KZ100 IC nanoprobing system

Zyvex offers complete probing solutions for the semiconductor failure analysis industry.

With over 20 systems worldwide, the KZ100 IC Nanoprobing System is the preferred choice in transistor characterization.
IC Probing

- FA labs are concerned that probing with FIB pads affects the transistor characteristic
- Characterize transistors in die at contact level
- Find and characterize non visual fails, which are difficult to diagnose with other techniques
- Probe 90 nm node technology and below (45 nm and shrinking)
- Probe copper and aluminum metal 1 layers

IC Probing of a 65nm Node
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90 nm Data – Threshold Voltage

Id vs Vgs

Gate Voltage

Drain Current

0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6

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90 nm Data – Family of Curves

Id vs Vds

Drain Voltage

Drain Current

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90 nm data – low current

Zero Gate Voltage Id vs Vds

Low Voltage Id vs. Vds

SEM compatibility

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<th>Type 2 SEM</th>
<th>FEI XL30</th>
<th>SEM</th>
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<td>FEI XL40</td>
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Manipulating the nanoworld

- Nanomaterials/Nanostructures characterization
- Manipulating individual nanoscale structures
- BioNano manipulation
- Chip scale probing
- Manipulating individual structures for TEM sample preparation, device fabrication, and basic research

Nanomaterials characterization

- Electrically probe individual nanostructures with ohmic contact
- Qualitatively probe mechanical properties of individual nanostructures
- Versatile platform allows for user customization of end effectors
  - Quantitative mechanical measurements
  - Microgripping
  - And much more
Ge Nanowire electrical probing

BioNano at a glance

- Characterize individual cells and individual organelles
- Combine multiple techniques (patch clamping, microinjection, and nanosurgery)
- Probe cells at a resolution never seen before in an optical microscope (Fluorescence)
Bio applications

- Cellular nanosurgery
- Micro and nano injection
- Precise and multiple patch clamping
- Cellular electrophysiology
- Intracellular biosensing

Life Sciences: Collagen Fiber

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TEM Sample Prep

Conclusions

Advantages
- Compatible with SEM and FIB platform
- 5 nanometer resolution movement
- Linear Motion in X,Y,Z
- Easy to learn, easy to use Joystick and computer control
- Utilizes controlled vacuum environment
- Proprietary NanoEffector Probes (<50 nm tip radius)

- Complete System Solution
  — Seamless Interface to Keithley 4200
  — Microscope Controls
  — XEI Anti-Contamination Unit
  — Applications development, support, and service from our PhDs and engineers.
Publications (truncated list)

- [www.zyvex.com](http://www.zyvex.com) – Applications Notes (truncated list)
  - Richard Stallcup II Probing transistors at the contact level in integrated circuits [www.zyvex.com](http://www.zyvex.com) Application Note 9708.


Upgrades and extensions

- Heated/Cooled Stage (Model 1; -10 to 135 C)

- Low Noise upgrade (Base noise < 10 fA, Leakage < 400 fA @ 5V)

- Encoded XYZ sample stage (select SEM models)
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Advantages

- Compatible with SEM and FIB platform
- 5 nanometer resolution movement
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- Proprietary NanoEffector probes (<50 nm tip radius)

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Advantages

- Complete system solution
  — Seamless interface to Keithley 4200
  — Microscope control via software
  — Advanced software for data capture and archiving
  — Anti-Contamination Unit
  — Applications development, support, and service from our PhDs and engineers

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TEM sample preparation system

- Available on FIB and dual beam platforms
- NanoEffector grippers
- 6 samples per hour lift out to placement
- 1 welding step
- Rotation for previewing samples
- STEM detection capable
- Compact design
- 4 DOF system
- Patented process