

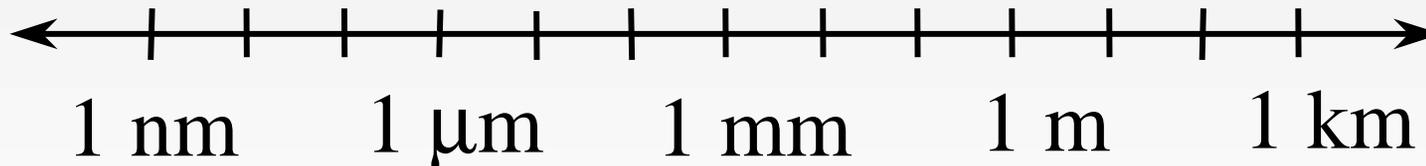
Mesoscale Opportunities at DARPA

William Warren

DARPA/DSO

wwarren@darpa.mil

Mesosopic



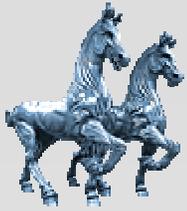
*Microelectro-
mechanical*



Conventional

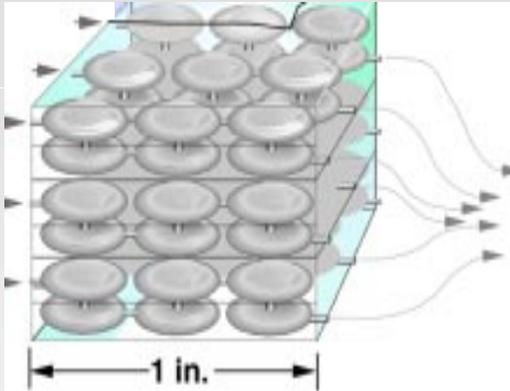


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Meso-Machines - “*The Right Size*”-Machines

BWD Detection Pumps

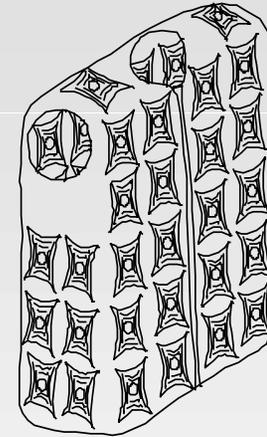


All “terrain” machines

5 cm



Cool Uniforms



Water Purification and
Desalinization

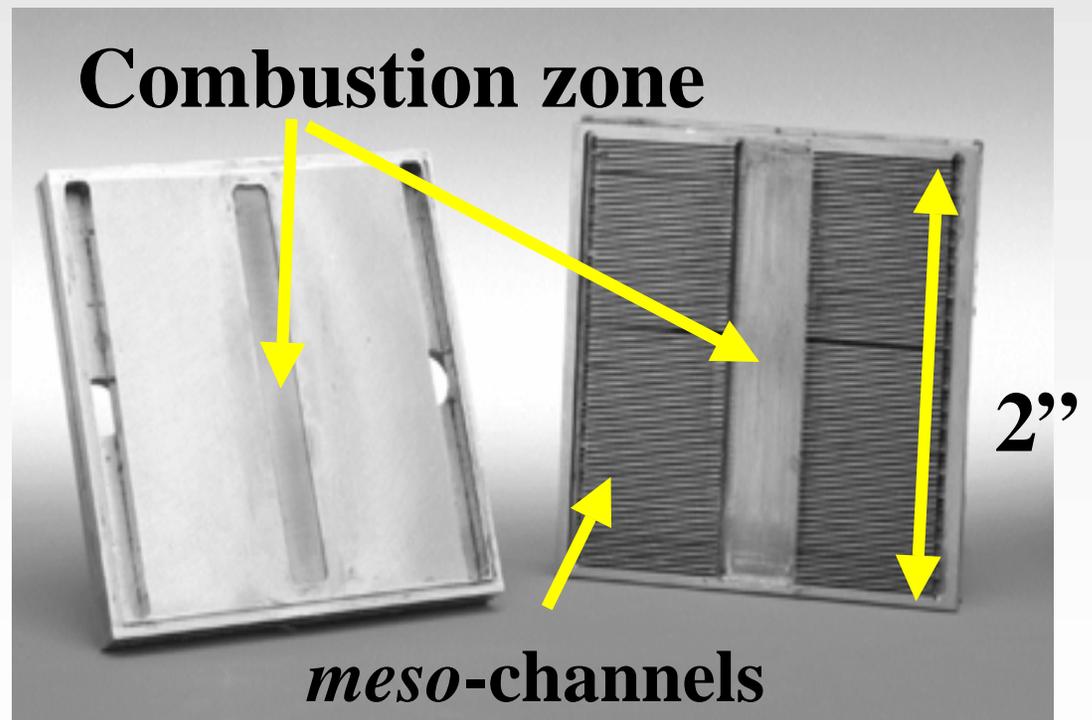


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Why Mesoscale Machines? -

- *Optimum* size for chemistry (combustion)
- *Optimum* size for heat transfer
- *Optimum* size for macroscopic electrostatic actuation
- Improved reliability
- Low cost
- True 3-D shapes



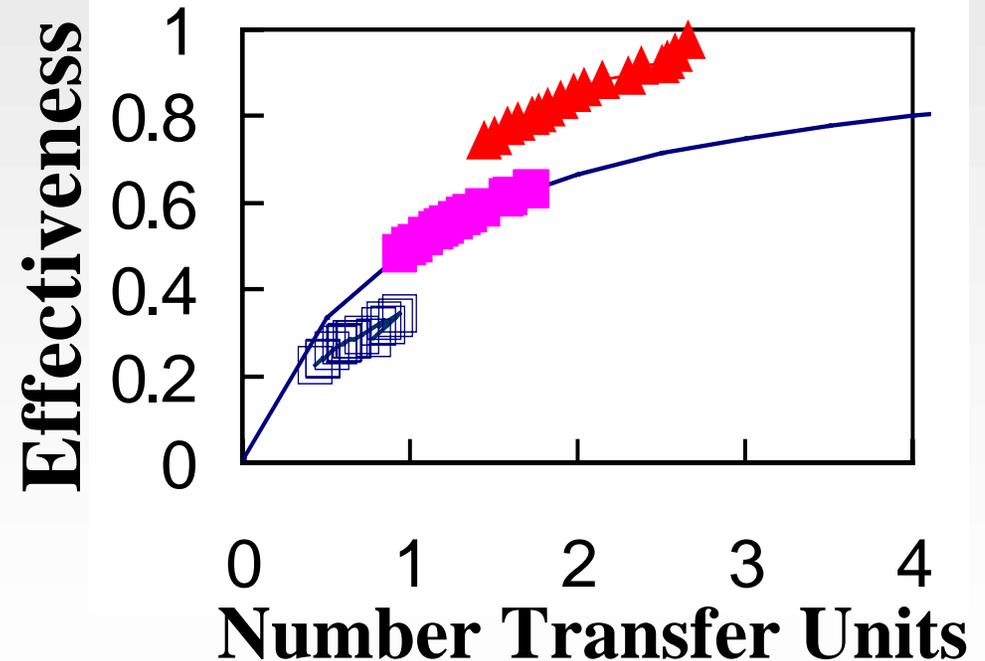
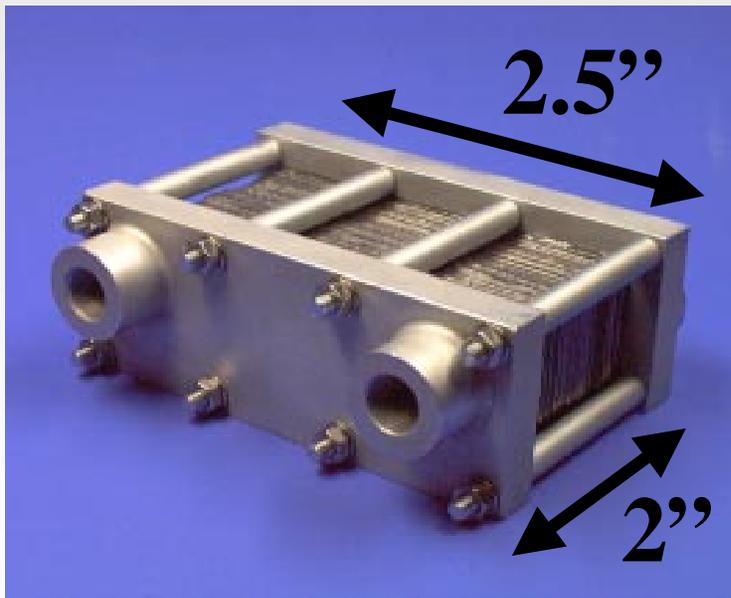
Pacific Northwest National Laboratory **DSO**

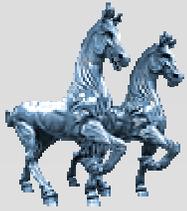


Phenomenal *Meso*-Heat Exchangers

MesoSystems Technology Inc.

- Macro-heat exchangers - 20-30% efficient
- Program start: *meso*-heat exchangers - 50-60% efficient
- Newest *meso*-heat exchangers - 96% efficient

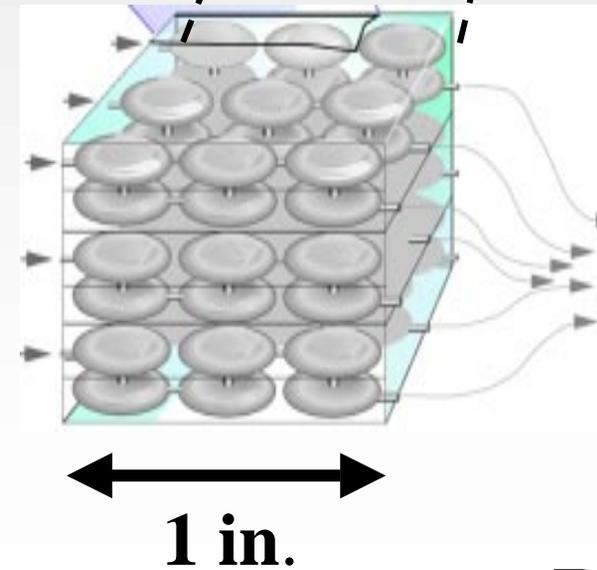
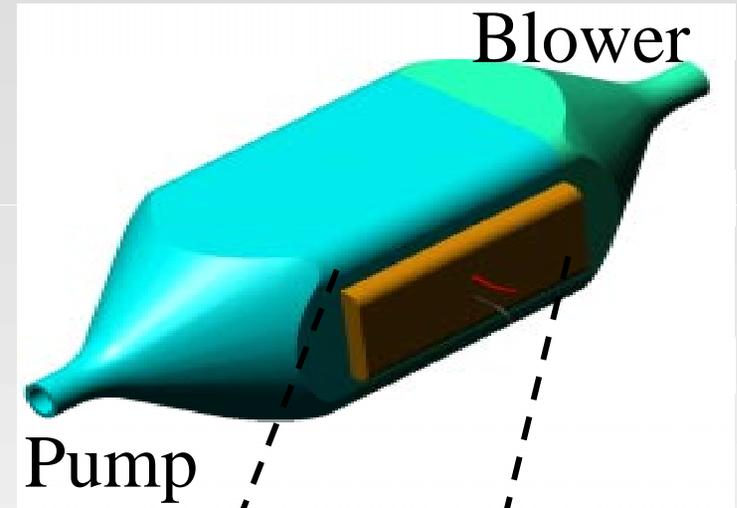




Efficient Multi-layer *Mesososcopic* Blowers

Honeywell Technology Center

- Macro flow rates ~ 10 l/min
- Figure of merit $> 50\times$ conventional pumps
- Pump attributes
 - 1 in^3 , 1/2 ounce
 - low-power (2 W), truly 3D
 - inexpensive materials (plastics)
 - simple to fabricate



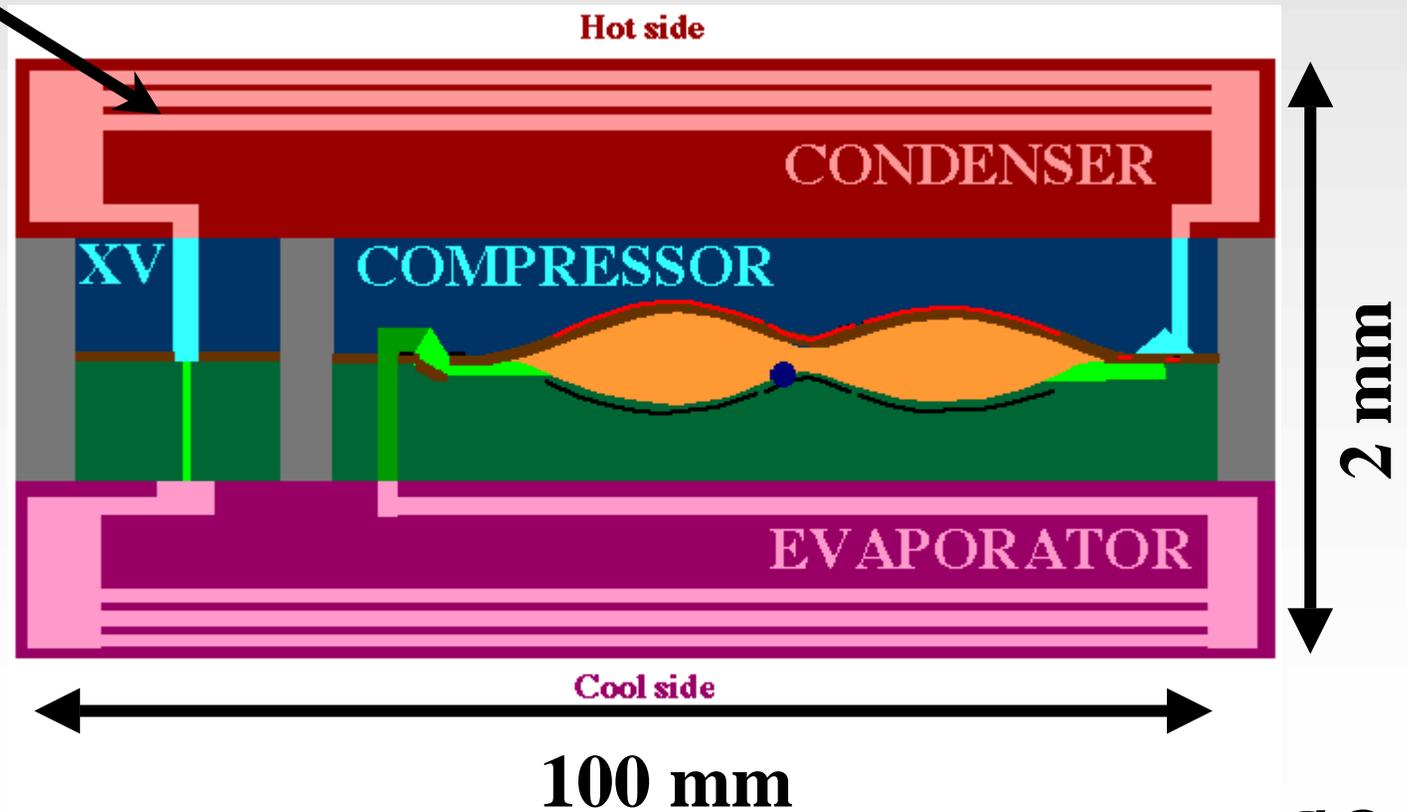
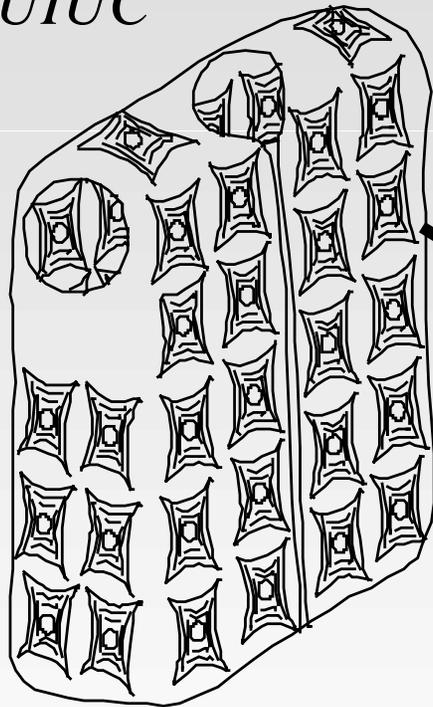
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Energy-Efficient Flexible *Meso*-Coolers

UIUC

- 1/3 weight of conventional systems
- Heat exchanger optimized at *meso*scale
- Low-power electrostatic *meso*-compressor



SO



Ingenious *Meso*-Machines Are Hopping

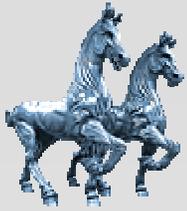
Sandia National Laboratories

- Build a vehicle around power system: 1 mg fuel/hop
- Combustion-powered autonomous hopping
- Exceptional mobility & range capability (10 km)
- Handles rough terrain



5 cm

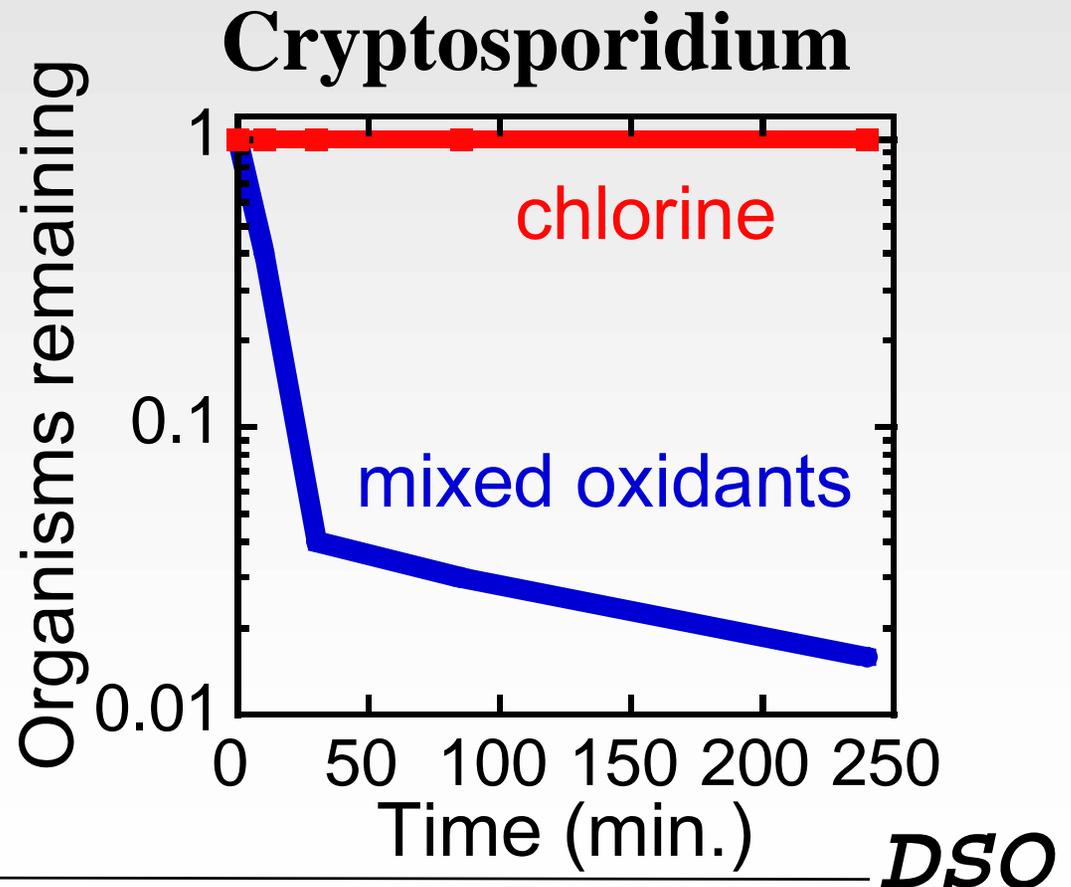
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The “Pen” Is Mightier Than The Sword!

LATA Inc. & MIOX Corp.

The “pen” creates mixed oxidants that destroy biological and chemical agents by creating ozone, oxy-chloride species, and radicals in an electrochemical cell.





Water Still the Size of a Coffee Mug

MesoSystems Technology Inc.

- Size ~ 750 cm³, weight ~ 0.5 kg
- Fuel = hydrocarbon fuels - no batteries
- Desalinization of seawater (no clogging)
- No BG spores in output water

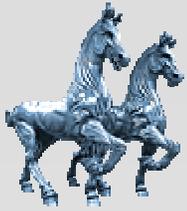
seawater
0.35% NaCl



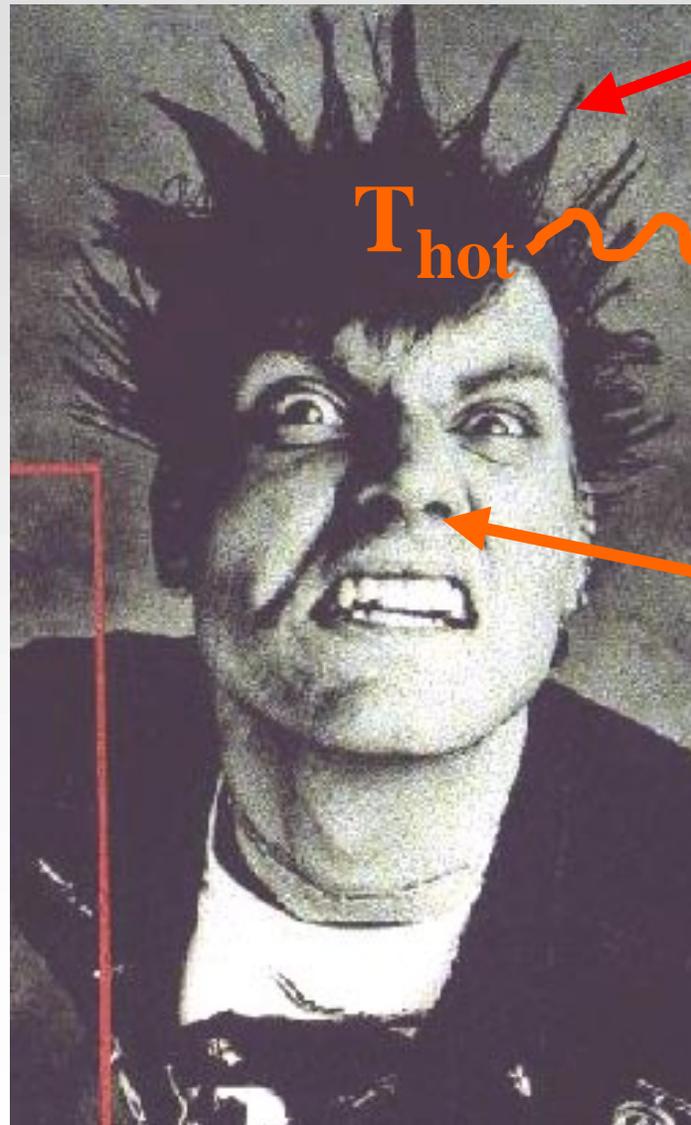
distilled water
~ 0% NaCl



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Meso-Channels for Heat Exchange Is Intuitive



MesoFins™

T_{hot}

\dot{Q}

T_{cold}

Steam Outlet

DSO



We Are Envisioning a *Meso-2000*

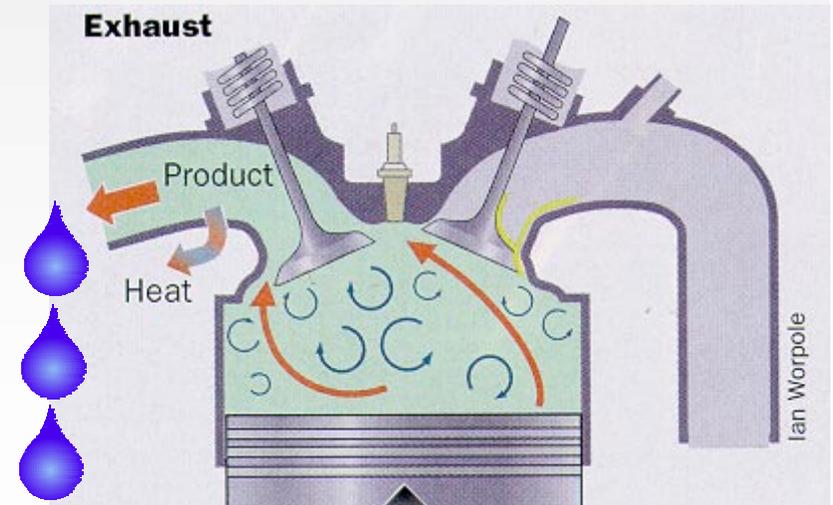
Water generation/testing meso-machines

- Water from combustion by-products
- Biologically inspired (how do dolphins drink?)

Today: condensation of humidity
using plastic wrap



Tomorrow:

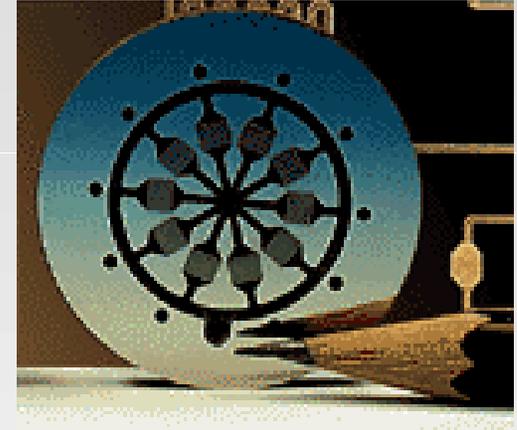


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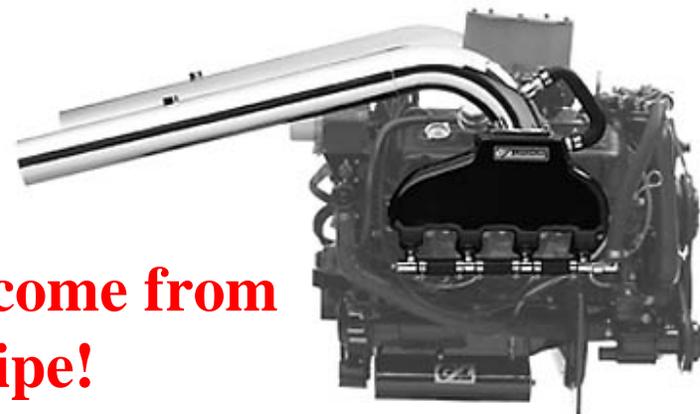


Meso-2000 Concepts

- Meso-chemistry: rapid production of vaccines and pharmaceuticals
- Meso-arrays: waste heat recovery for cooling, water generation and purification

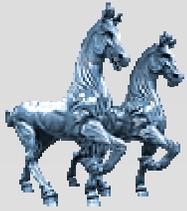


IMM

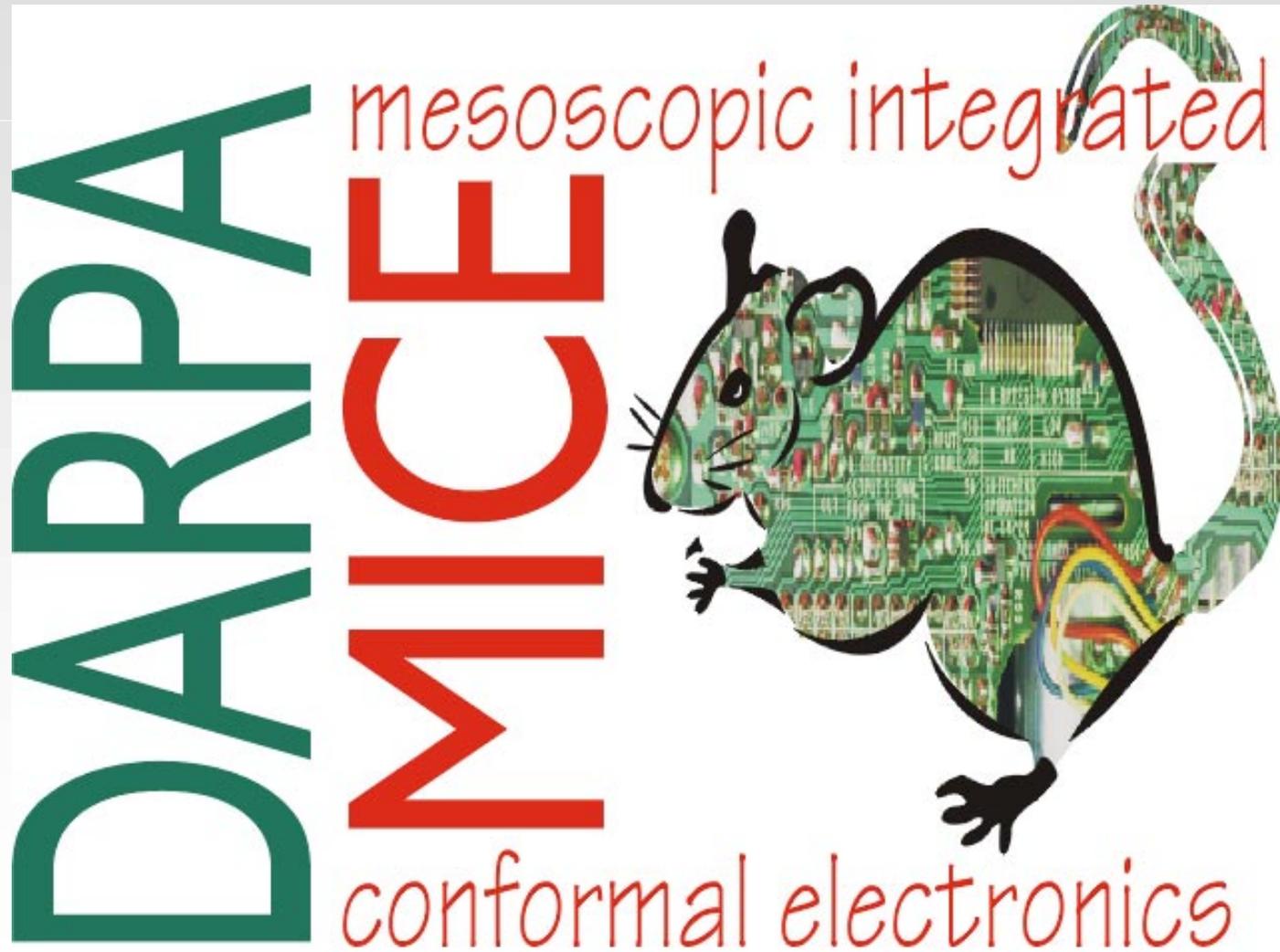


**Good stuff can come from
this tailpipe!**

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Forgotten *Mesosopic* Electronics



DSO

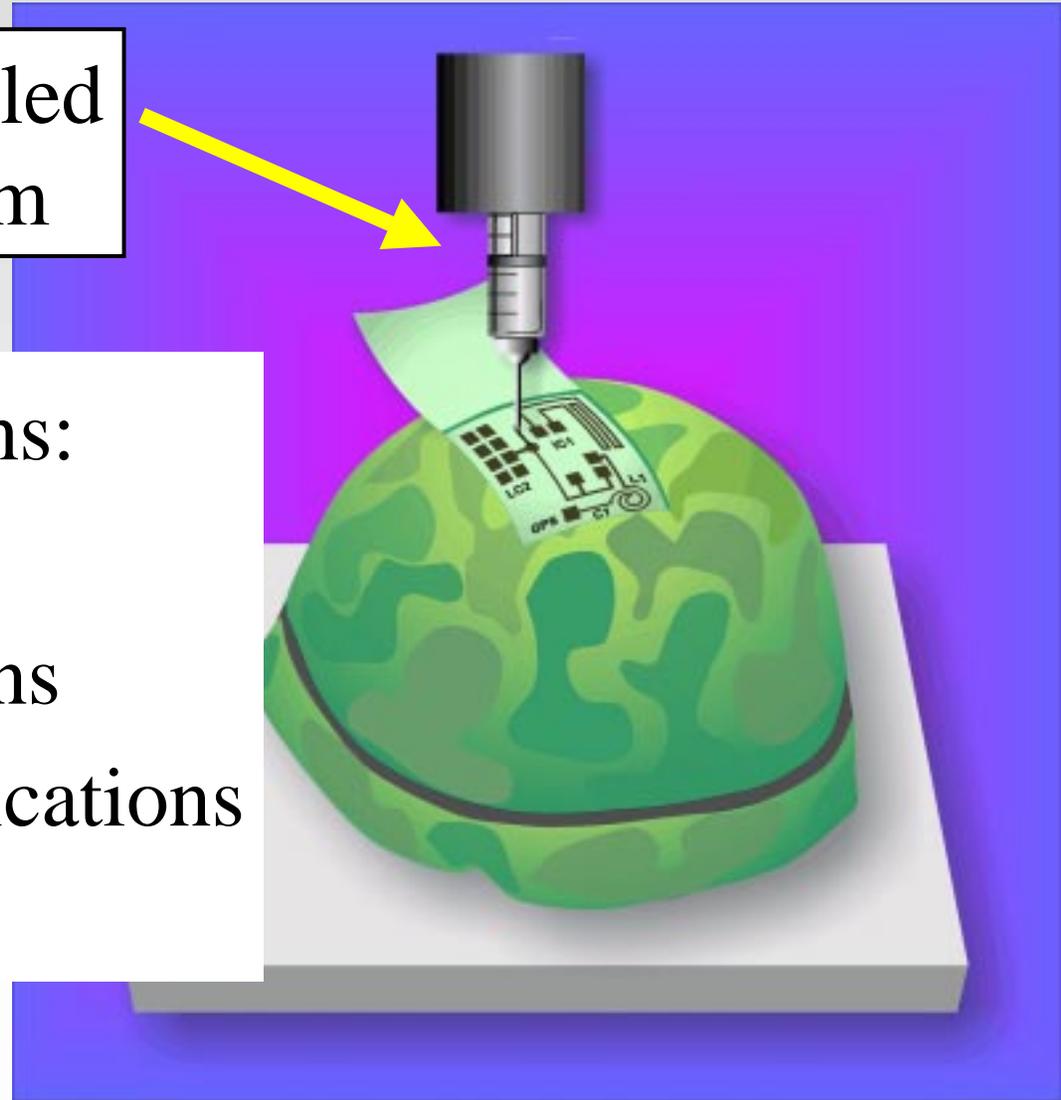


3D Conformal Direct-Write Electronics

Robotically controlled
direct-write system

Possible Applications:

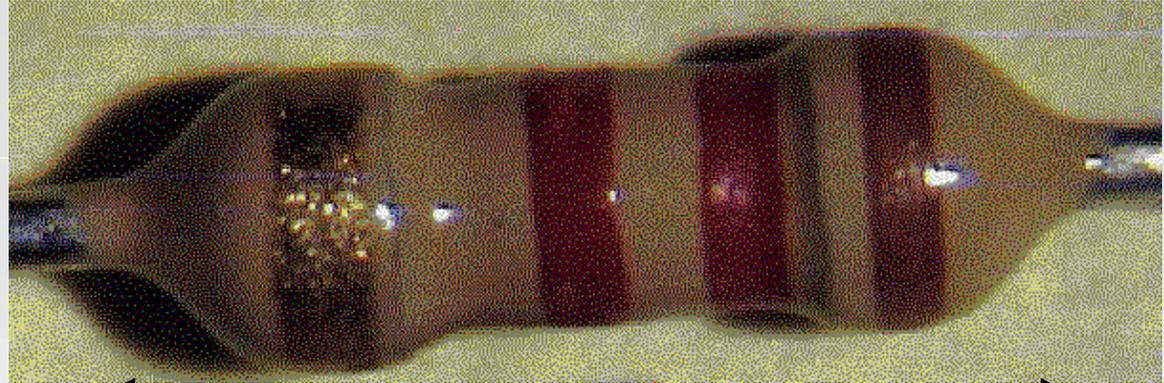
- Microsatellites
- Miniature munitions
- Wireless communications
- Security printing





Lilliputian *Meso*-Electronics

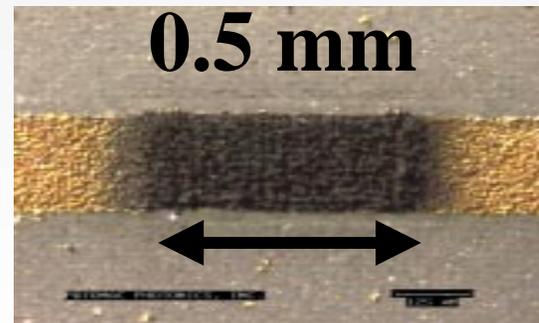
Conventional
through-hole
mount



6 mm

Direct-Write

- 2 - 4x smaller
- 20x thinner
- No solder
- 300K deposition
- Multilayer



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Direct-Write Passive Components

Potomac Photonics Inc./Naval Research Laboratory

- 3-D fabrication
- *in situ* trimming
- Room temperature deposition
- Works with any material
- Conformal

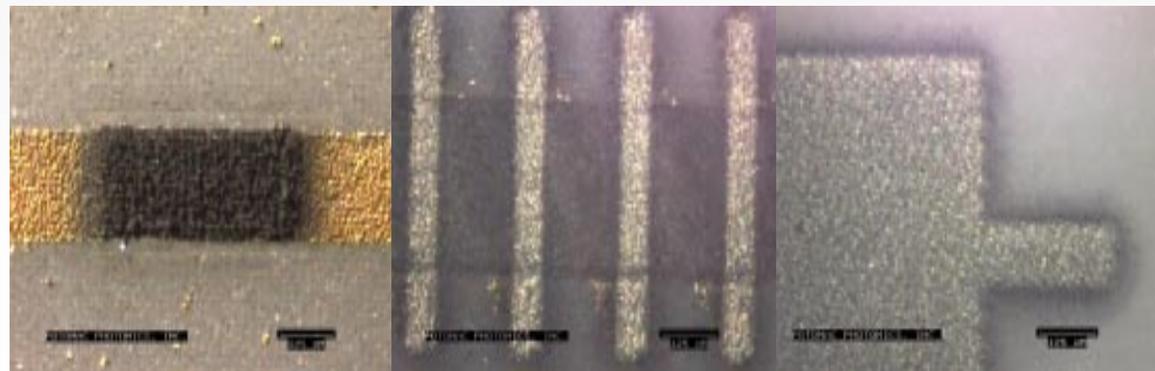
30 μm Au lines



Resistors

Inductors

Capacitors



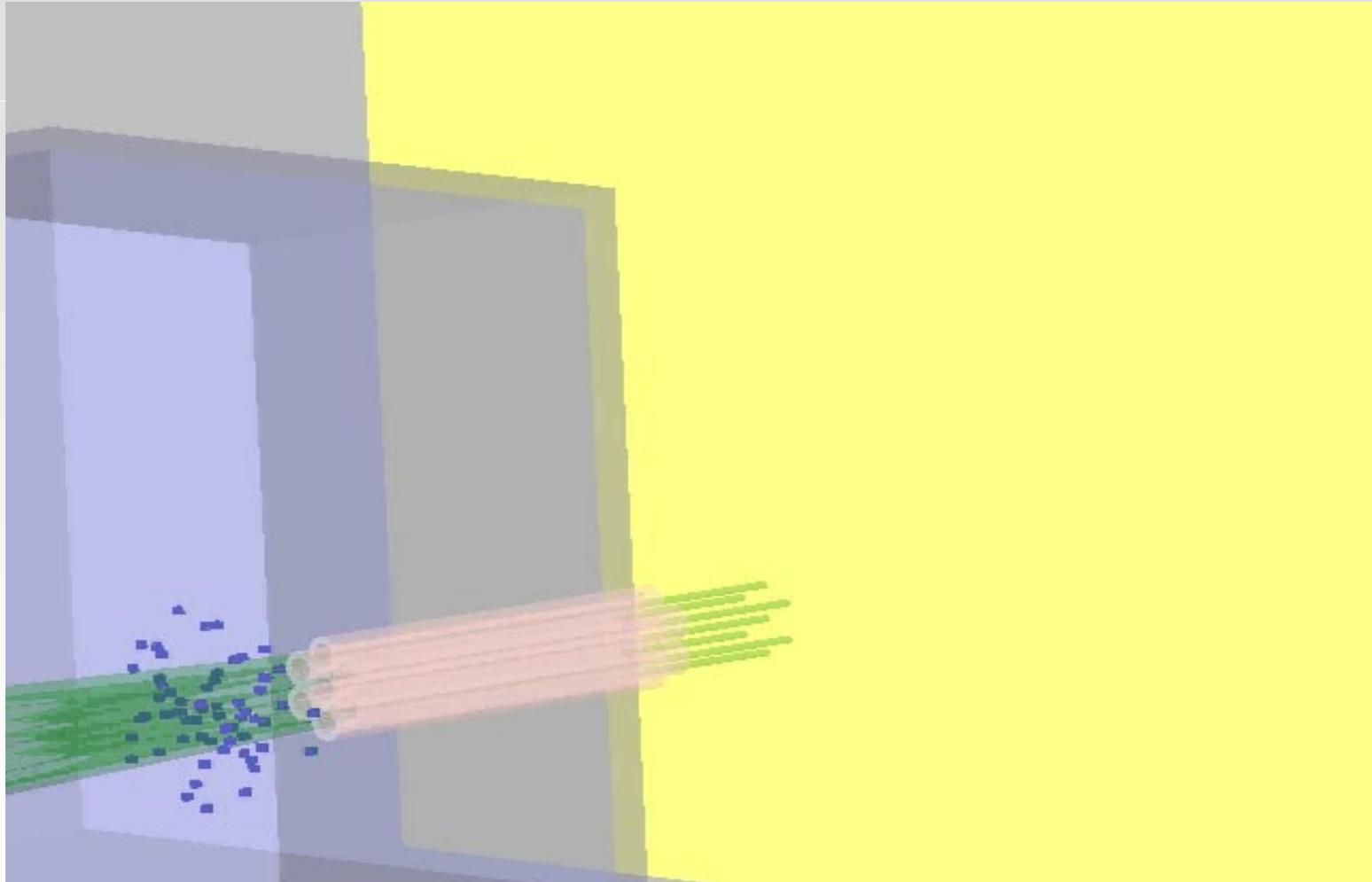
DSO



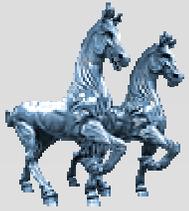
Laser Guided Deposition Process

Optomec Design Corp.

Dense Materials on Low Temperature Substrates

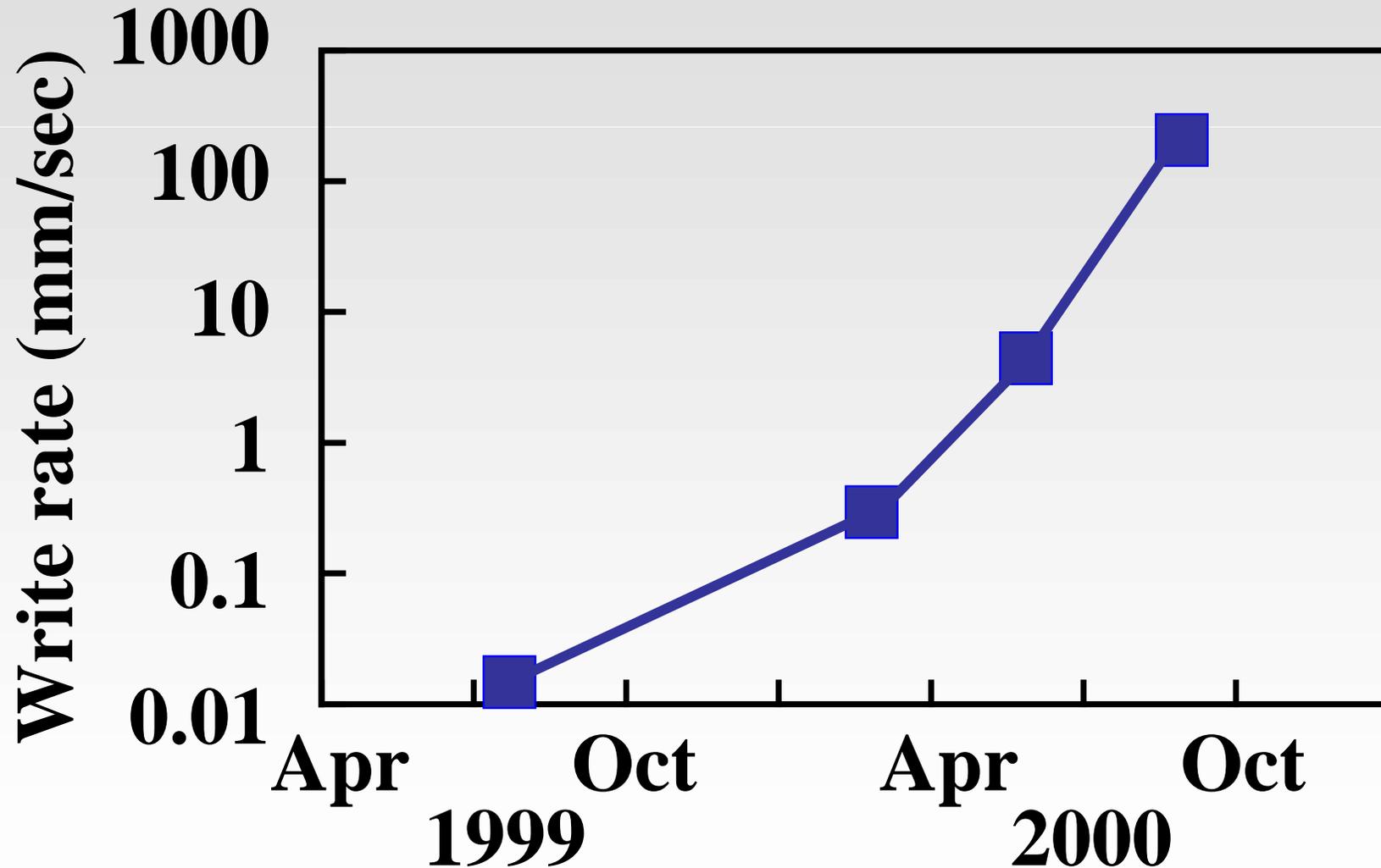


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Customers Demand Rapid Manufacture

Potomac Photonics Inc.

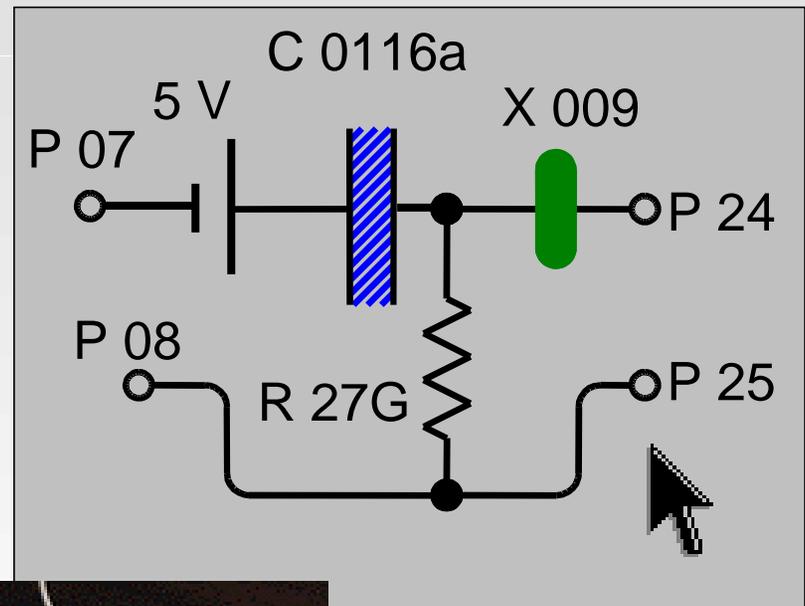


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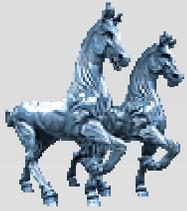


www.mesofab.com

- Host website devoted to *mesoscale* technology
- Tutorials & background information
- Links to team members, end-users, manufacturers
- Updated software, “recipes” and components lists
- Place an order!



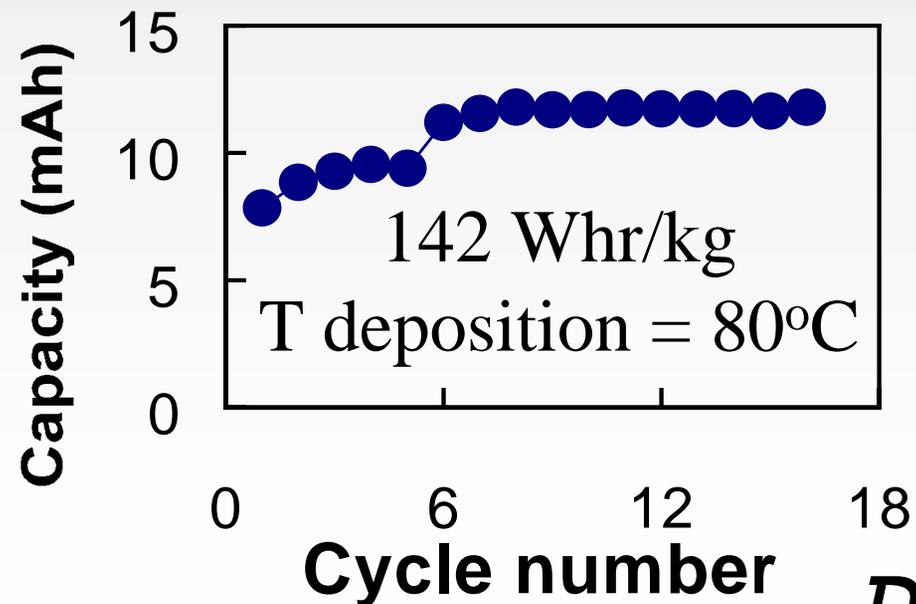
Potomac Photonics Inc.



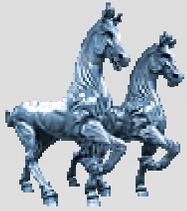
Batteries are Included!

Batteries, Solar Cells & RF Charge Pumps

- Reduced weight/improved performance
- Rugged/emplaced on any surface
- Fully integrated with the structure
- Capture incident energy (solar/electromagnetic)



SRI International

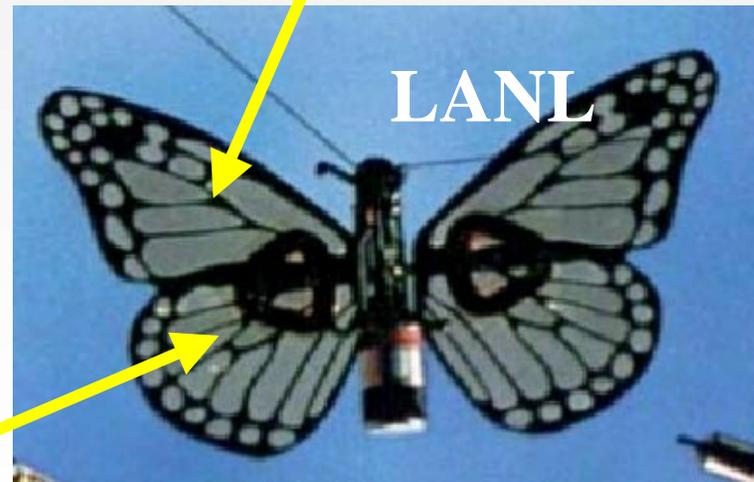


Of MICE and Meso-Machinists

MICE will integrate rugged, miniaturized electronics with meso-machine structures



Passives and circuitry integrated with the structure



Integrated batteries

DSO