DEVELOPMENT OF A MICRO LHP USING NOVEL COHERENT POROUS SILICON

A SYSTEM FOR THERMAL MANAGEMENT OF SPACE SOLAR POWER GENERATION SYSTEMS

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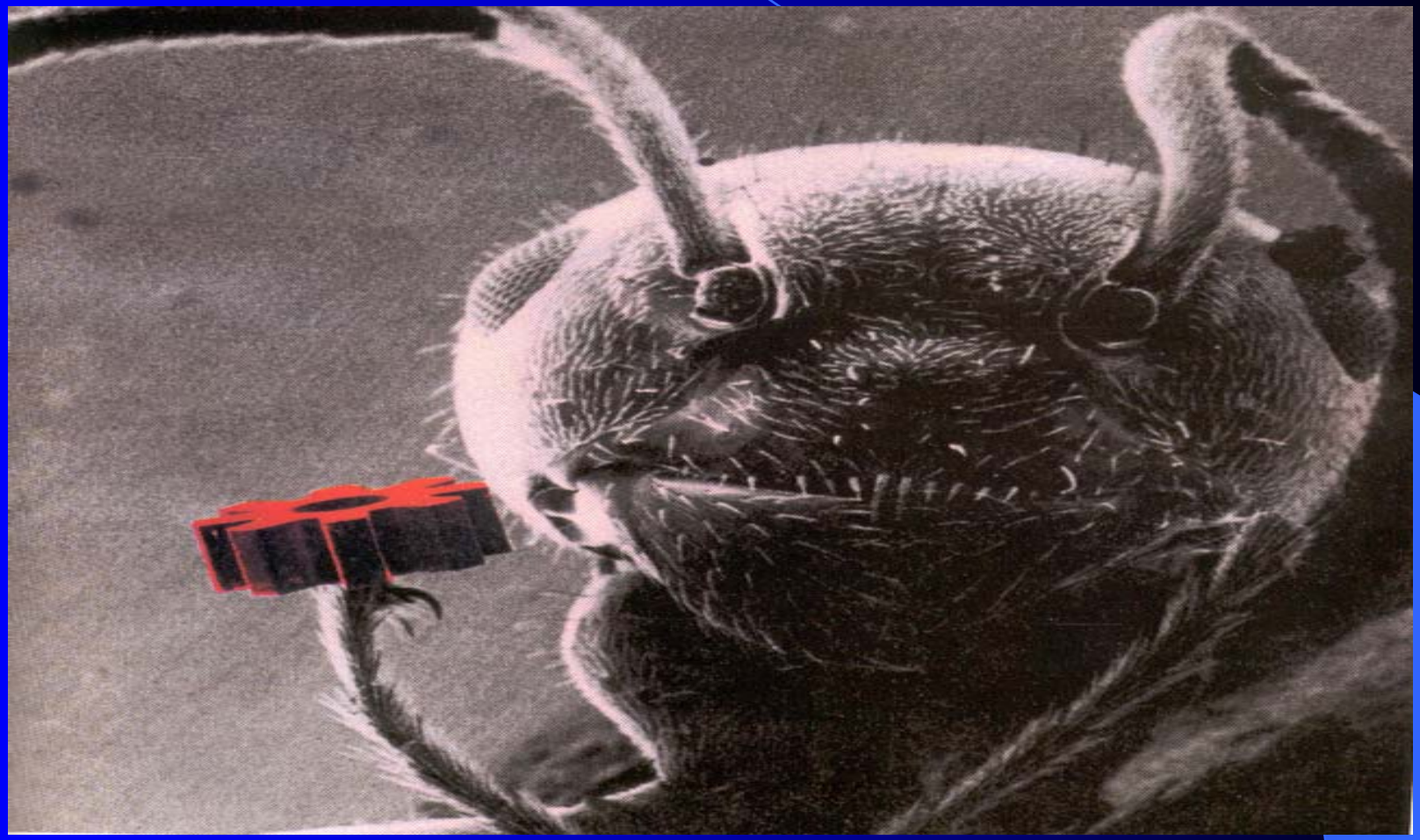
THE SIZES WE DEAL WITH

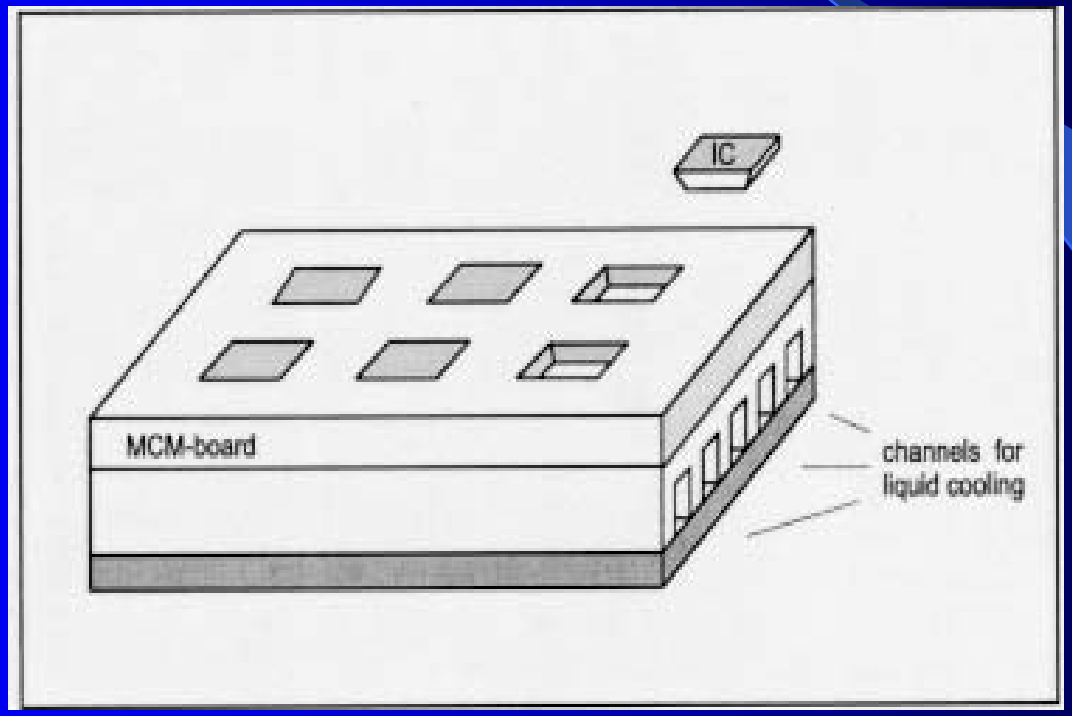


Micro-machined Gear Vs Ant's Head

APPLICATIONS

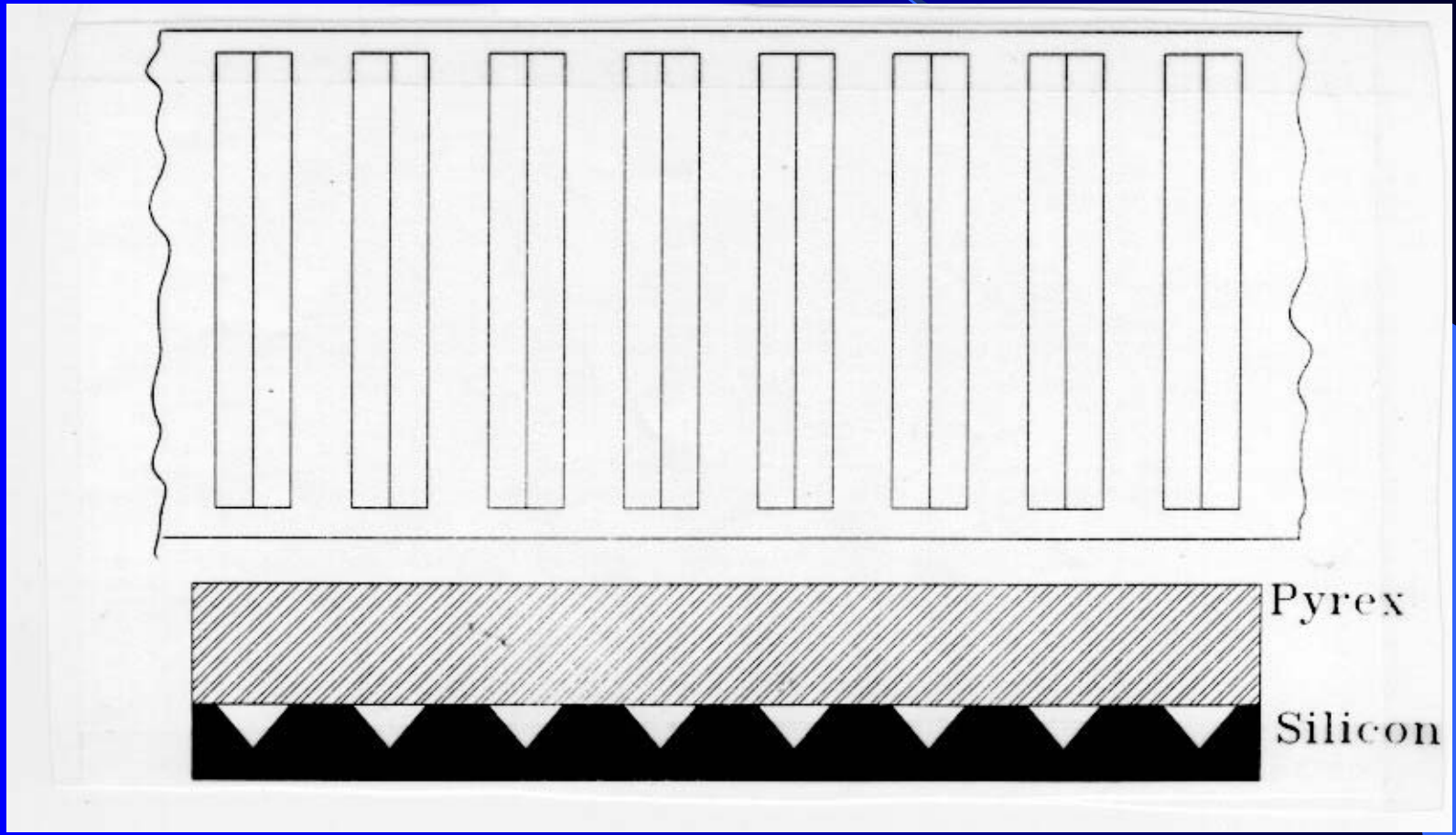
- Microelectronics Cooling
- Thermal Management of SSP
- Planar Configurations (Surfaces)

MULTICHIP MODULE

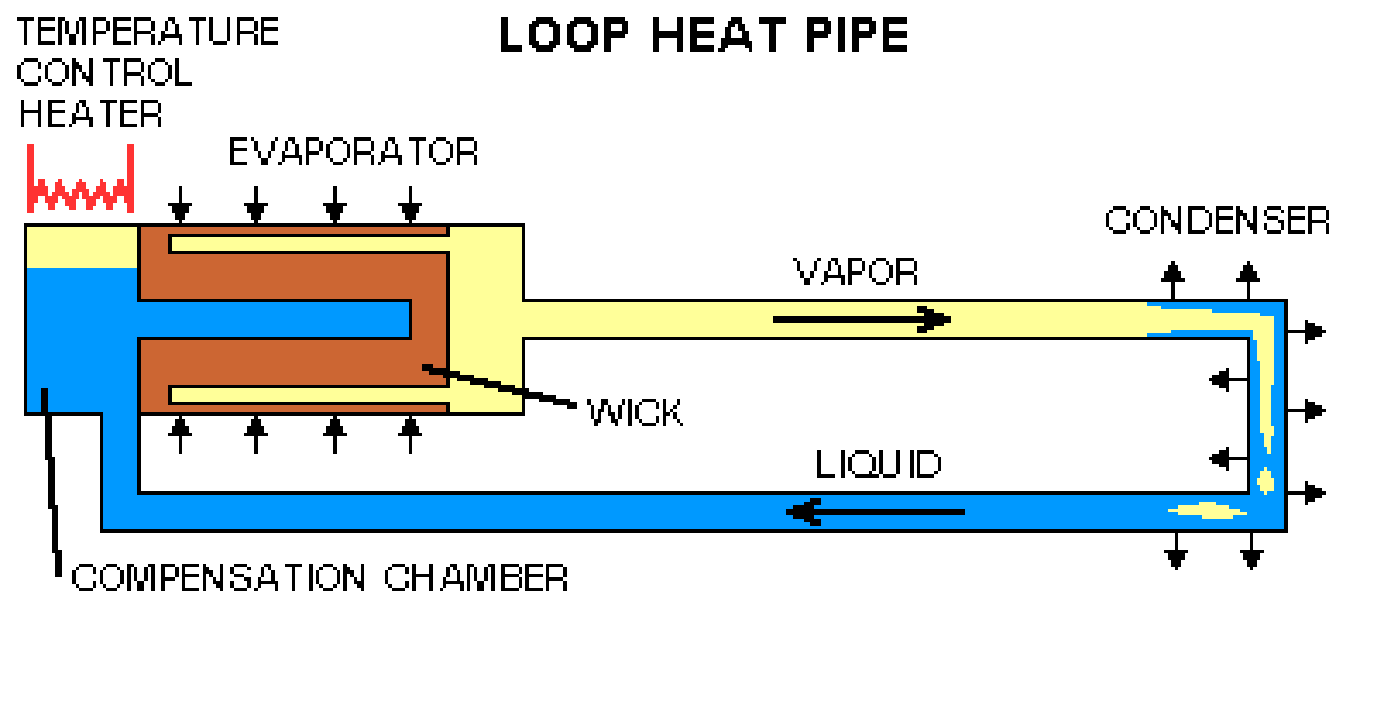


IC carrier board and integrated thermal management system in (100)silicon

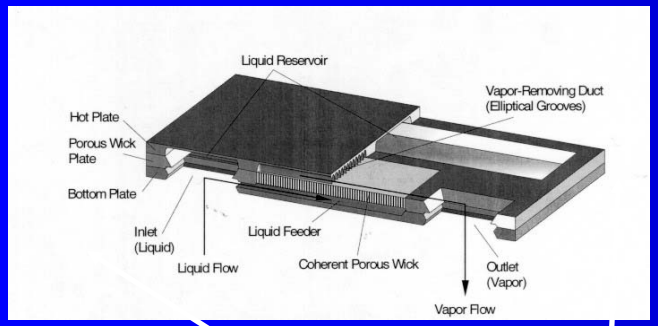
MICRO HEAT PIPE ARRAY

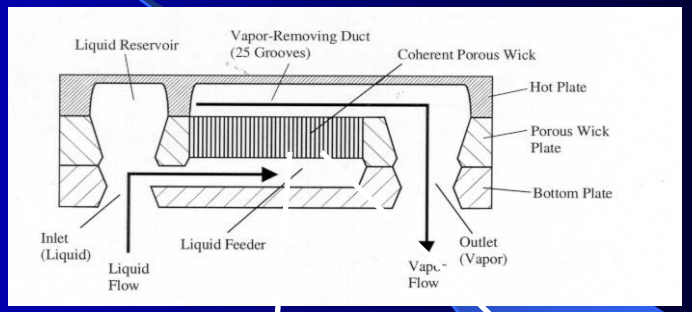


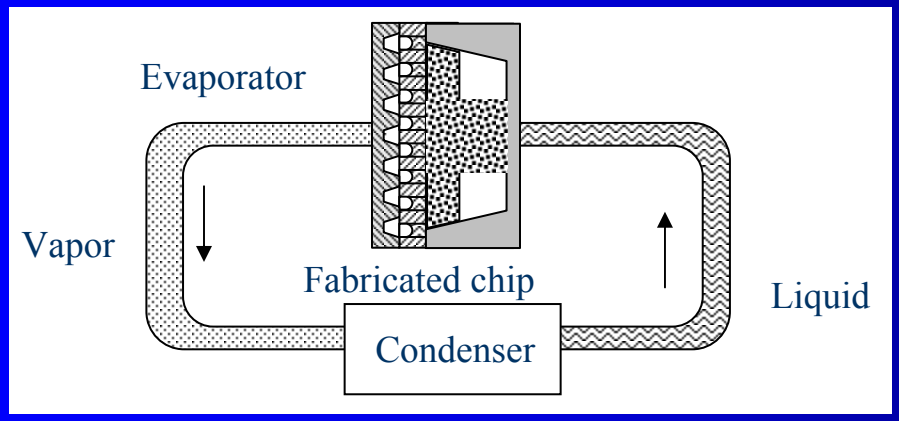
"ORDINARY" CYLINDRICAL LHP

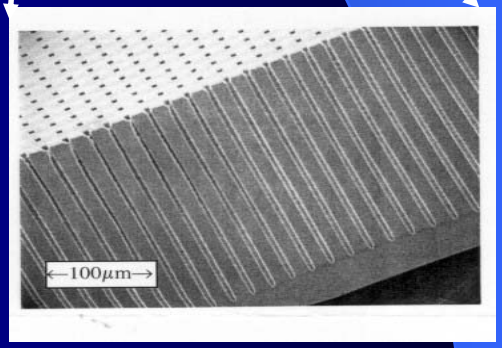


LHP USING CPS

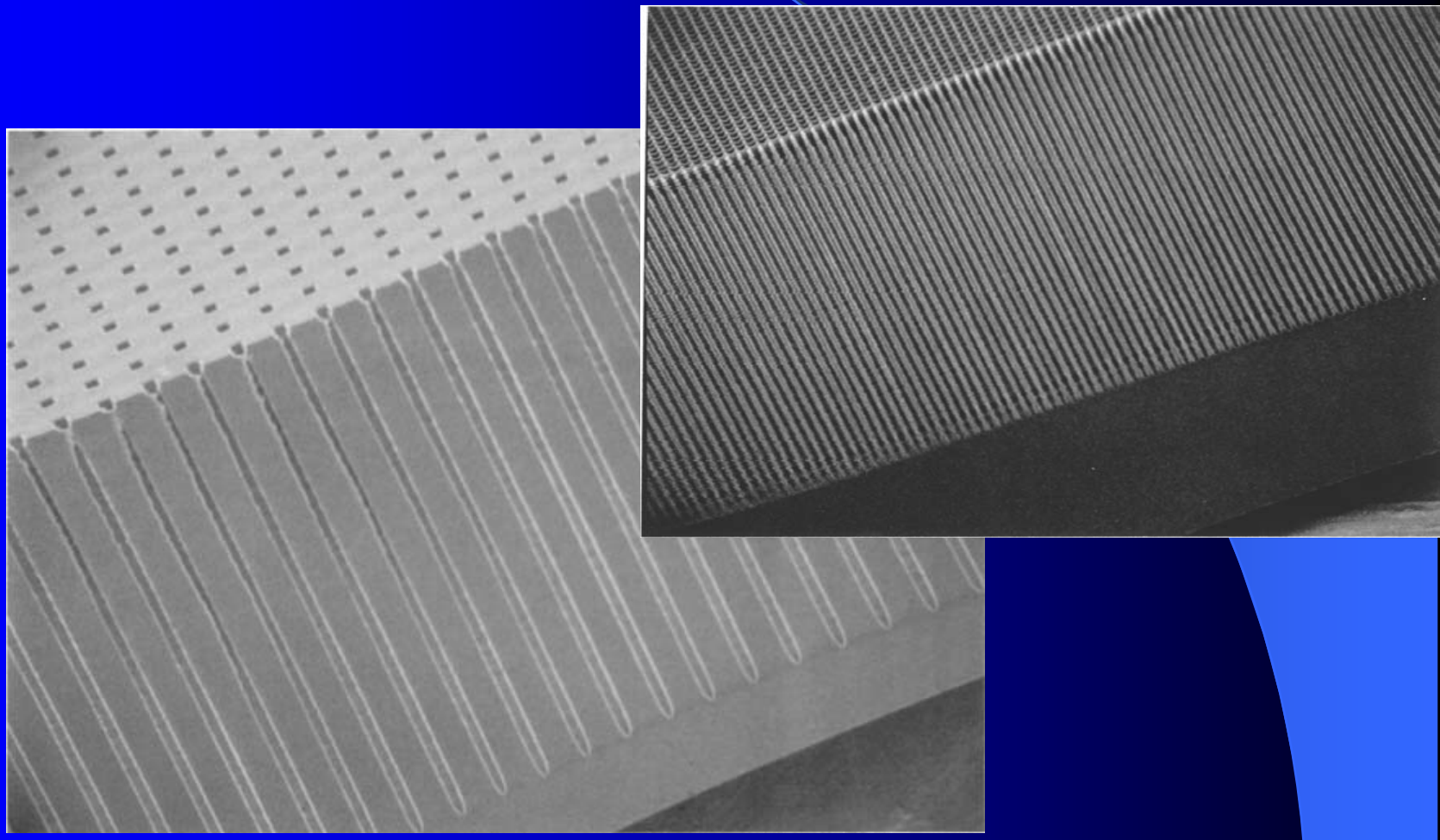




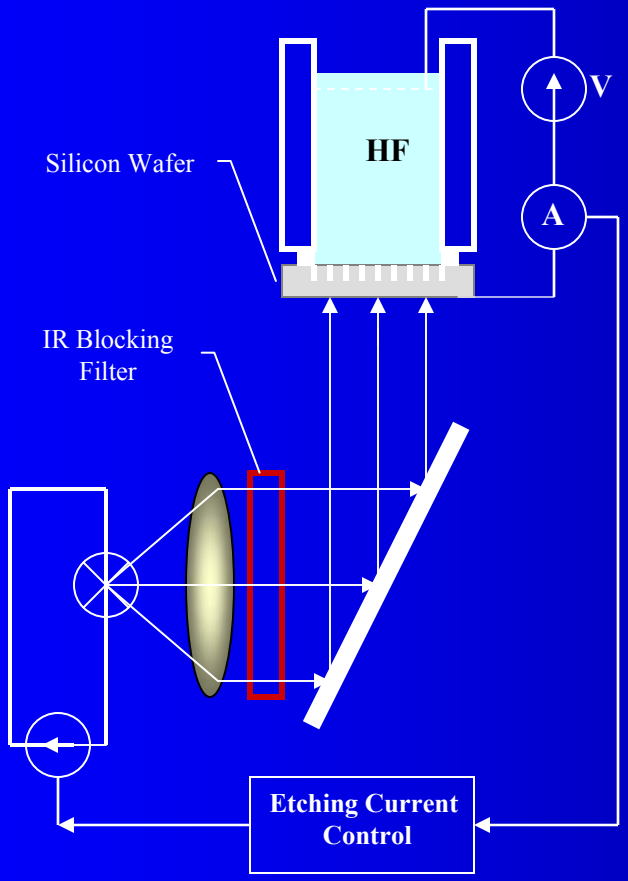


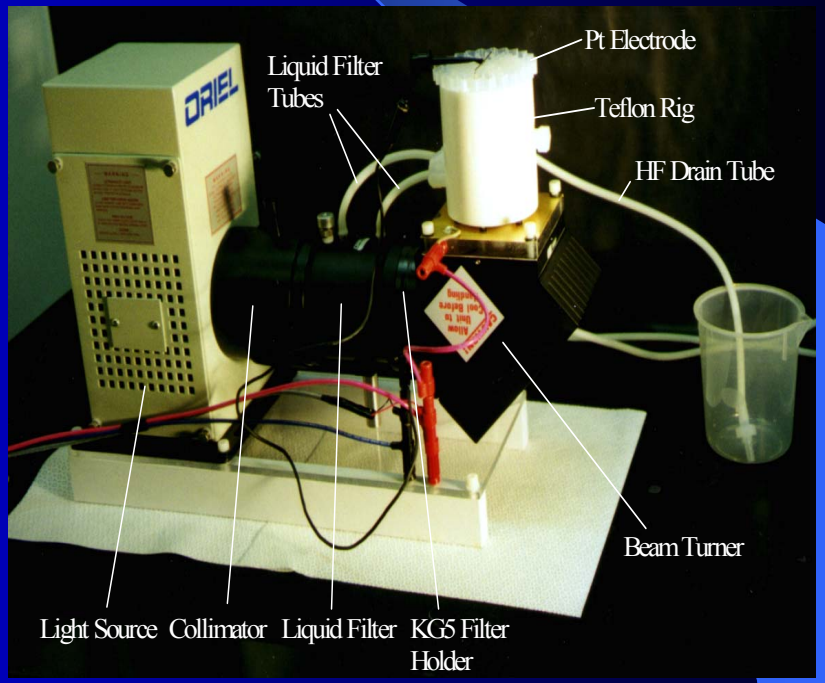


SEM OF CPS WICKS

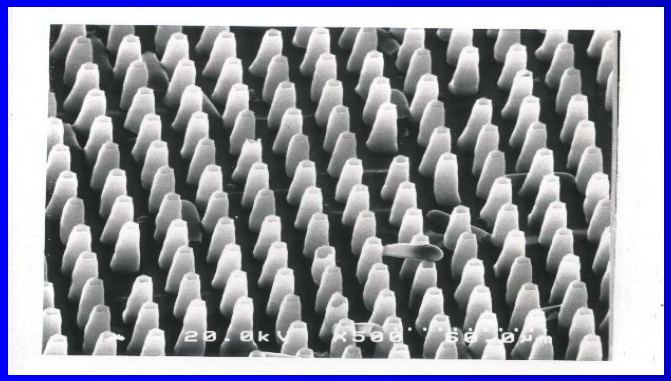


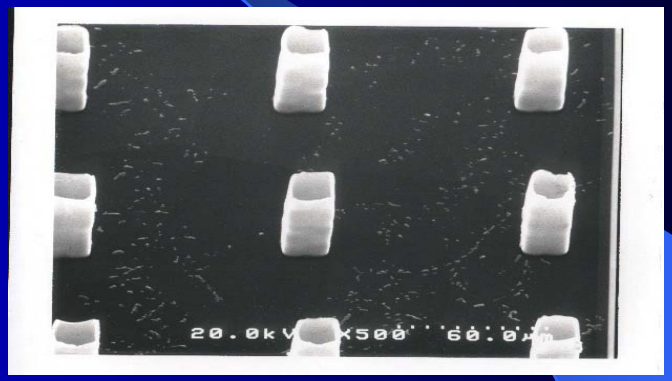
CPS FABRICATION SYSTEM

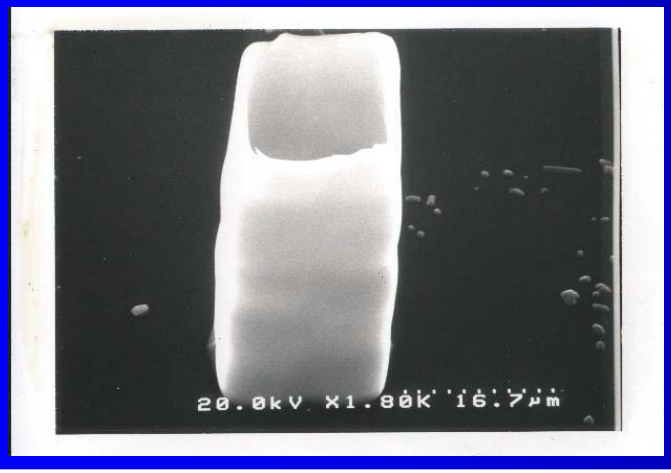


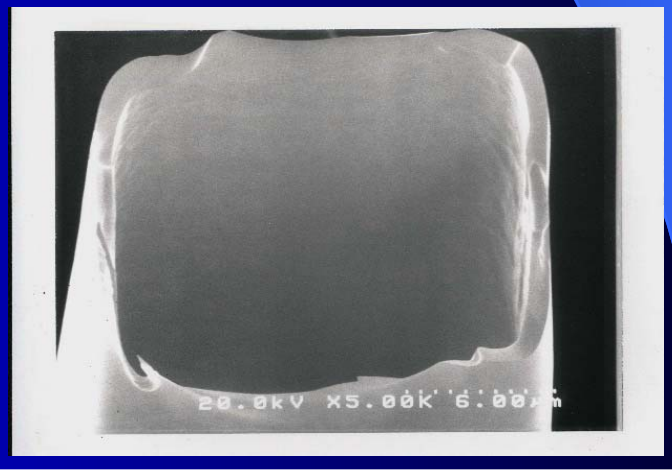


SILICON DIOXIDE NEEDLES

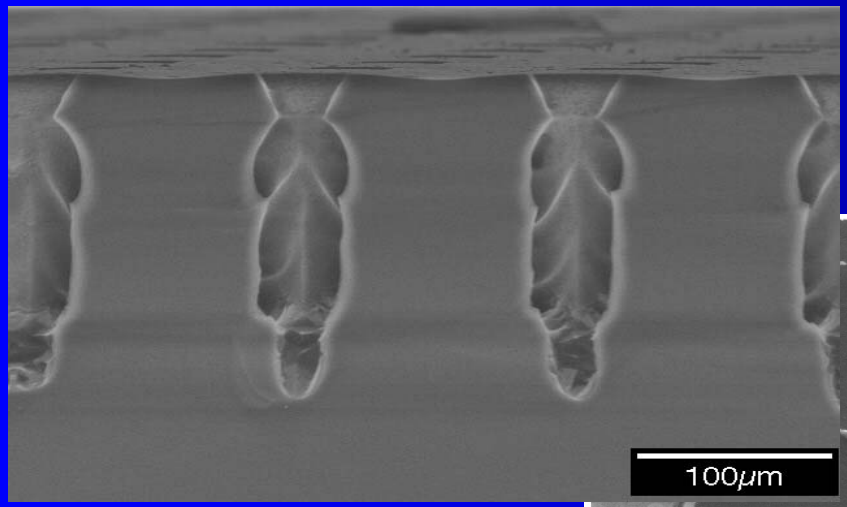


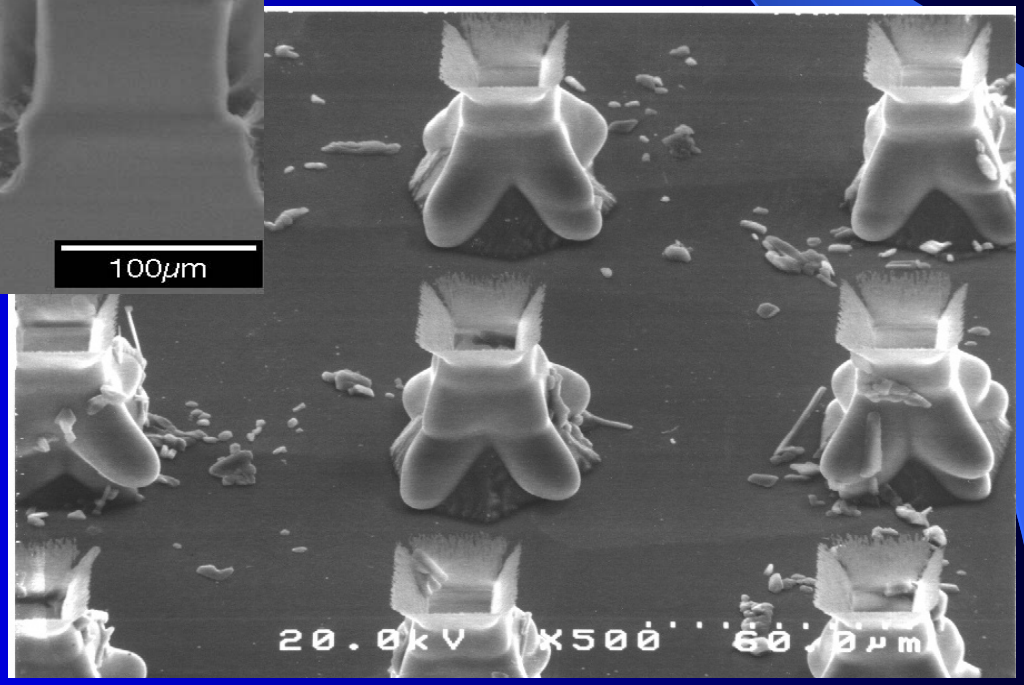




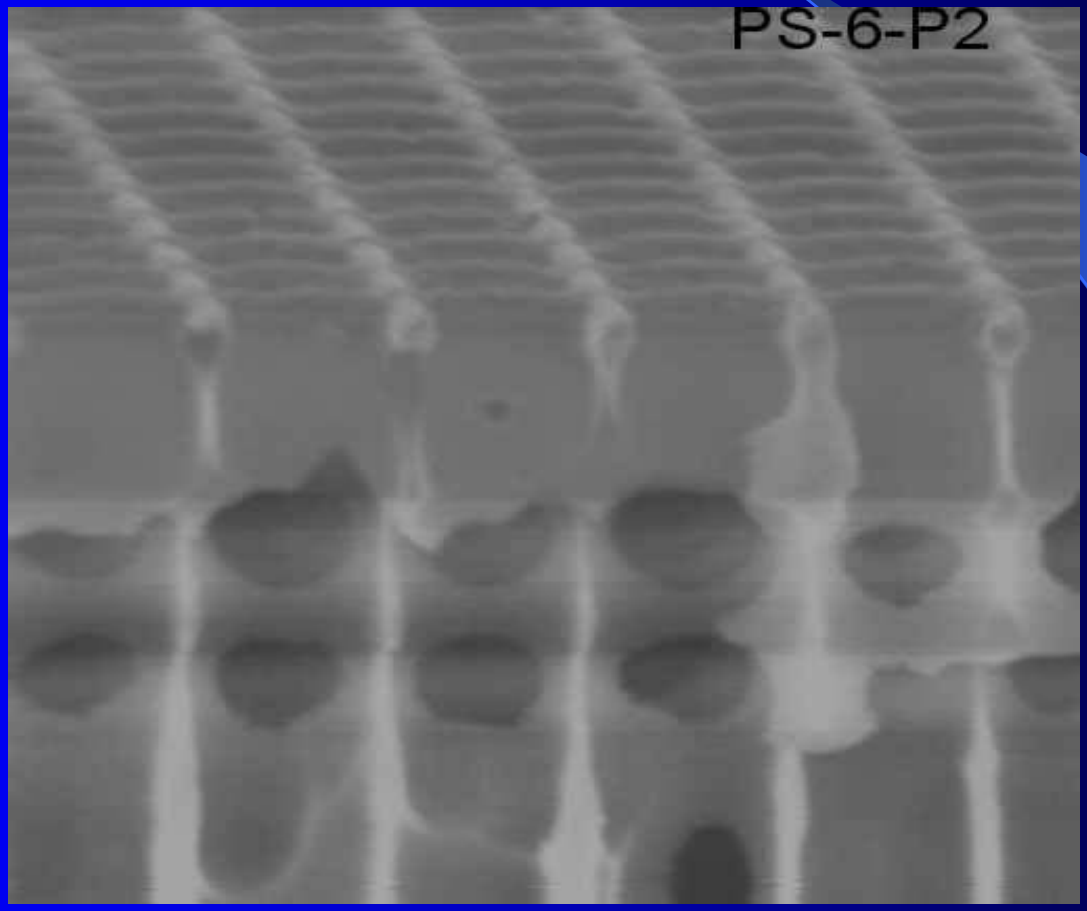


"FISH HOOK" CONFIGURATION IN CPS

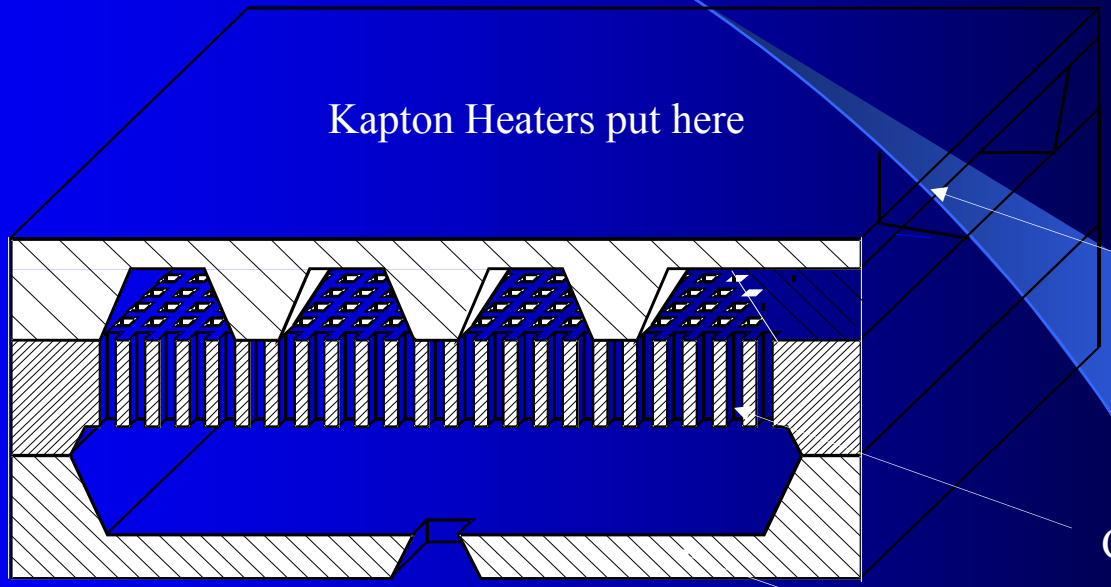




CROSS PERMEATION POSSIBILITIES

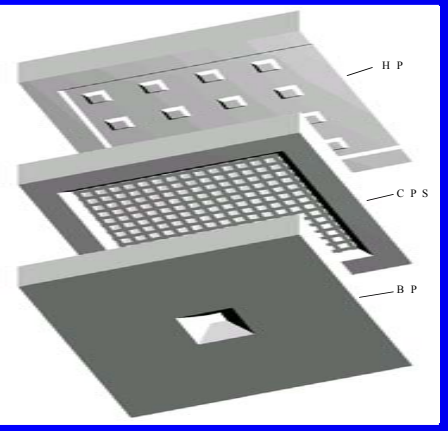


LHP PACKAGE



Cross-section of an Integrated Evaporator.

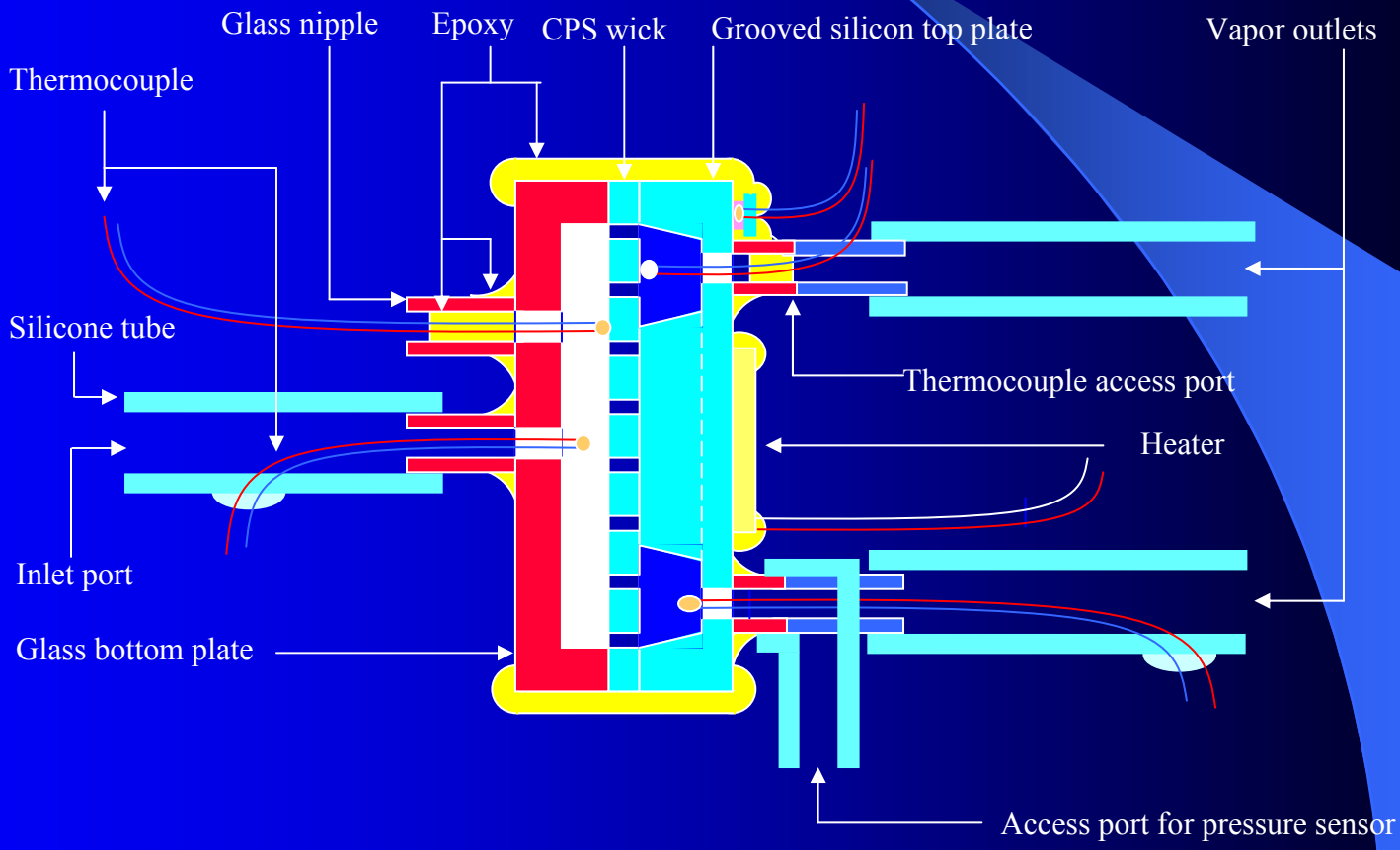
Bottom reservoir can be Fabricated Either in glass or silicon



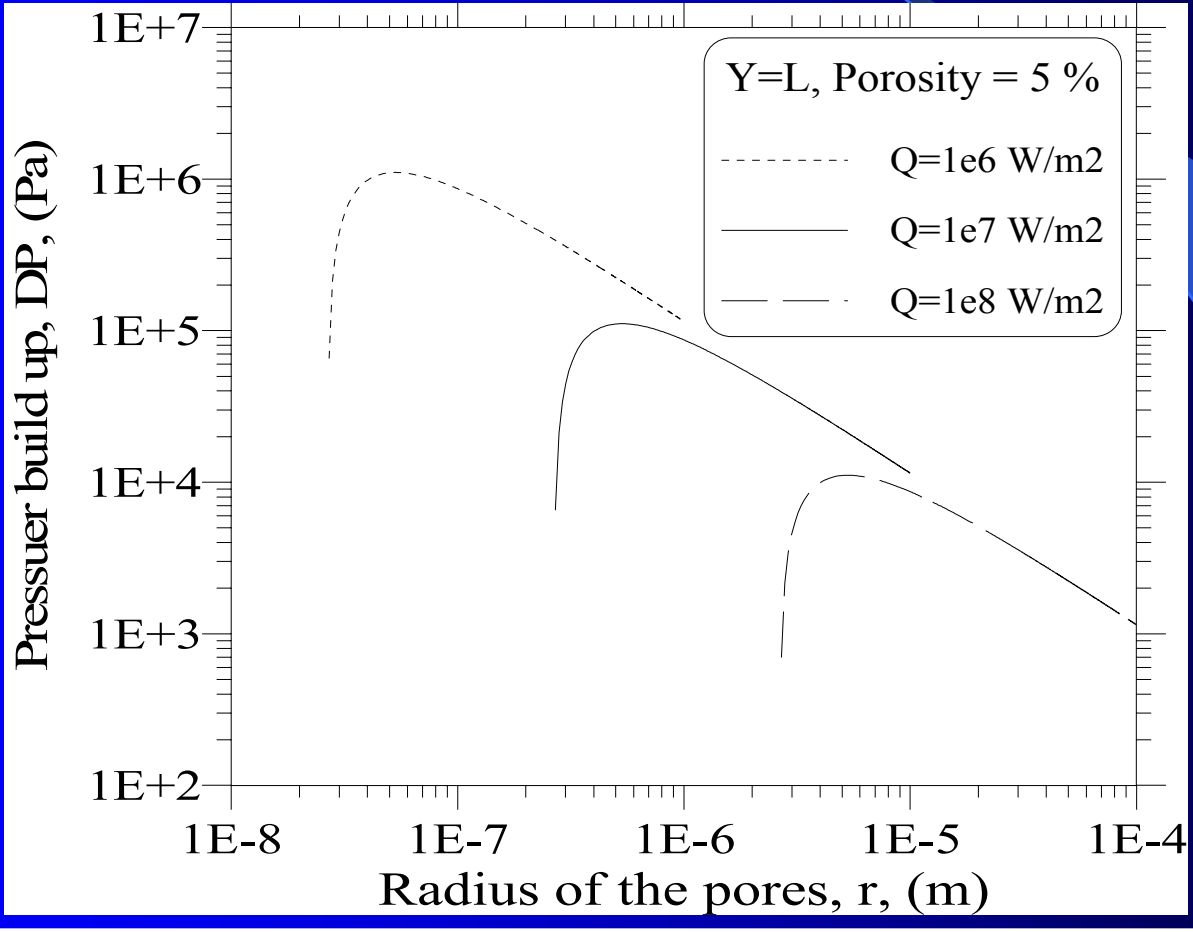
BBT RESULTS

Pore Size (microns)	measured pressure (psi)	Theoretical pressure (psi)
10	2.27	4.23
5 (pressurized in liquid side)	4.54	8.46
5 (pressurized in vapor side)	5.76	8.46

PACKAGING IN LHP



PRESSURE DROP VS. RADIUS OF PORE



CURRENT AND FUTURE WORK

- Complete testing of current wicks
- Optimize wick thickness and thermal isolation
- Design thermal optimization model
- Refine wick fabrication to 70% porosity and 2 μm pore diameter
- Fabricate and test optimized wick
- Achieve efficient LHP test cell, hopefully toward 300 W/cm^2

CPS FABRICATION

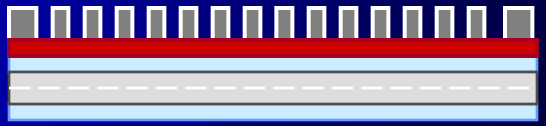
N Doped (100) Silicon Wafer
Measurement: Thickness
Thickness: 300 Micrometers
Measurement: Resistivity

Dry Thermal Oxidation
Temperature: 1070 Degrees Celsius
Time: 2 Hours
Thickness: 0.15 Micrometers

Dry / Wet / Dry Thermal Oxidation
Temperature: 1050 Degrees Celsius
Time: 0.5 / 1 / 0.5 = 2 Hours
Thickness: ~ 0.6 Micrometers

Primer and Photoresist Application
Photoresist: Shipley S1818
Spread Speed: 500 RPM
Spin Speed: 5000 RPM
Thickness: 1.5 Micrometers

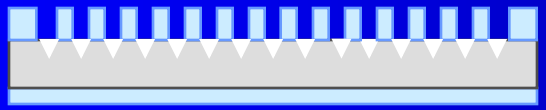
Phosphorus (N+) Diffusion
Temperature: 960 Degrees Celsius
Time: 60 Minutes



Ultraviolet Photolithography
Exposure: 11 Seconds
Develop: 30 Seconds

CPS FABRICATION (Cont..)

Etch Pit Initiation in the Oxide
Etchant: Buffered Oxide Etchant



Etch Pit Initiation in the Silicon
Room Temperature Etch
Etchant: 46 KOH: 54 DI H_2O

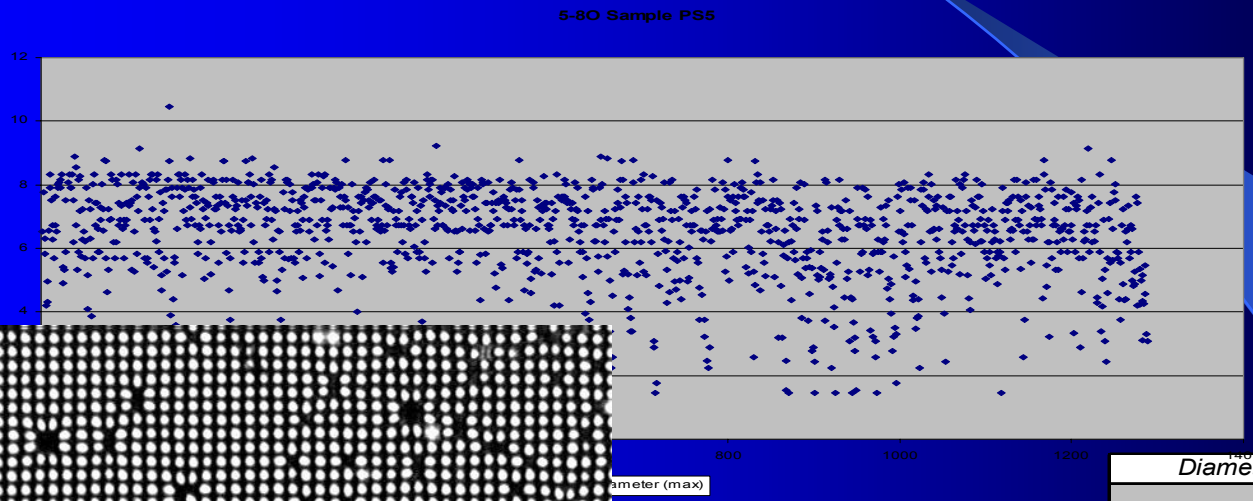
Oxide Removal
Etchant: Buffered Oxide Etchant

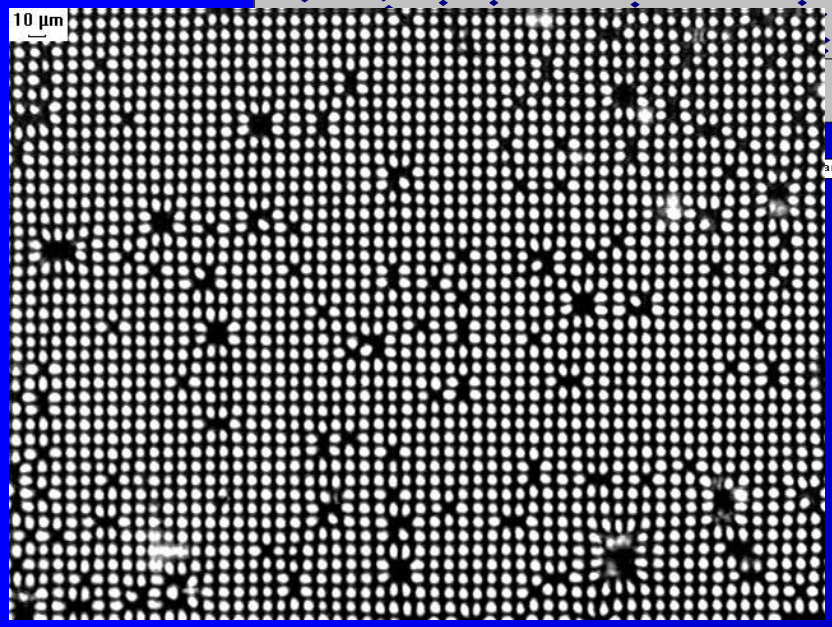
Metallization
Aluminum (1% Silicon): 0.5 Micrometers
Rapid Thermal Anneal
Time: 60 Seconds
Temperature: 350 Degrees Celsius
Photolithographical Patterning

Coherent Porous Silicon Etch
Room Temperature Etch
Etchant: 2.5 HF: 97.5 DI H_2O

Coherent Porous Silicon
Wafer Backside Is Lapped Or Etched

IMAGE PRO SOFTWARE WICK ANALYSIS





Software used to Show Porosity of 25%

Area of Pores	42648.52
Total Area	168248.2
Porosity	0.253486

Diameter (max)	
Mean	6.516854541
Standard Error	0.040178402
Median	6.729595
Mode	6.729595
Standard Deviation	1.438027602
Sample Variance	2.067923384
Kurtosis	1.170617541
Skewness	-1.059077127
Range	8.991106
Minimum	1.459854
Maximum	10.45096
Sum	8348.090667
Count	1281
Confidence Level(95.0%)	0.07882265