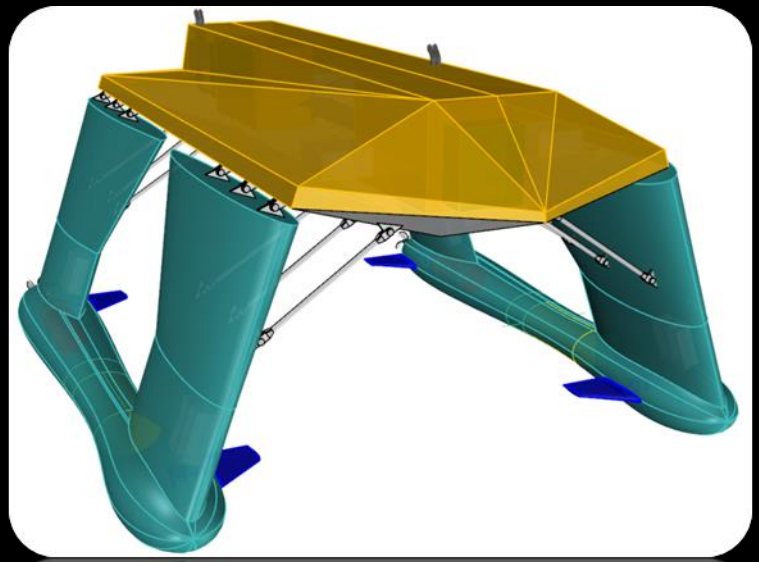
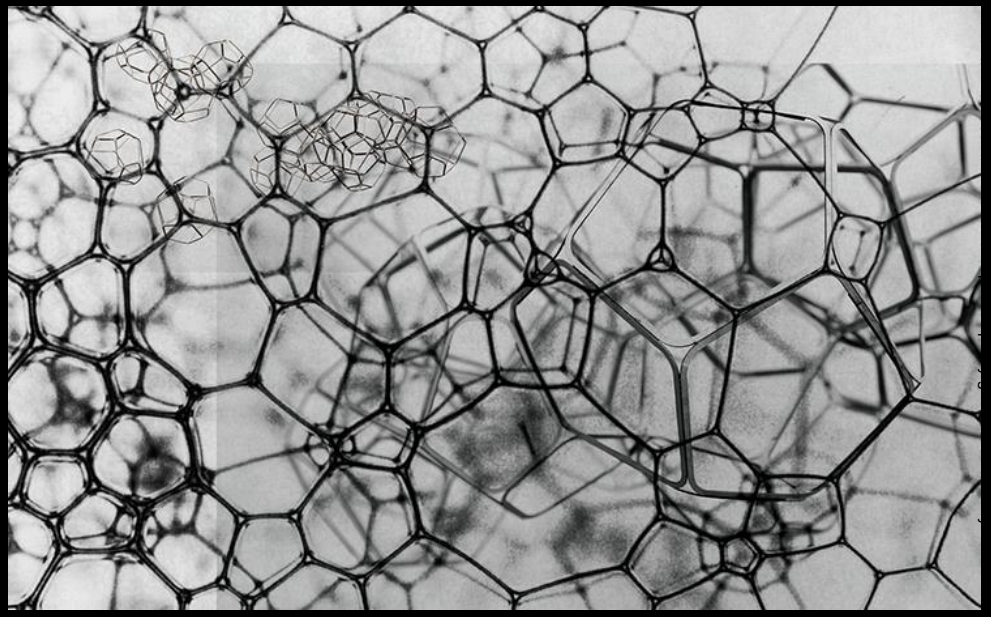
2D to 3D MICROSENSOR IMAGING ARRAYS

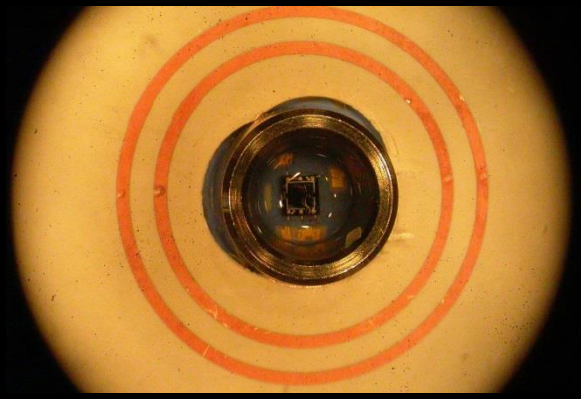
Stan Ivanov, David Fries, Geran Barton
College of Arts
University of South Florida
Email: dfries@usf.edu



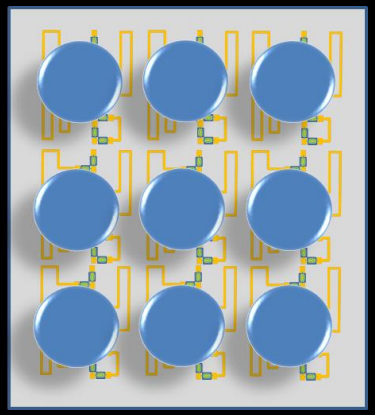


1.Packaging Focus: Area Array Packaging in 3D

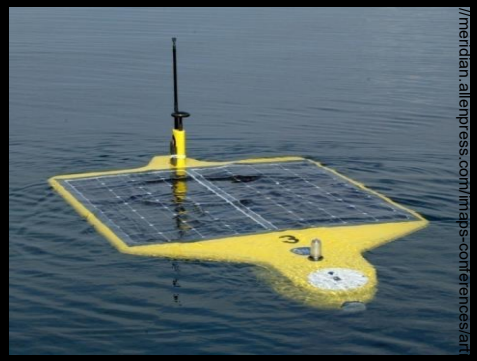
" CTP- Pixel"



"Pixel Array "



Imaging Sensor Skins

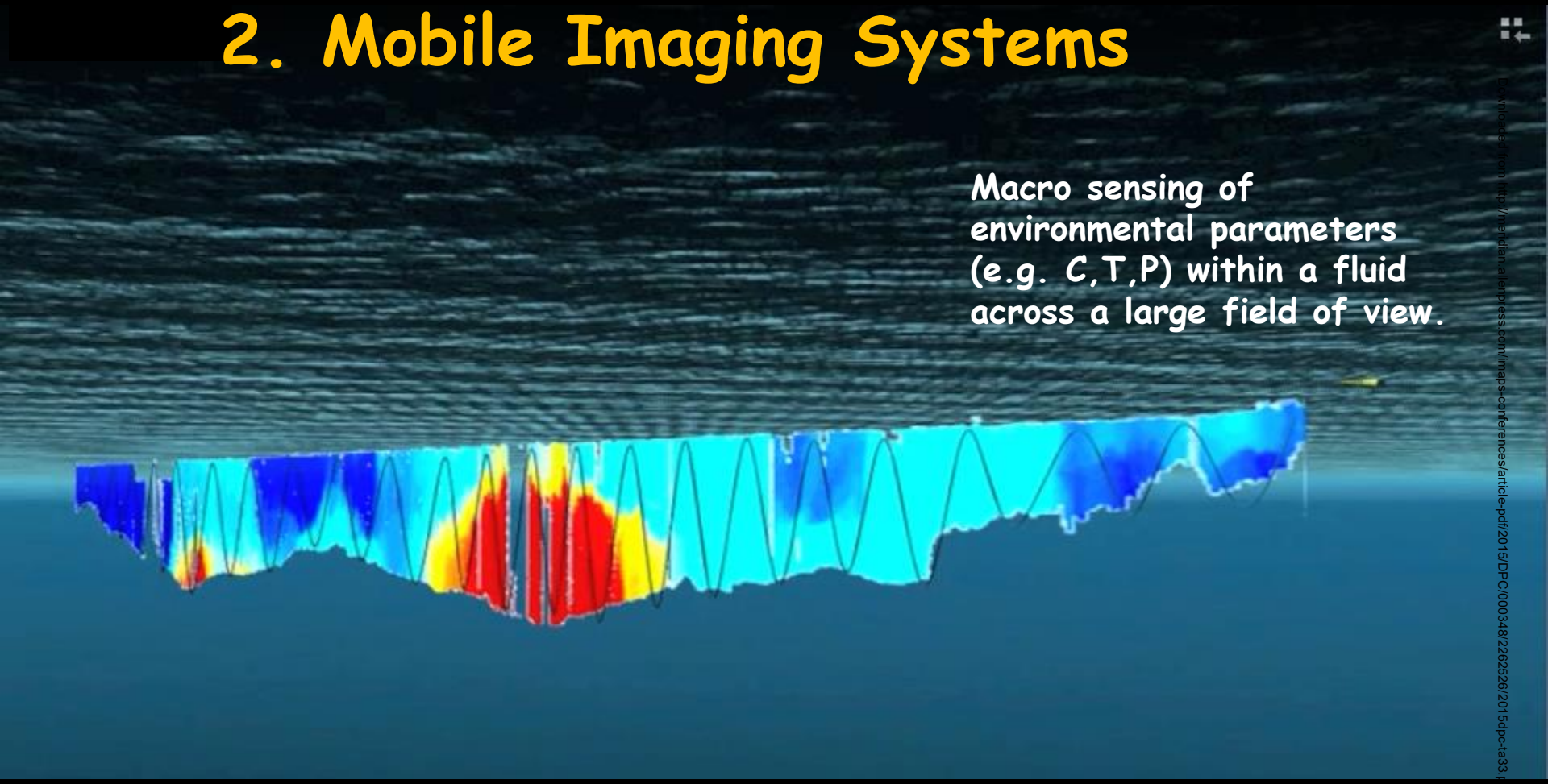


Imaging in 3D space

Sensor systems typically measure a localized space around a single sensor element. Expanding these single sensor elements into arrays and into 3D permits spatial distribution measurements of a particular parameter and allow flux visualizations.

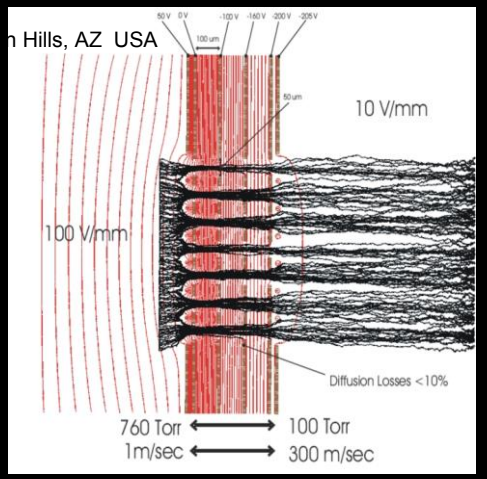
Most Drone Geometries are non-planar and in 3D

2. Mobile Imaging Systems



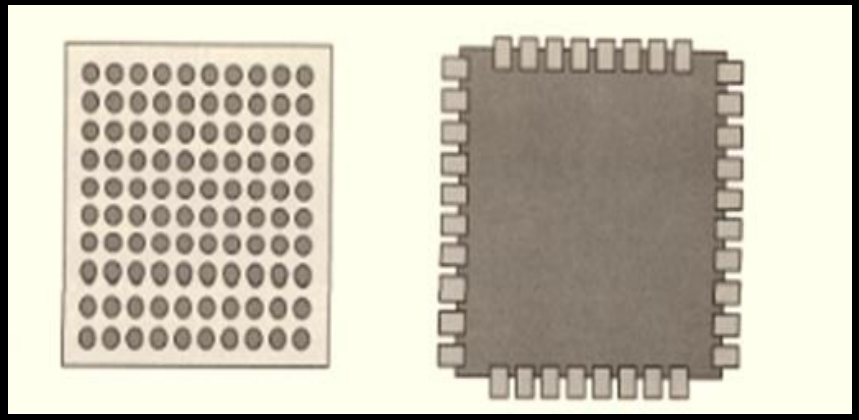
Extending the high spatial resolution imaging over large areas is a desirable feature for new "vision" modes on autonomous robotic systems and for deployable environmental sensors.

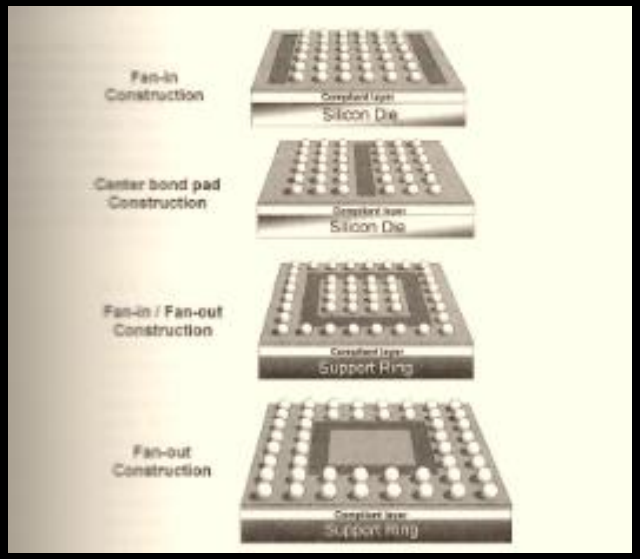
Area Array Packaging



- Create addressable arrays for sensing, and patterned structures and geometries for force and field control/shaping
- Move beyond flat sheets into conformal systems for imaging new environmental parameters
- Explore 2D/3D architectures for nets and volumetric measurement and sampling systems

Array Sensor Systems- Inspirations





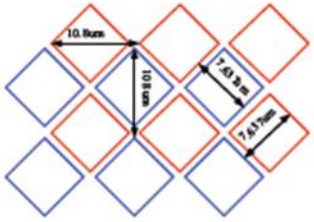


Figure 1-3. 0.45-in. DMD Diamond Pixel Geometry

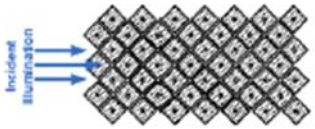


Figure 1-4. 0.45-in. DMD Diamond Pixel Array Configuration

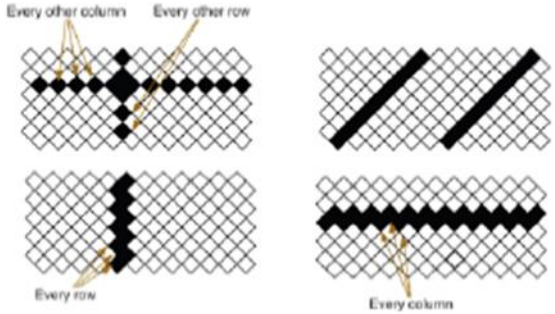
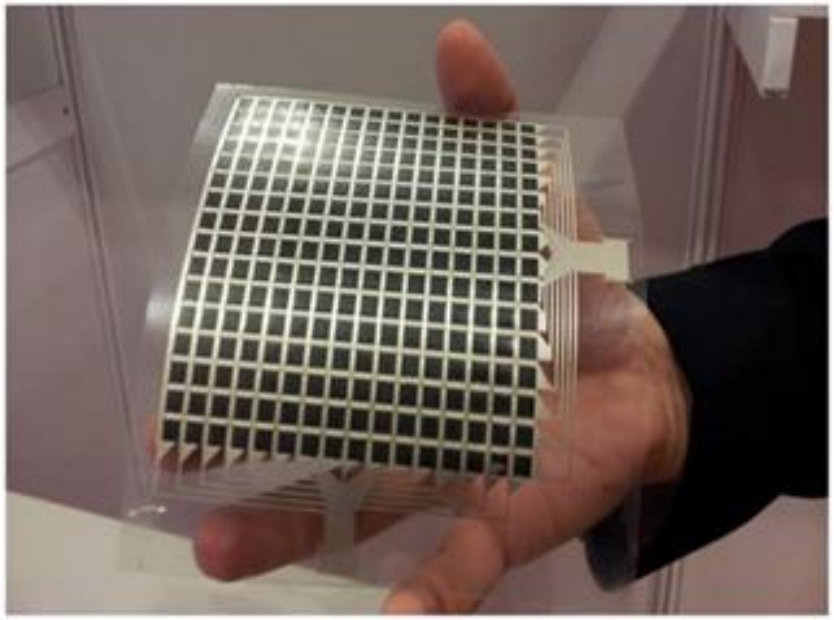
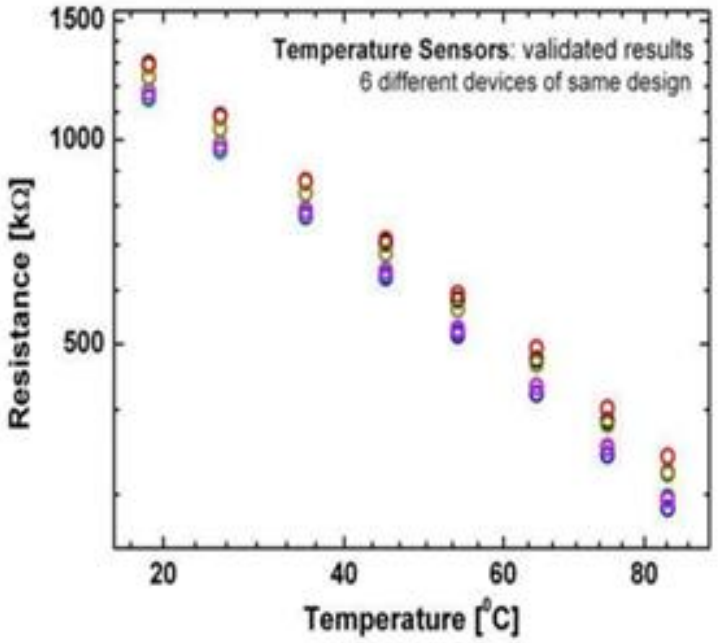


Figure 1-5. Diamond Pixel for Vertical, Horizontal, and Diagonal Lines

Printed temperature sensor

- PST Sensors
- Based on a silicon ink
- Compatible with a variety of substrates





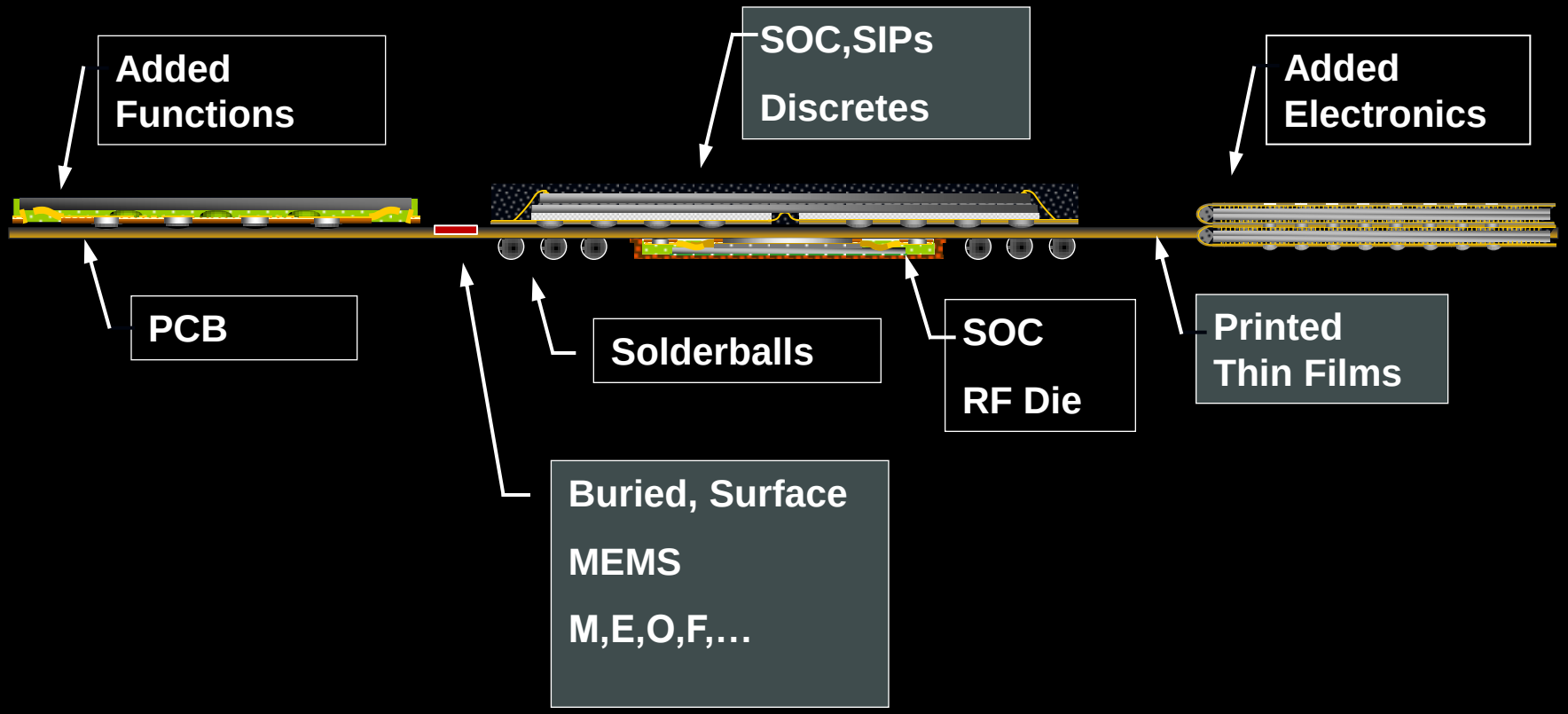
Architectural and Construction Approaches

- 2D
  - PCB
  - PCBMEMS
- 3D
  - Current Mono/Bi Materials
  - Emerging One Button Multi Material
- 2.5D
  - Fused PCB and 3DP Processes

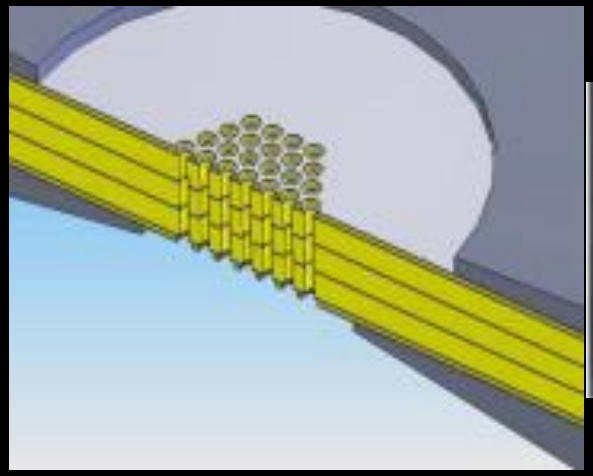

2D
Fab

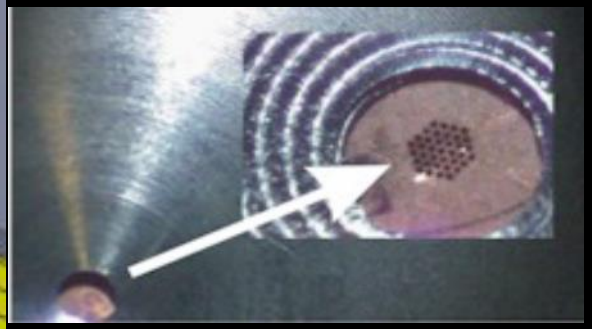
PCB/MEMS Systems

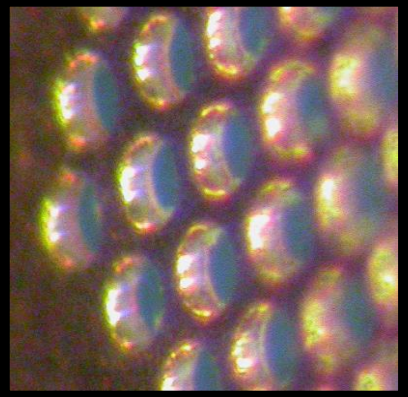
PCBMEMS: The combined insertion of mechanical, fluidic, optical and electronic functions into the PCB landscape, which permits a complex "system on a board".

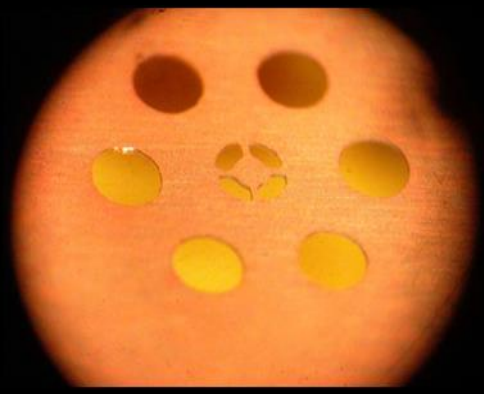


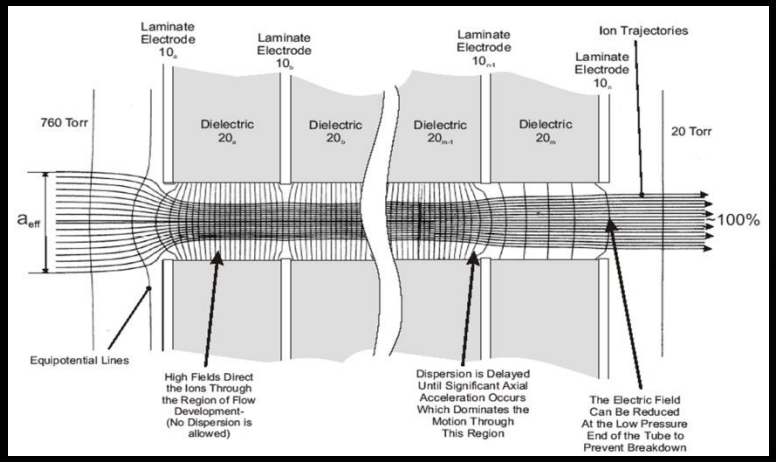
Micro Ion Optics Devices and Systems

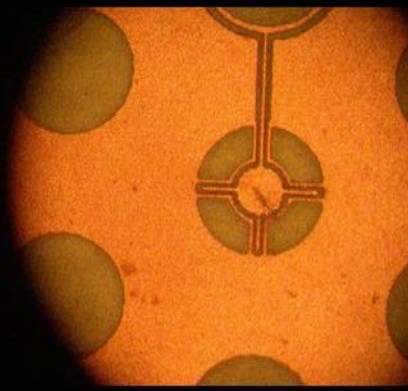






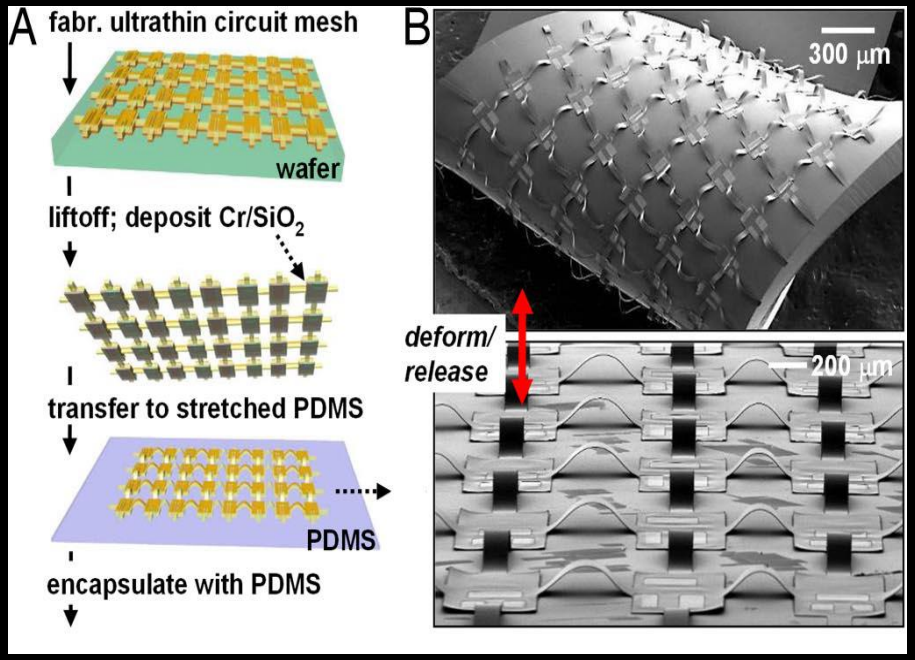


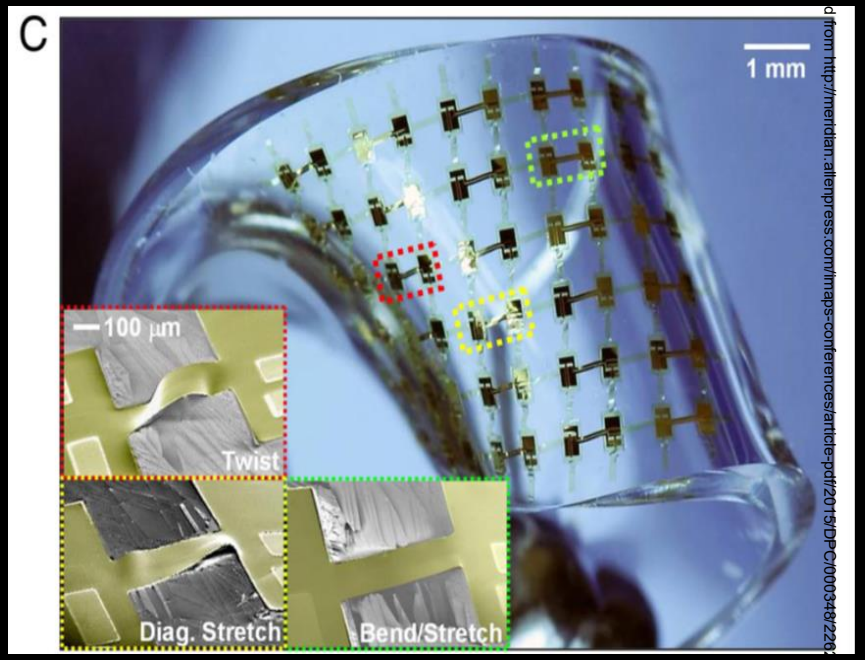


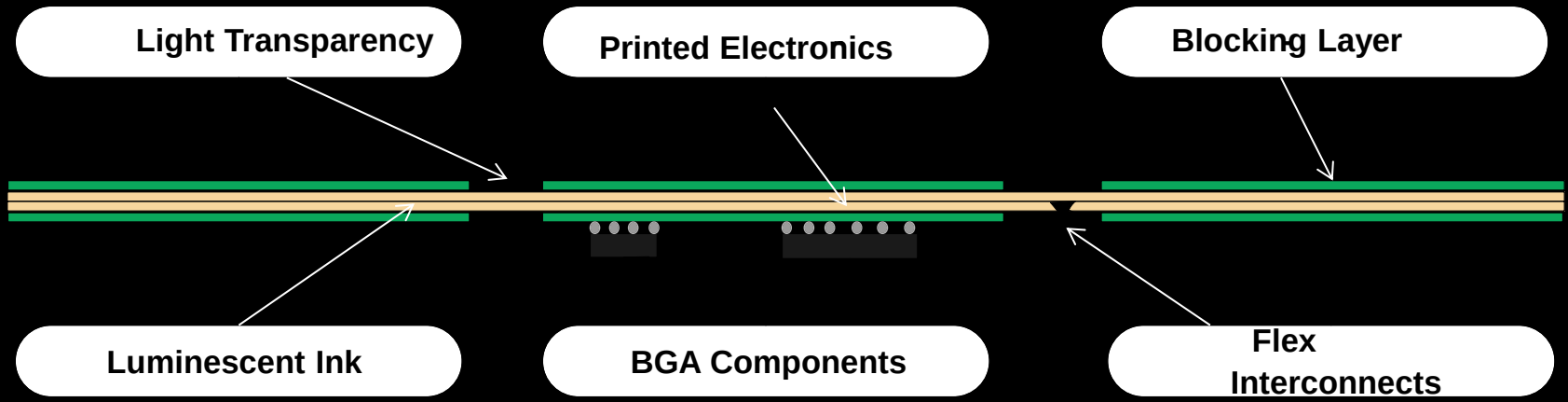


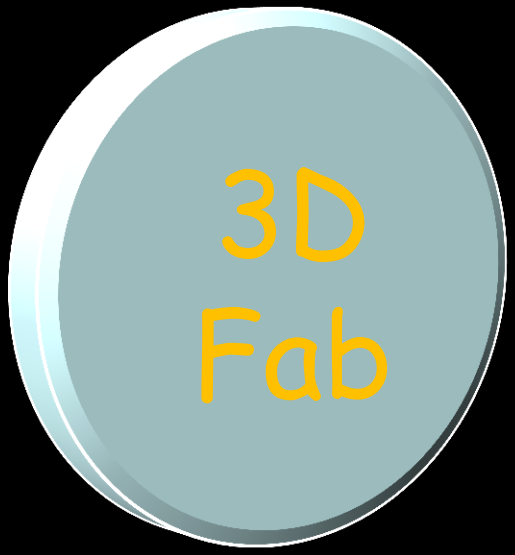
Patterned microstructures and geometries for flow and electrostatic field shaping using PCB-MEMS

Competitive 2D Process- Printed Electronics







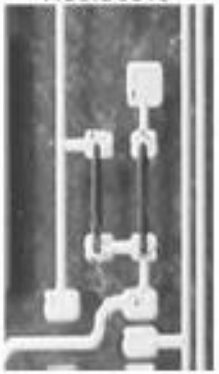

3D
Fab

3D Direct Printing onto Flat Substrates

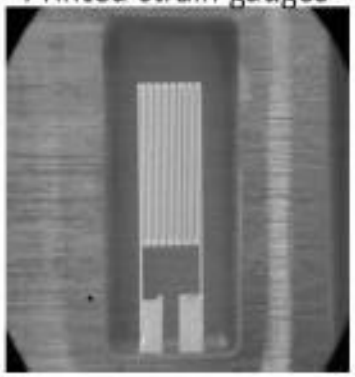
Antenna on UAV

Interconnects on bare die

Resistors



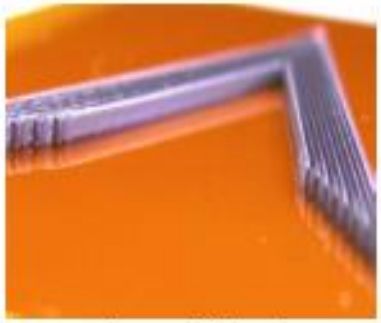
Printed strain gauges



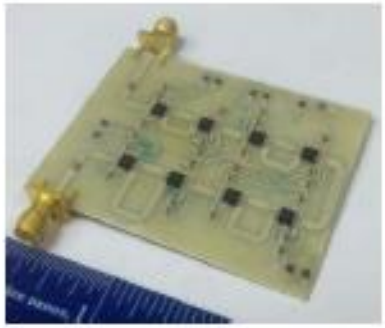
Lattices

RF strip guides

Ceramic filled Polymer



Iron filled Silicone



ULTEM™ Printed Silver multibit Phase Shifter


2.5D
Fab

2.5D Systems Packaging
Merged Electronics and Form

2D Flex

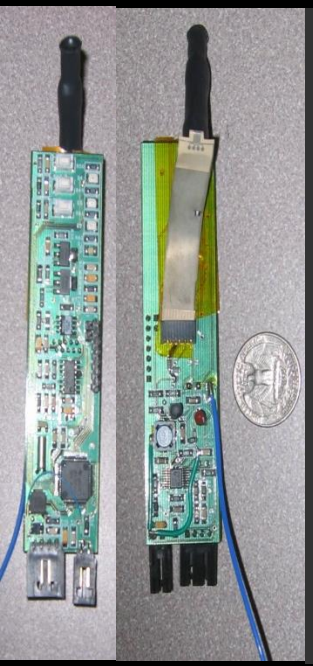
- Large Area Possibilities
- Conformal and Rigid-Flex
- Established Process
- PCBMEMS systems packaging option

3D Print

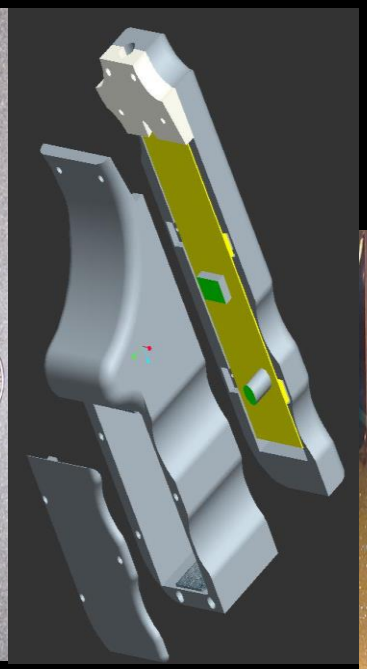
- Relatively Large Area
- 3D shapes: spheres, tubes, conformal
- Emerging Process
- Structural Materials available

2.5D Std Application- Genetic Analyzer

- Instrument produces comparable results to Lab equipment
- Provides on the spot “red light”/“green light” detection
- Data is stored and downloaded via USB
- Prototype runs on 3V disposable battery or via USB power



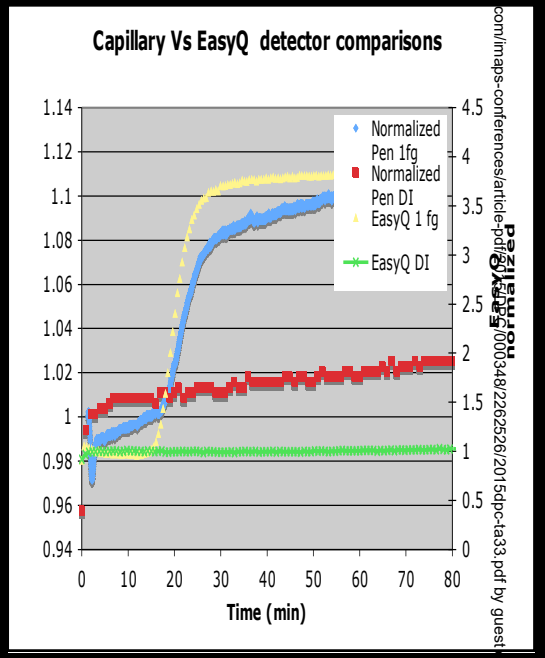
Flex and Rigid Packaging



CAD packaging

3DP

Construction of 2.5 prototype

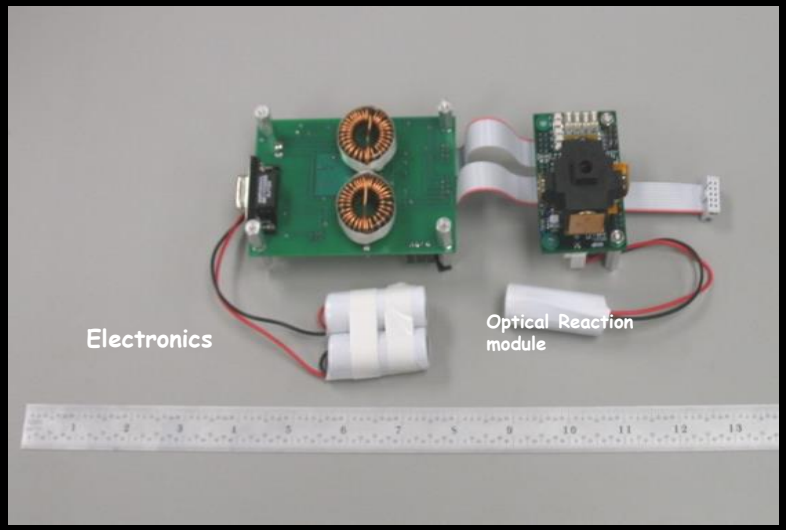


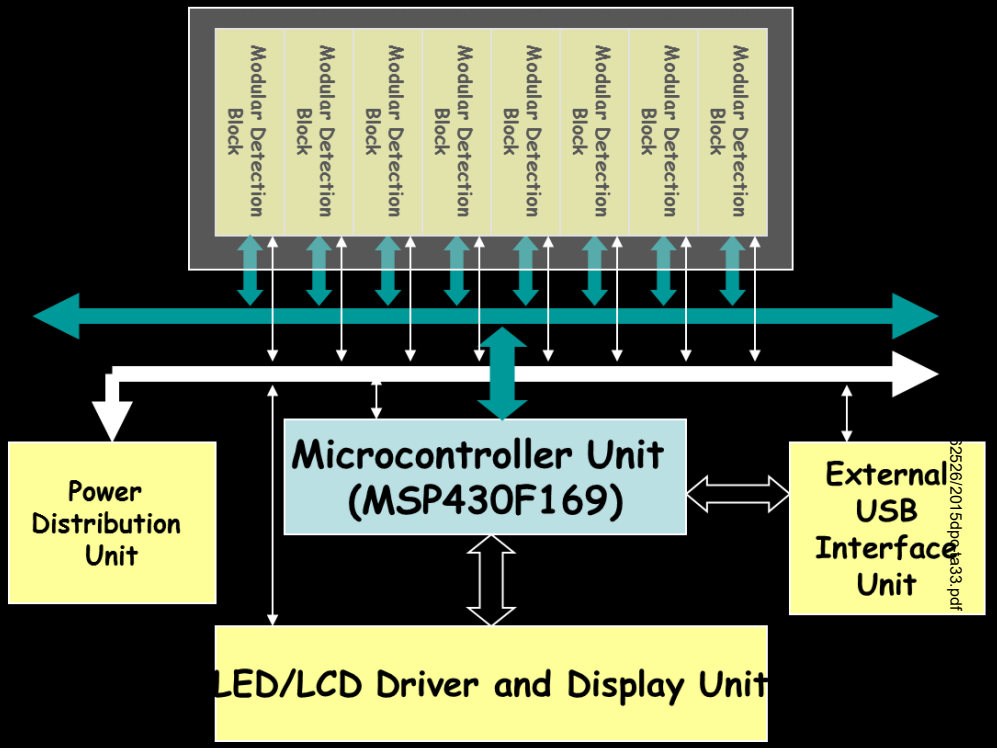
Comparative results

2.5 D Application Multi-Channel Handhelds Microbial Detector

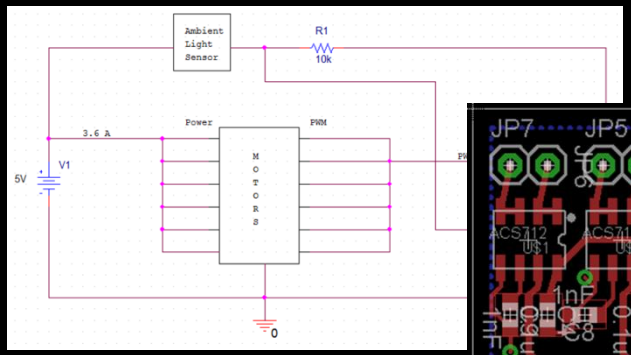
3rd Generation Analyzer Internal View

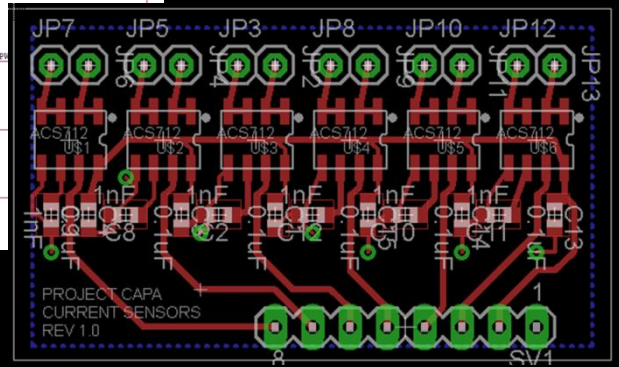
Modules allow simultaneous multi-sample analysis





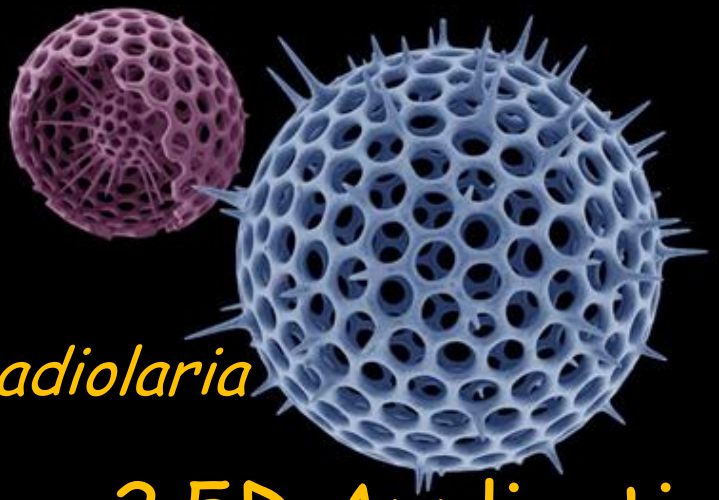
2.5D Application – Thought Controlled Prosthetic System



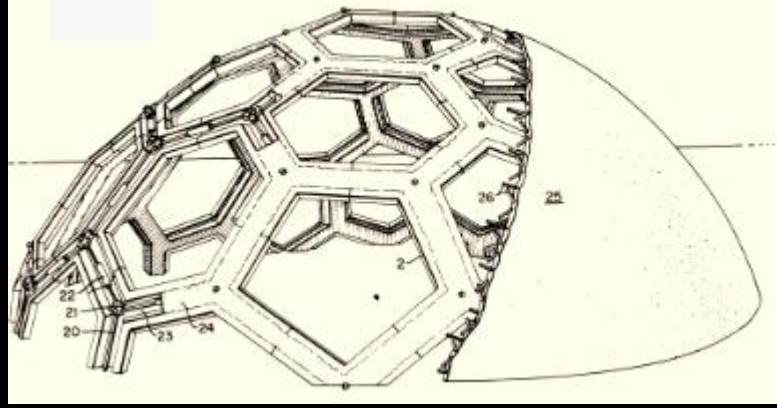


Separate 3DP and Embedded Rigid PCB controllers/sensors/actuators

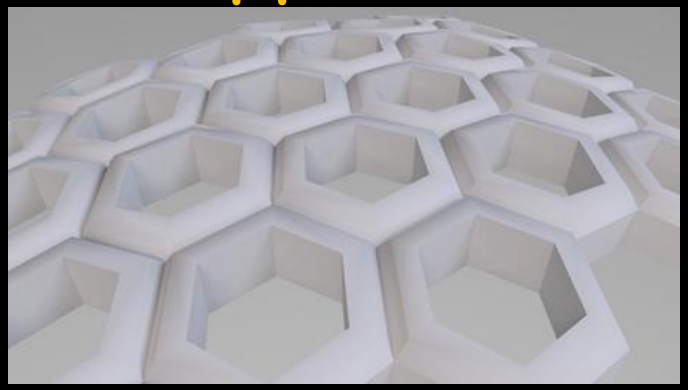
Arduino system- Rigid system, limited packaging options



Radiolaria

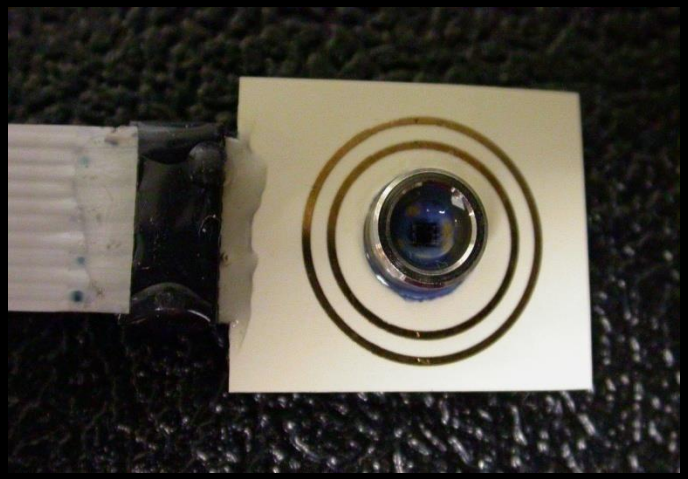


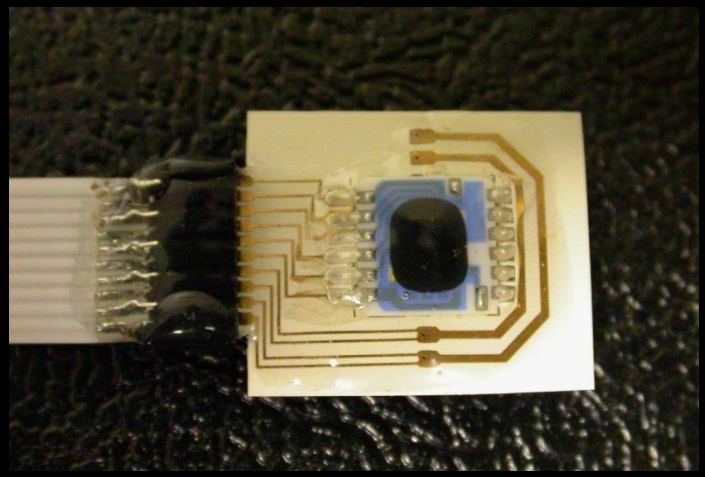
2.5D Application -Array Sensor Systems



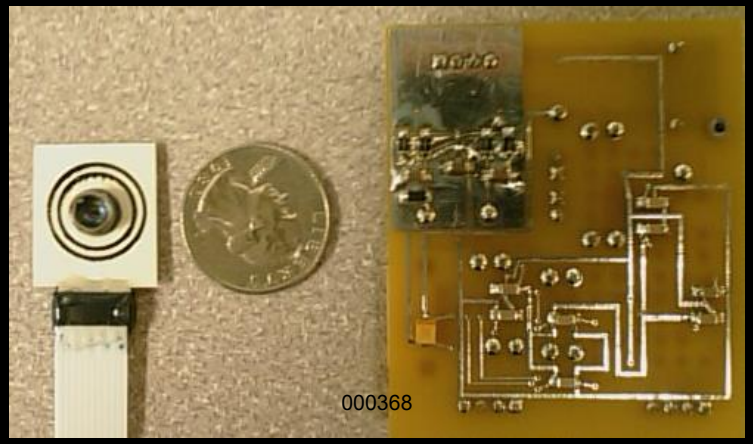
- *Ocean organisms that utilize a similar additive construction process to 3D printing.*
- *Their cell bodies secrete a substance mainly composed of silica to form intricate exoskeletons used as a system of protection.*
- *Correlation can be made between the radiolaria's construction process and the plastic extrusion system of the 3D fused deposition model printer*

Mini C,T,P- "Salinity"



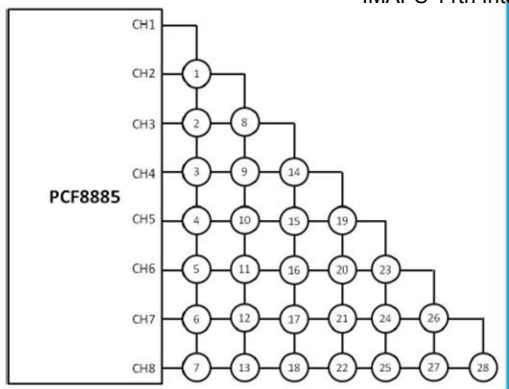


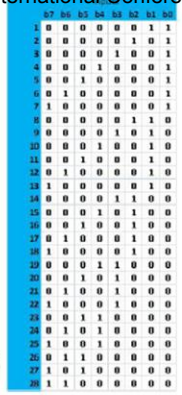
The reduced package size biotag CTD sensor system showing the temperature and pressure chip protruding through a chemically milled via hole along with concentric conductivity rings (front side image-left) and the backside image (right) with chip on flex LCP.



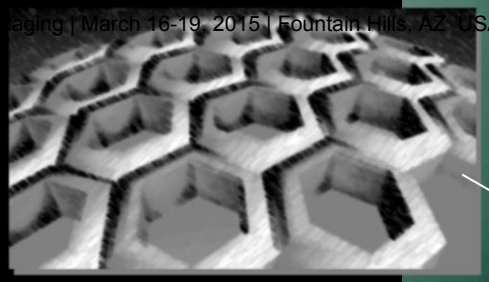
Array Salinity Camera System

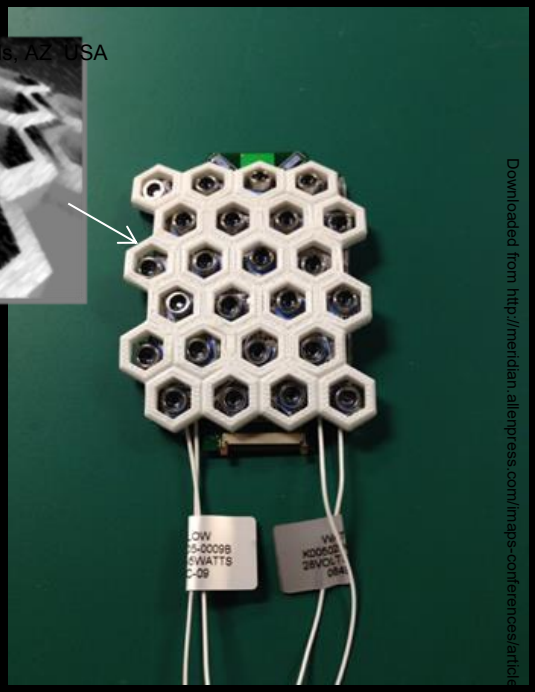
PCF8885: Single Device with up to 28-Sensors

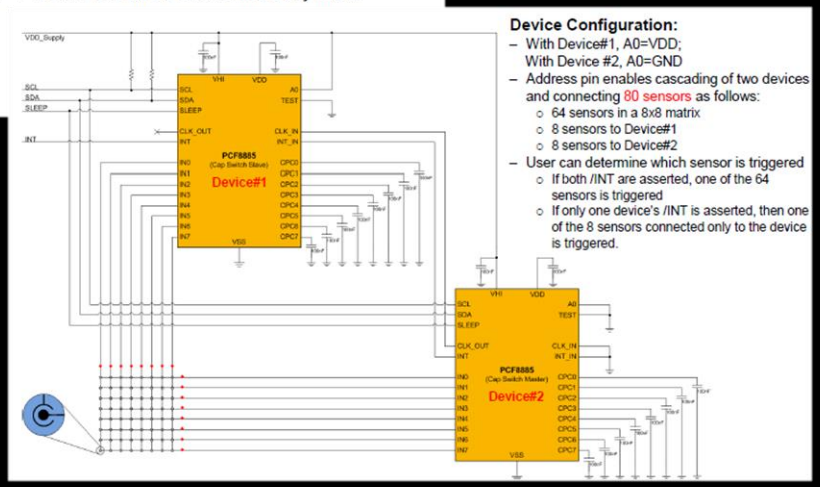




- Sensors 1 to 28 are each connected to two channels
  - Sensor 1 is connected to CH1 & CH2
  - Sensor 2 is connected to CH1 & CH3
  - Sensor 8 is connected to CH2 & CH3
- Total of 28 Sensors
- Device should be used in the 2-key mode

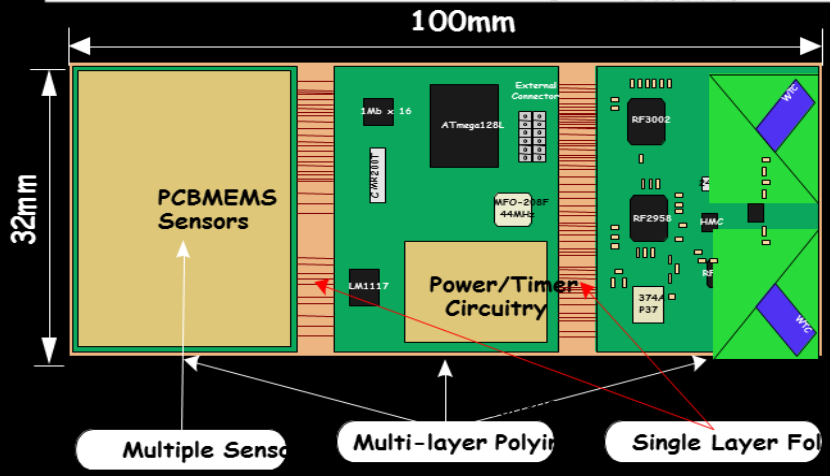


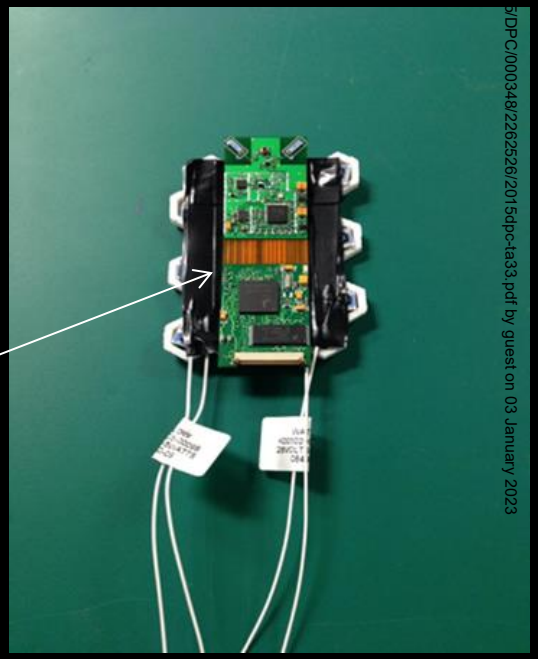




Device Configuration:

- With Device#1, A0=VDD;
  With Device #2, A0=GND
- Address pin enables cascading of two devices and connecting 80 sensors as follows:
  - 64 sensors in a 8x8 matrix
  - 8 sensors to Device#1
  - 8 sensors to Device#2
- User can determine which sensor is triggered
  - If both /INT are asserted, one of the 64 sensors is triggered
  - If only one device's /INT is asserted, then one of the 8 sensors connected only to the device is triggered.





pH and list of other candidates

- Bare die ISFET (ion-sensitive field effect transistor)
- Chip on board assembled on standard package
- The die require external AgCl reference on PCB
- The silicon chip has embedded temperature sensor for external compensation.

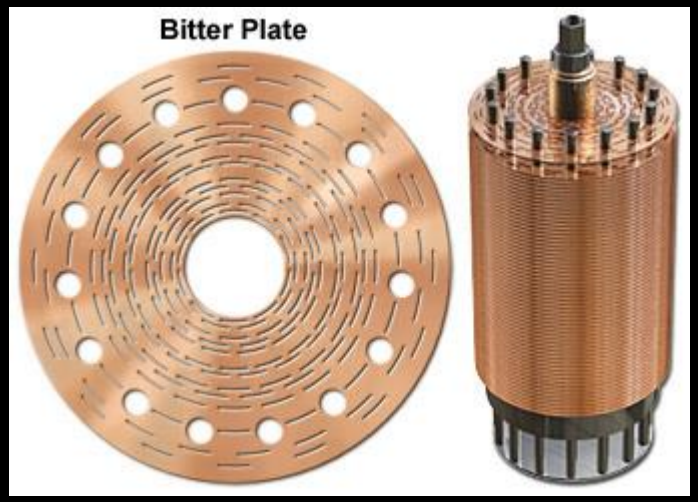
Electrochemical
Samplers
Separation Membranes
Back Scatter Fluorimetry
Ion Traps

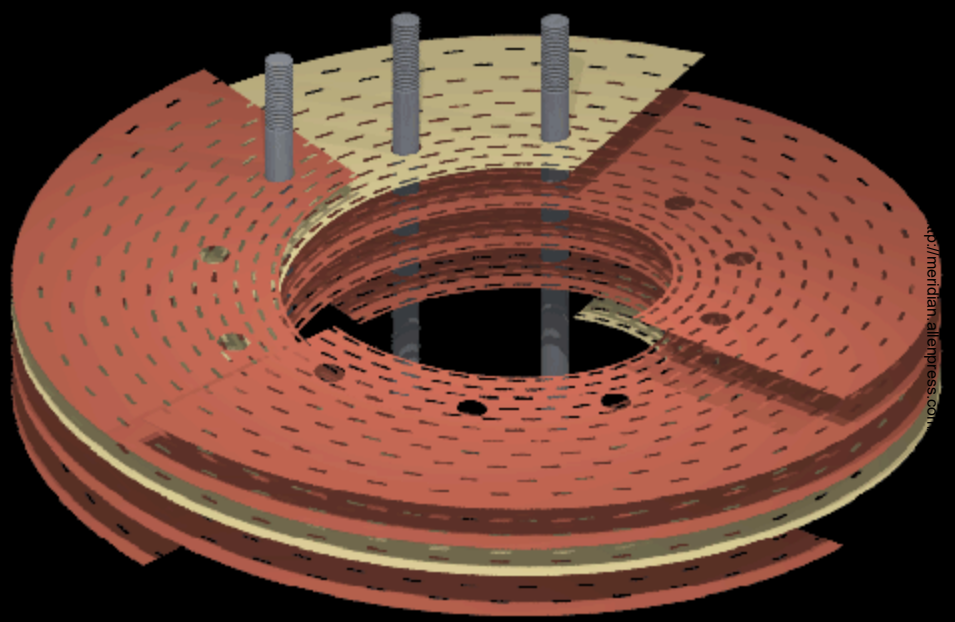
3D Imagers

3D Printing: Monolithic Material

Raymond Rumpf: Spatially variant dielectric grid for electromagnetic fields. Material is UTEM™

Ryan Wicker: Metallic foam for heat exchangers, chemical filters or impact absorbing material. Material is titanium.

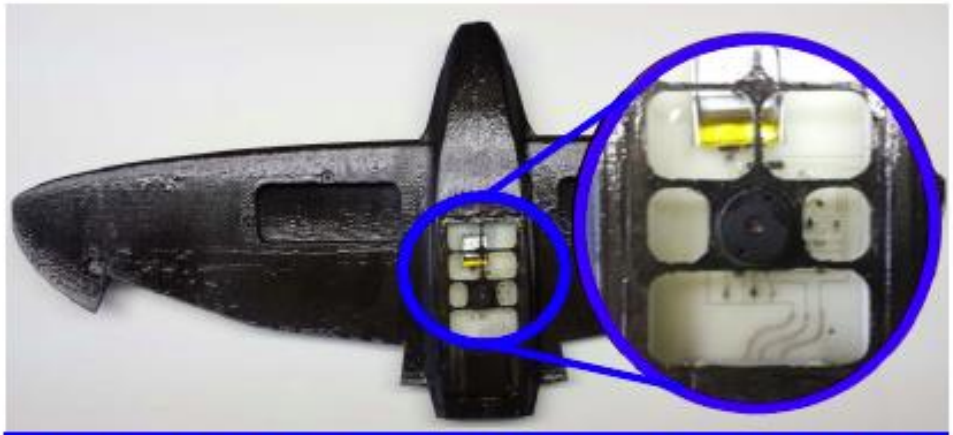




Microsystems by Stacking and Spacing

- Direct Printing has the advantage of conformal electronics on diverse surfaces.
- 3D Printing has the advantage of unique true 3D shapes.
- Both have the advantage of Digital to Fabricate.
- The combination produces advanced Electrically Functional Structures

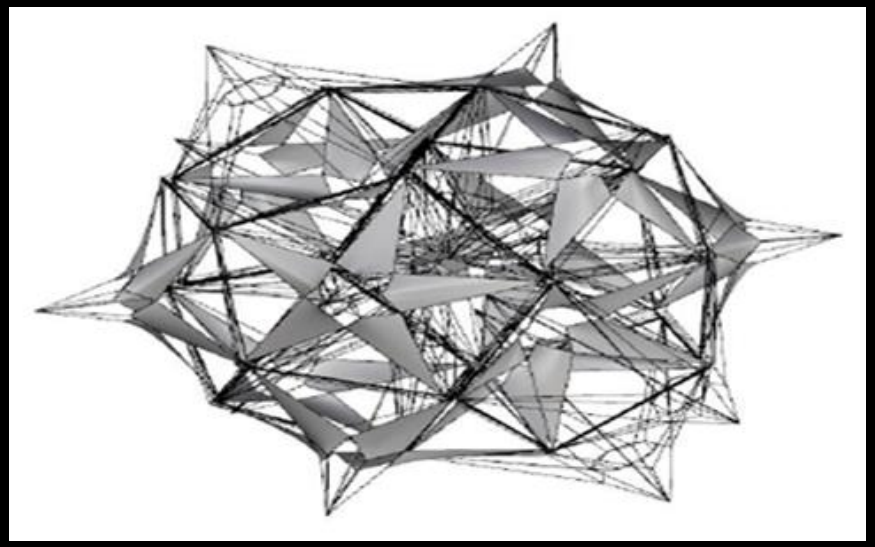
Direct printed timing circuitry on 3D printed top.



Direct printed camera circuitry on 3D printed UAV.

nScrypt 3Dn Series Multi-Pump tool has options for Direct Printing (SmartPump™) and 3D Printing (nFD Pump™). This can also print composite materials. New materials need to be developed and optimized, but this has been shown to be feasible.

Architectures: 3D Networks and Space Frames



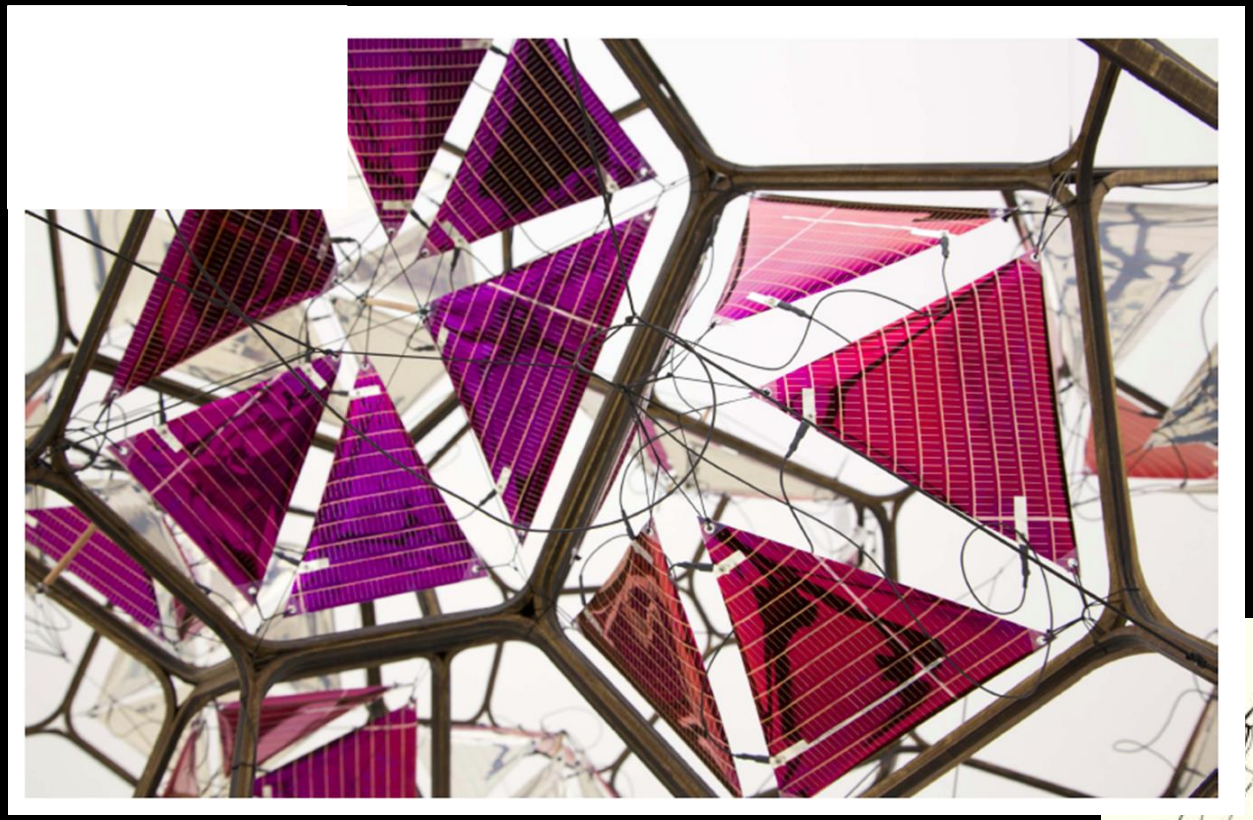
Architectural objects for showing distribution of solid planes and supporting struts and string tension members.

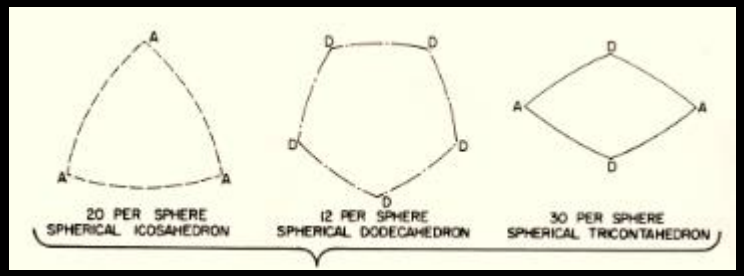
Upper: is a distributed design type

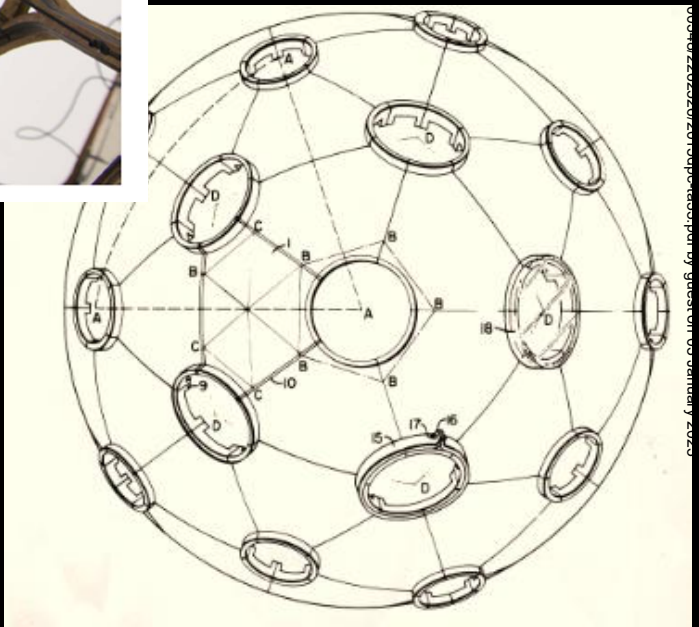
Lower: is initial geometrical prototype.

These objects are an example of materials, structures and architectures for 3D imagers.

Architectures: 3D Networks and Space Frames







3D distributed array element prototype image. Flexible film of photovoltaics elements are stretched in tension between structural posts using tension strings

photovoltaic film is made using a roll-roll thin film vapor deposition process

tension members can be either solid fabric fibers or can be flexible fabric signal/power cables

Thanks!

Tomas Saraceno
Ken Church
Ross Willoughby