Flexible and Integrated Electronic Systems

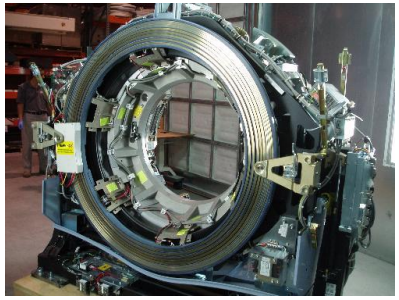
Nancy Stoffel
GE Global Research

GE Products, Systems, Technology

PRODUCTS

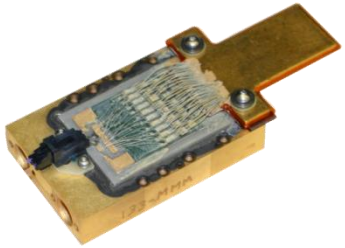
CTQs: SWaP, $$, etc.

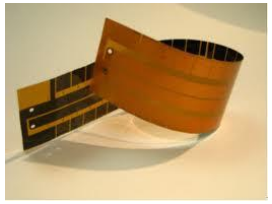
SYSTEMS & COMPONENTS

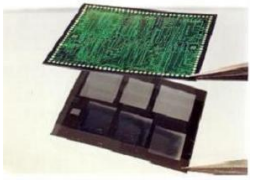


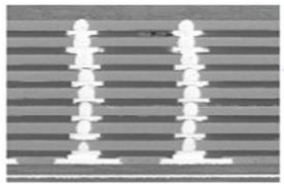
CTQs: Efficiency, Torque, etc.

PACKAGING TECHNOLOGY









CTQs: Size, Heat Flux Density, etc.

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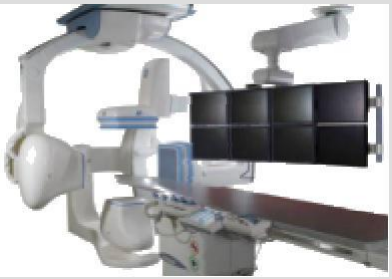
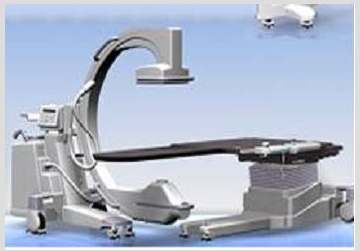
Digital X-ray at GE

Diagnostic X-ray

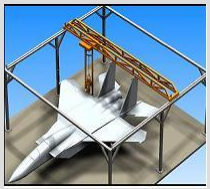


Interventional/Surgical X-ray

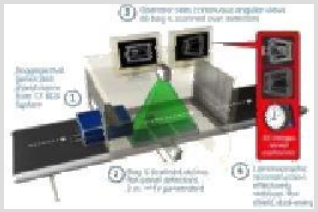



Breakthrough Detector performance, capacity, & cost






Inspection Technologies



Security

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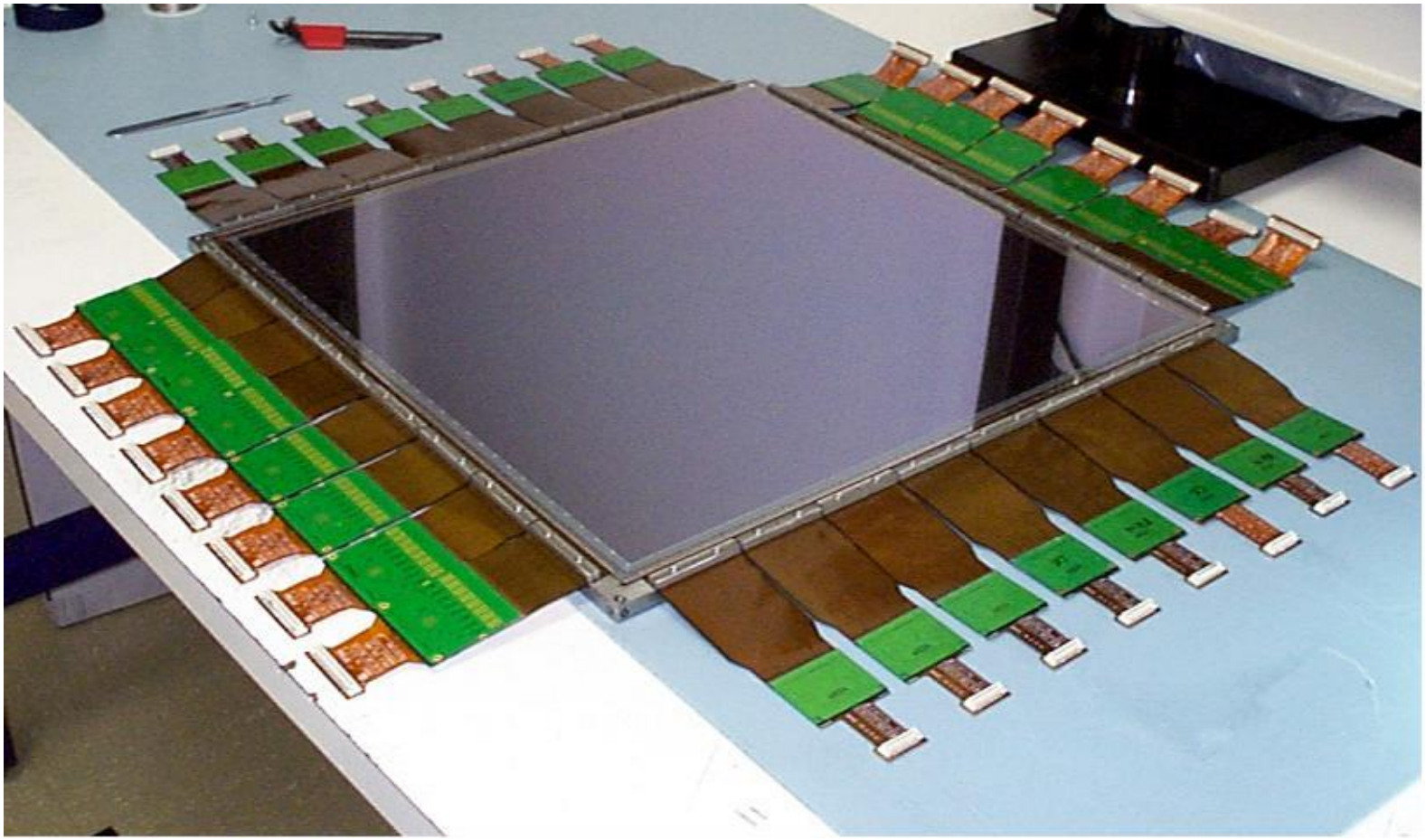
Connecting the Panel …

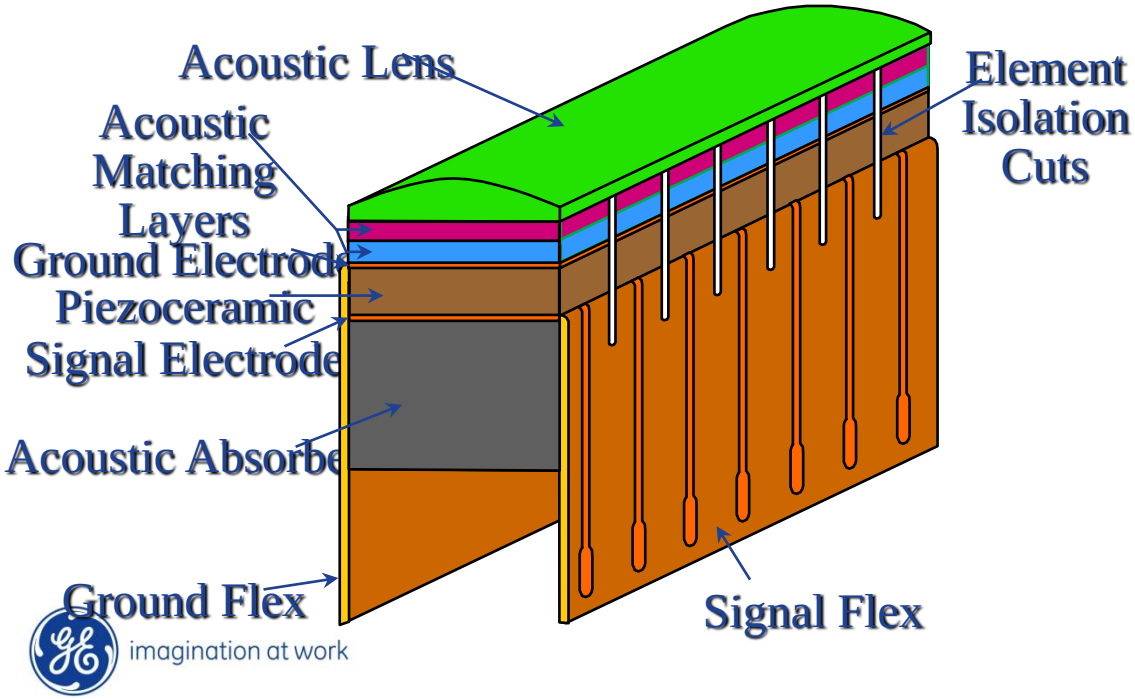


4 Million Pixels “only” Require 4000-8000 Connections

Hand-Held Ultrasound

- Mass adoption through miniaturization and targeted clinical solutions
- Enables near-continuous monitoring
- From thousands to millions of users

Transducer Structure



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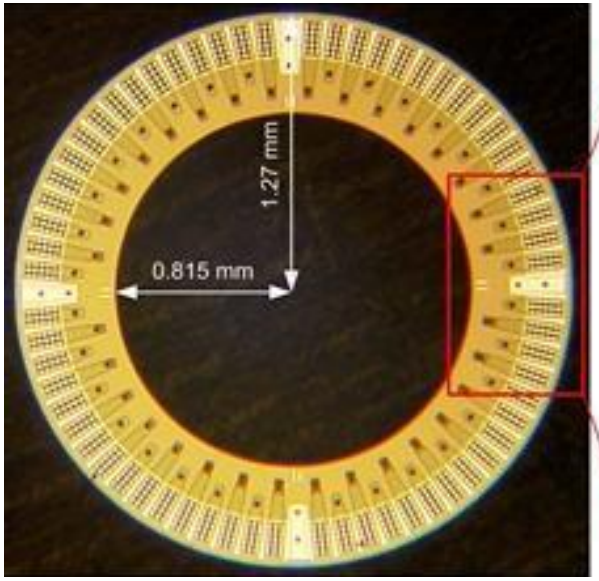
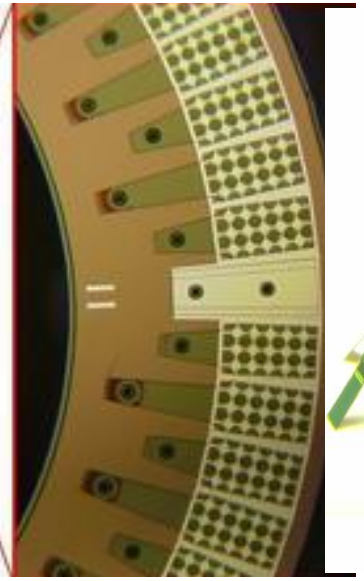
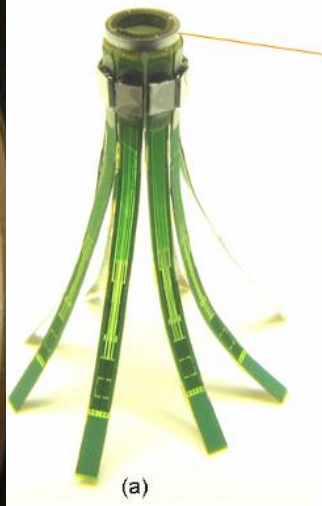
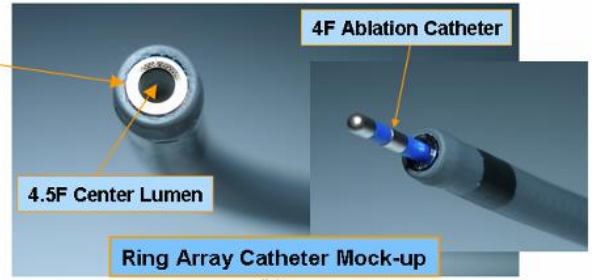
U/S Ring Arrays in Catheters

A. Nikoozadeh, et al, "Forward-Looking Volumetric Intracardiac Imaging Using a Fully Integrated CMUT Ring Array," in *Proc. IEEE Ultrasonics Symp.*, 2009, pp. 511-514.

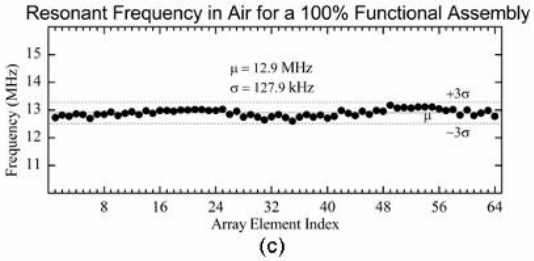






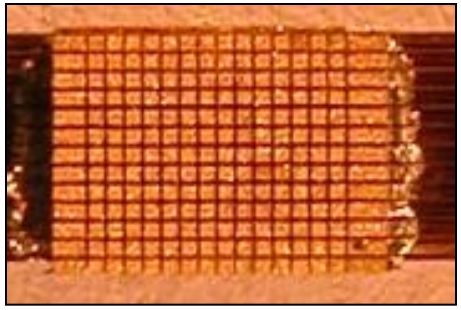


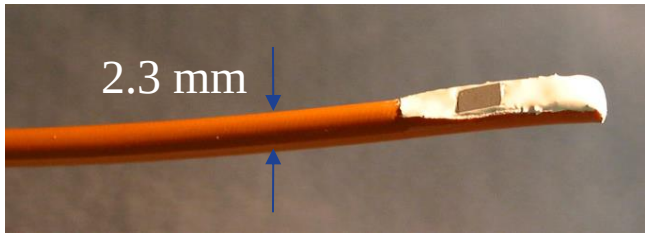
(b)



(c)

2-D Arrays in Catheters



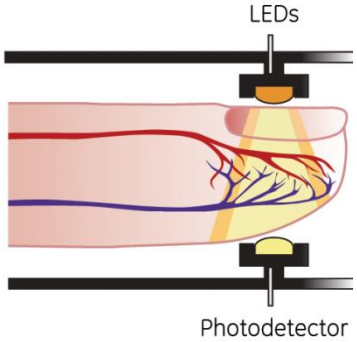


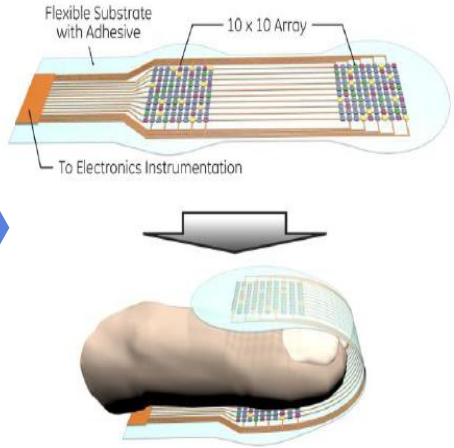
Side-Viewing 2D Array
7 Fr, 5 MHz, 112 Elements
(W. Lee, Duke University,
IEEE Trans UFFC, 2004)

6-layer flex circuit, 1.9 mm wide
(MicroConnex & Duke: S.W. Smith, IEEE Ultrasonics Symposium, 2002

Flexible Electronics: Patient Monitoring

Current : Emitter/Sensor Clip





Future: Wear-able Patient Monitor

nbmc
Nano-Bio Manufacturing Consortium

Applications

General Care/Assisted Living

ICU

Home

DOD/AFRL

Telemetry

imagination at work

ARPA-E AMPED Program

Advanced Management and Protection of Energy Storage Devices (AMPED)

Innovation: *"... comprehensive solutions that combine data from novel sensors with advanced models, system designs, and controls [that] can drastically enhance the utilization and rate capabilities of battery systems within safe limits while extending their lifetimes."*

SotA Pack Measurements:

- Voltage
- Current
- Temperature (select cells)

Enhancement over State of the Art:

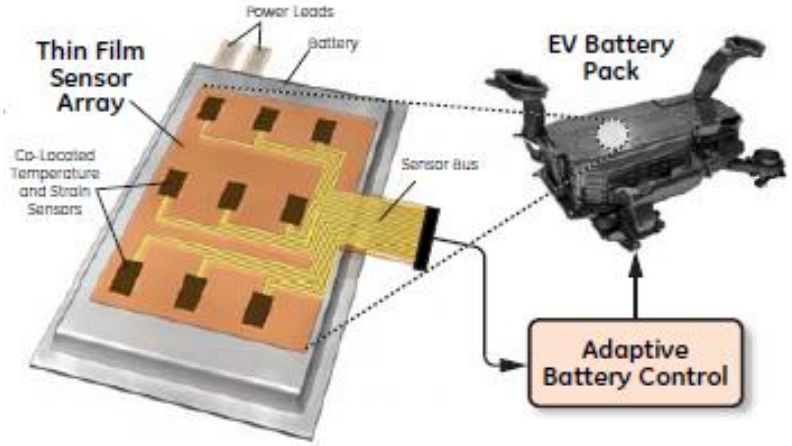
- In-situ cell expansion/strain
- Arrayed surface temperature measurements

Novel Approach:

- Thin film sensor packaging for integration between cells
- Combine new observability with multi-physics models & parameterization for cell SoH

System Benefits:

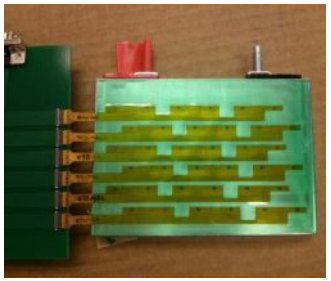
- Detailed view of individual cell/pack health
- Improved cell utilization



imagination at work

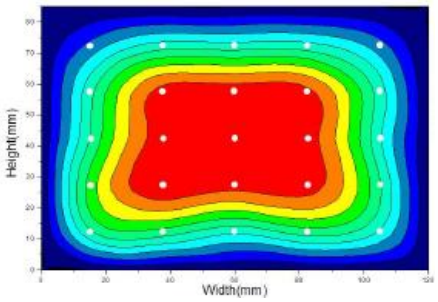
Program Layout

Sensor Development



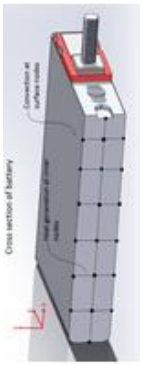
Ultra-thin Temp & Expansion sensor development

Cell Characterization



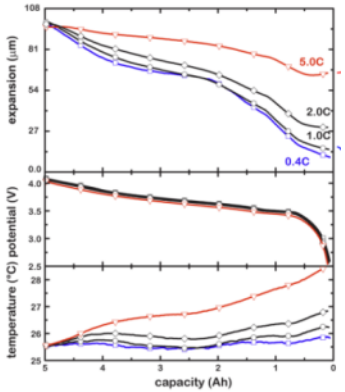
Low & high C-rate testing
Temp distribution
Surface deformation

Multi-Physics Models



Thermal
Electrochemical
Mechanical

Model Order Reduction



Observability integration
Controls Development

Integration & Validation

Estimation / Limits
- State of Power
- State of Charge
- State of Health

Multi-parameter in-situ cell monitoring to increase operating window and improve SOH

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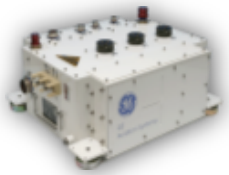
SiC for Power Electronics Enables New Product Capabilities

GE SiC MOSFET

1/2	Space & weight, or
2x	Power Density
2x	Reliability
50°C	Higher temperature capability

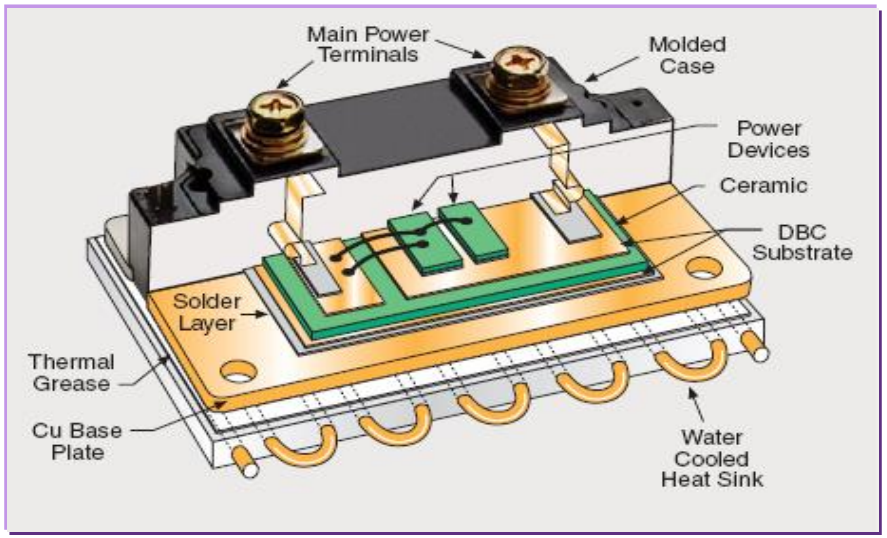


Generation

Conversion

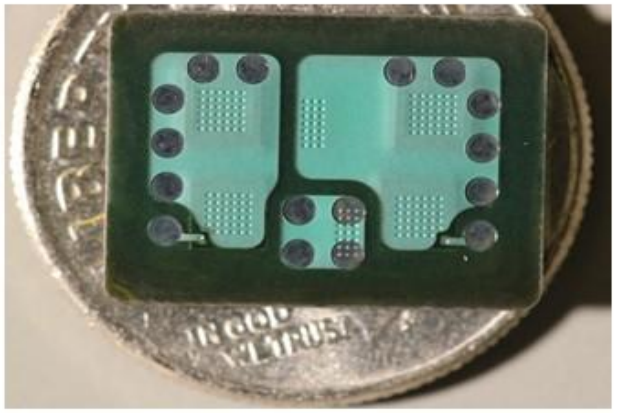
Distribution

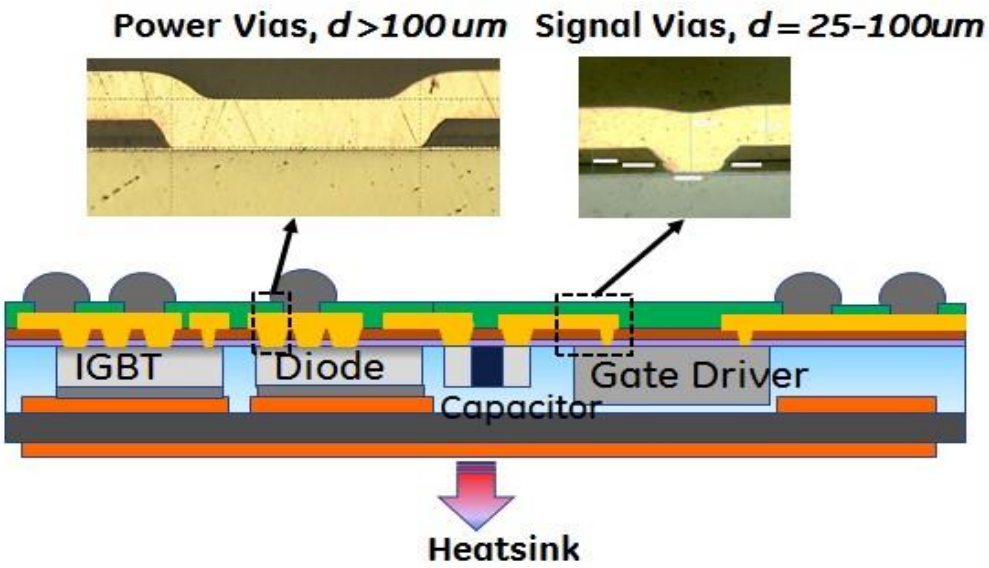
Limitations of Standard Power Module



- Electrical limitations
  - Current sharing
  - Package inductance too high
  - Wirebond current handling
- Thermal limitations
  - Baseplate-to-heatsink thermal resistance
  - Low power density (including heatsink)
- SiC module power limitations
  - Yield and cost challenges associated with wirebonding many small SiC devices

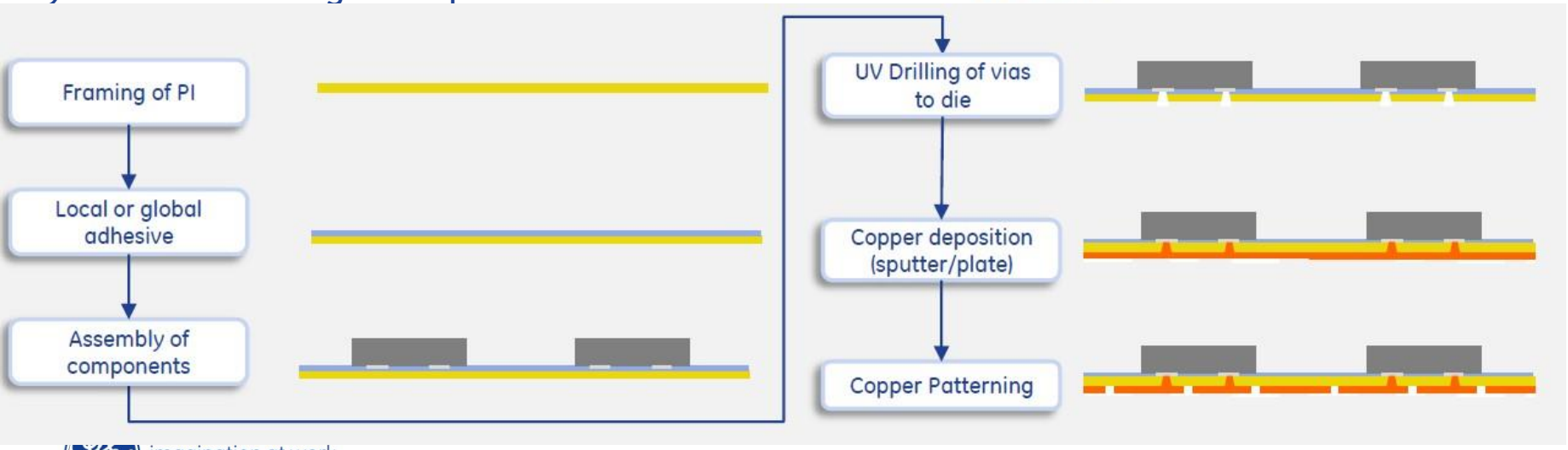
Power Overlay (POL) Platform: Realizing the full benefit of SiC power electronics





Direct copper interconnect

Polyimide based integration platform



Embedded Technologies: GE Applications

GE Aviation and Critical Power divisions driving active component embedding adoption for high mix / low volume applications

GE is developing a cost effective HVM capable supply chain for embedded active components with its partners

Miniaturization with improved electrical and thermal performance as well as reliability are primary drivers for component embedding adoption within GE

Embedded Technologies Within GE

GE was one of the earliest adopters of embedded technology in the early 90s with GE's internally developed "Chips First" technology

Imbera Electronics Oy was acquired in 2013 to strengthen GEs position in IP, manufacturing know-how, product designs and value chain development

Through both internally developed technologies and the Imbera Electronics acquisition, GE holds extensive IP pool and technology know-how on several solutions for component embedding

The GE POL (Power Overlay) technology is in NTI by GE business divisions and HVM supply chain is being developed in 2014/15 through a licensing program

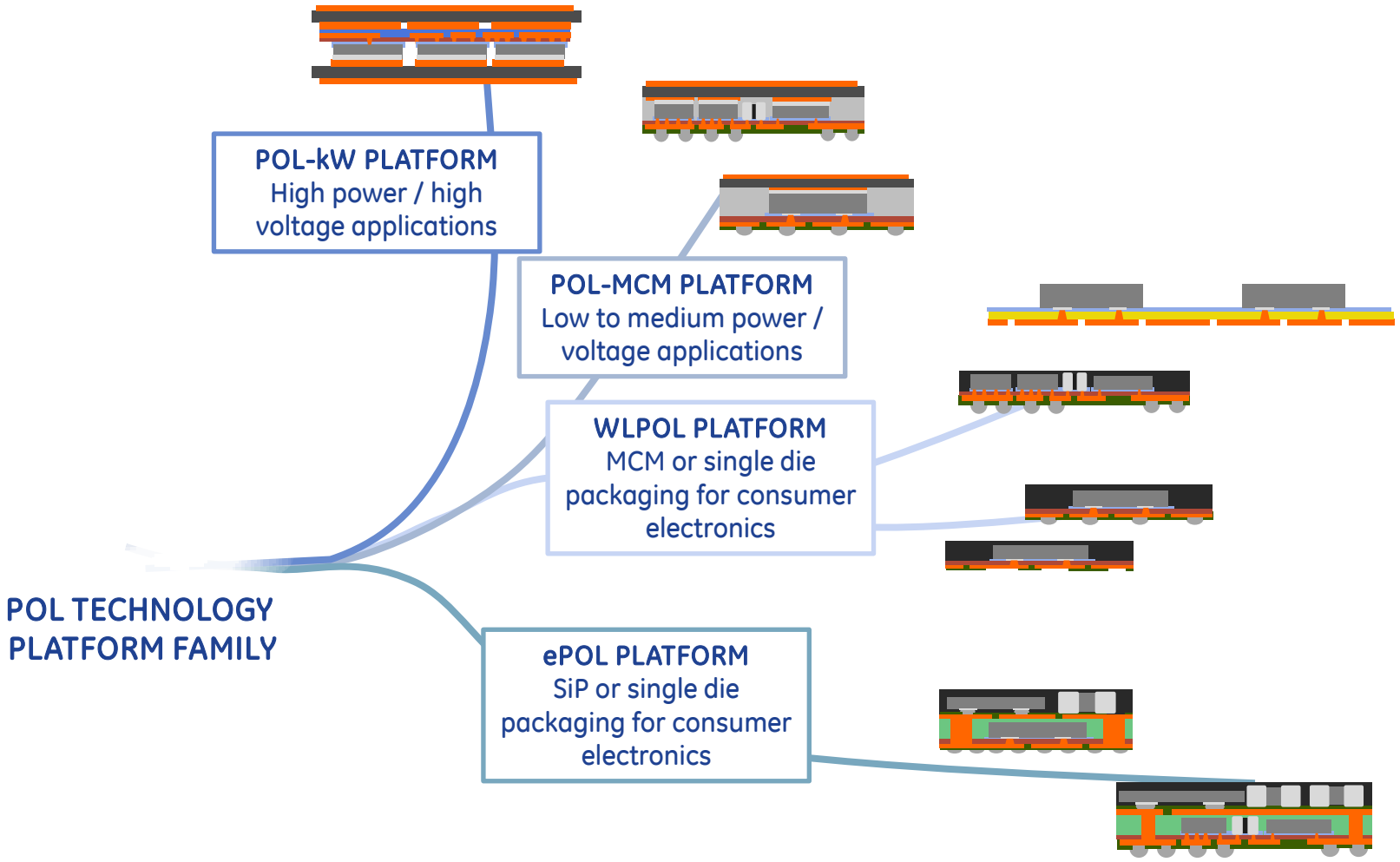
POL technology	IMB technology
- Qualified by GE business units - ~200 US & foreign patents - Supply chain development ongoing	- Technology used by GE partners - Over 100 US & foreign patents - Supply chain expansion ongoing

There are already Multiple Licensees to the GE IP & Technology – a recognition of the foundational position of GE's IP

imagination at work

POL Platform Family

- Advanced packaging technology ideal for consumer electronics as well as high power and RF apps



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POL Technology Attributes

Good scalability to HVM	Novel large area PI based routing technology provides stable foundation for component assembly and routing with minor dimensional instability.
Improved die design	Small POL microvia together with high component-to-microvia alignment enables reduction in die I/O area and pitch.
Semiconductor grade interconnection layer	High quality PI and adhesive layer with no fillers enables excellent process control with perfect V-shape POL microvia via and high production yield.
Excellent reliability	Highly controlled materials with low impurity levels enables reductions in material layer thicknesses without sacrificing product reliability.
Short lead time / competitive cost level	Direct Al, Au or Cu land contact enables shorter lead time as well as lower manufacturing cost level.

Summary
Flex and organic electronics diverse uses within GE

Growth driven by need for miniaturization, flexible form factor, performance gains

New technology projects are often collaborative involving partners in development and in move to HVM