Flexible and Integrated Electronic Systems
GE Products, Systems, Technology

PRODUCTS

CTQs: SWaP, $\$, etc.

SYSTEMS & COMPONENTS

CTQs: Efficiency, Torque, etc.

PACKAGING TECHNOLOGY

CTQs: Size, Heat Flux Density, etc.
Digital X-ray at GE

Diagnostic X-ray

Interventional/Surgical X-ray

Breakthrough Detector performance, capacity, & cost

Inspection Technologies

Security
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

- Acoustic Lens
- Acoustic Matching Layers
- Ground Electrode
- Piezoceramic
- Signal Electrode
- Acoustic Absorber
- Ground Flex
- Signal Flex
- Element Isolation Cuts
U/S Ring Arrays in Catheters


2-D Arrays in Catheters

Side-Viewing 2D Array
7 Fr, 5 MHz, 112 Elements

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: Wearable Patient Monitor

Applications

General Care/Assisted Living

ICU

Home

DOD/AFRL

Telemetry
**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
Program Layout

Sensor Development

Cell Characterization

Multi-Physics Models

Model Order Reduction

Integration & Validation

Ultra-thin Temp & Expansion sensor development

Low & high C-rate testing

Temp distribution

Surface deformation

Thermal

Electrochemical

Mechanical

Observability integration

Controls Development

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

imagination at work
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 GE’s 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.

<table>
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<tr>
<th>POL technology</th>
<th>IMB technology</th>
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<tr>
<td>- Qualified by GE business units</td>
<td>- Technology used by GE partners</td>
</tr>
<tr>
<td>- ~200 US &amp; foreign patents</td>
<td>- Over 100 US &amp; foreign patents</td>
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<tr>
<td>- Supply chain development ongoing</td>
<td>- Supply chain expansion ongoing</td>
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There are already Multiple Licensees to the GE IP & Technology – a recognition of the foundational position of GE’s IP.
POL Platform Family

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

POL-kW PLATFORM
High power / high voltage applications

POL-MCM PLATFORM
Low to medium power / voltage applications

WLPOL PLATFORM
MCM or single die packaging for consumer electronics

ePOL PLATFORM
SiP or single die packaging for consumer electronics
## POL Technology Attributes

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