Project Introduction

Indiana Integrated Circuits, LLC (IIC) proposes to develop the customizable, high-performance microchip interconnect technology called Quilt Packaging (QP) to address NASA's requirement for high performance integration of heterogeneous microwave systems. QP is an affordable, scalable, patented edge-interconnect technology for joining microchips of disparate materials and/or process technologies into monolithic-like systems that perform electrically as if they were one chip. QP enables sub-micron chip-to-chip alignment, extremely small (< 10 micron) chip-to-chip gaps, and can be implemented in multiple substrate materials, including SiGe, GaAs, Si, InP, GaSb, SiC, GaN, and more. Quilt Packaging can enable extremely low-loss, wide-bandwidth integration of MMIC modules comprising disparate material systems and/or process technologies. QP has demonstrated less than 0.1 dB insertion loss up to 100 GHz, and under 1 dB out to 220 GHz. Initial reliability testing of QP chipsets have demonstrated no degradation or mechanical issues, having undergone thermal cycling from -40 C to 125 C for over 350 cycles and counting. In addition to excellent microwave performance, QP has the potential for decreasing system size, weight and power. The proposed effort will leverage previous work in GaAs and Si QP to demonstrate a heterogeneously integrated "quilted" chipset of SiGe, GaAs and/or InP chips. Resulting data from this Phase I will directly apply to the design, fabrication and demonstration of a functioning MMIC module in Phase II. Throughout Phase I consideration will be given to NASA system needs and transition to production-level Quilt Package chip fabrication with commercialization partners Research Triangle Institute and Northrop Grumman Corp. for manufacturing scale-up of Quilt Packaging enabled MMIC modules.

Anticipated Benefits

Quilt Packaging (QP) technology advances microwave chip packaging beyond the current state-of-the-art by enabling extremely wide-bandwidth, low-loss heterogeneous integration of disparate material and/or process technologies. Implementation of QP can increase system performance while decreasing cost, size, weight and power of MMIC modules. Quilt Packaging has demonstrated chip-to-chip less than 0.1 dB of insertion loss up 100 GHz, and under 1 dB up to 220 GHz. This extremely high level of performance reduces or eliminates the need for complex ceramic substrates, additional passive devices for tuning, and eliminates tradeoffs between choosing on substrate or another due to packaging limitations. With fewer and lower losses in the MMIC chain, the overall power budget of the system can be reduced while still maintaining an acceptable signal-to-noise ration. These benefits directly address the needs of microwave and remote sensing systems for present and future NASA science missions. Given the "across-the-board" improvements Quilt Packaging brings to microwave and remote sensing systems, this enabling technology is anticipated to enhance the capabilities of a wide spectrum of future NASA programs.
High frequency systems are increasingly important for both aerospace and commercial applications. Similar to NASA's remote sensing and space-based needs, the aerospace and defense industry is utilizing higher frequencies and requires heterogeneous integration for maximum performance on radar, EW, communications and other systems. In the commercial market, cellular backhaul using point-to-point microwave is a growing market. In addition to cellular backhaul, baseband processing, mobile communications and remote sensing are also growing markets for which Quilt Packaging integration of MMIC modules is well-suited.

**Primary U.S. Work Locations and Key Partners**

<table>
<thead>
<tr>
<th>Organizations Performing Work</th>
<th>Role</th>
<th>Type</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>🌟 Goddard Space Flight Center (GSFC)</td>
<td>Lead Organization</td>
<td>NASA Center</td>
<td>Greenbelt, MD</td>
</tr>
<tr>
<td>Indiana Integrated Circuits</td>
<td>Supporting Organization</td>
<td>Industry</td>
<td>South Bend, IN</td>
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</tbody>
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Organizational Responsibility

**Responsible Mission Directorate:**
Space Technology Mission Directorate (STMD)

**Lead Center / Facility:**
Goddard Space Flight Center (GSFC)

**Responsible Program:**
SBIR/STTR

**Project Management**

**Program Director:**
Jennifer L Gustetic

**Program Manager:**
Carlos Torrez

**Project Manager:**
Matthew L Walker McInden

**Principal Investigator:**
Jason Kulick

For more information and an accessible alternative, please visit: https://techport.nasa.gov/view/17889
Closeout Documentation

Final Summary Chart
(https://techport.nasa.gov/file/15385)

Images

Briefing Chart Image
Heterogeneous Chip Integration for
GHz Systems, Phase I Briefing
Chart Image
(https://techport.nasa.gov/image/30060)

Technology Maturity
(TRL)

- Start: 3
- Current: 3
- Estimated End: 3

Technology Areas

Primary:
- TX11 Software, Modeling,
  Simulation, and Information
  Processing
  - TX11.6 Ground Computing
    - TX11.6.8 Cloud Computing