On-Shoring the Next Generation of Advanced Packaging

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SkyWater Technology
Kissimmee, FL 3473
We are the only **U.S.-owned** pure-play foundry.

Extending a legacy of manufacturing excellence to meet the industry’s needs in a **post-Moore’s Law reality**

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
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<tbody>
<tr>
<td>2005</td>
<td>65 nm qualified</td>
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<tr>
<td>2008</td>
<td>Cypress 65 nm qualified technology foundry opens to non-Cypress customers</td>
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<tr>
<td>2017</td>
<td>SkyWater 65 nm qualified technology foundry opens to non-Cypress customers</td>
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<tr>
<td>2017</td>
<td>SkyWater received DMEA Cat 1A Trusted Accreditation</td>
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<tr>
<td>2018</td>
<td>SkyWater and MIT selected for DARPA 3DSoC program</td>
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<tr>
<td>2019</td>
<td>$170 M rad-hard technology and building expansion announced</td>
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<tr>
<td>2020</td>
<td>3-year anniversary of SkyWater completion of Cypress ToP contract</td>
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<tr>
<td>2021</td>
<td>Florida Advanced Packaging Facility integrated into operation</td>
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<tr>
<td>2021</td>
<td>$112M IPO closed April, 2021</td>
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</tbody>
</table>
SkyWater Minnesota
Bloomington, MN

OPERATION
200 mm equipment
91,000 ft² Cleanroom
Class 10 + SMIF
10,000 30 ML CMOS wafers or 50,000 MOSFET wafers per month
90 nm+ feature geometries

CERTIFIED
ISO9001 / IATF16949 Automotive Certified
ISO13485 Medical Certified
ISO14001 Environmental Certified
DMEA Cat 1A Trusted
ITAR and Secure Processing Supported

SkyWater Florida
Kissimmee, FL

OPERATION
200 mm equipment
Size: 109,000 ft² total
26,000 ft² of class 1000
9,400 ft² of class 10,000

Notes
Site added to operation Feb 2021
DMEA Cat 1A Trusted – pending, planned 2H 2022
Facility will enable custom advanced packaging solutions
We streamline the concept to production journey.

WHO WE ARE

Technology as a Service℠ (TaaS℠)

Innovation as a Service

Manufacturing as a Service

Advanced Technology Services (ATS) enable co-creation of differentiated solutions which are the unique expression of the combined customer/SkyWater multi-disciplinary technology teams.

Wafer Services supply customers with ICs and microdevices for commercial or mission ready products.
Model Enables Early Foundry Engagement

Technology as a Service (TaaS)

Advanced Technology Services (ATS) vs. Wafer Services

- Technology as a Service (TaaS)
  - Advanced Technology Services (ATS)
    - Concept & Feasibility
    - Technology Demonstration
    - Process Development
  - Custom Process Flows
  - Co-Creation
  - Optimization for Manufacturing

- Wafer Services
  - Product Design
  - Product Qualification
  - Volume Manufacturing
  - Product Design Kits
  - IP Library & Ecosystem

- Technology / Manufacturing Readiness Level
  - Low
  - High

- Efficient R&D
- Accelerated Time-to-Market
- Volume Manufacturing

Mixed-Signal, Superconducting, 3DSoC, 3D, MEMS, Power Discrete, Advanced Packaging, Photonics, Rad-Hard
<table>
<thead>
<tr>
<th>Platform</th>
<th>Aerospace &amp; Defense</th>
<th>Advanced Computing</th>
<th>Automotive &amp; Transportation</th>
<th>Bio-Health</th>
<th>Consumer</th>
<th>Industrial / IoT</th>
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<td>MEMS</td>
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SkyWater Florida
AP Facilities & Operations

**Fab Building:** 109,000 ft² total
- 26K ft² of class 1000 – 11.8K ft² available to grow
- 9.4K ft² of class 10,000 – 4.3K ft² available to grow

**Electricity:** Two power feeds to site
- ~22MW-h/day – utility able to support growth
- Uninterruptable Power Supply (UPS):
  - Safety (100%) & Tools (~60%)

**Tools (69) / Capacity:**
- 61 tools – 42 in use, 19 in installation/start up
- 8 tools with no current plans
- Capacity model in development

**Systems / MES:**
- Integrated MES system with SWMN
- Lot movement / controls

**Certifications:**
- ISO9001 audit ready: December 2021
- Trusted Foundry certification in process

**Workforce:**
- Growing to 220 jobs at full utilization of fab space
- Transition to 24X7 work environment as ramp continues

**The OC Office building**
- 21,000 ft² office area (SW 4th floor)
United States Government and commercial customers work with SkyWater in two ways: directly, or indirectly via non-profit Bridg.

1. **SkyWater:**
   - Supports direct customer engagement for technology development and production services
   - Is the exclusive operator of the Kissimmee, Florida Fab (Center for Neovation) and manages all aspects of facility and wafer processing operations.

2. **Bridg:**
   - Supports customers and programs requiring a non-profit interface for services
   - Supplies project management services for existing USG programs and pursues other complementary technology programs
   - Is commissioned to secure support and funding for a U.S. NMI for advanced packaging

The Center for Neovation
Owned by Osceola County, Florida
Capabilities for Advanced Integrations

- Silicon Interposers w/TSV
- Hybrid Bonding
- Fan-In/Fan-Out
- Solder Bumping & Assembly

SkyWater MN

Design Services
Front-End Fabrication Services
Advanced Packaging
Assembly & Test
Si Interposer Development
Heterogeneous Integration & Advanced Packaging

Establishes silicon interposer capability for the industrial base

*BRIDG Industrial Base Analysis and Sustainment (IBAS) Program

**Roadmap**

- **Phase 1**: Silicon Bridge Interposer
  - Cu metal layers
  - 0.5 to 2.0um thick Cu/oxide
  - Linewidths from 0.54 to 5um
  - Spacing from 0.30 to 15um
  - Multi-layer film stress near 0
  - AV/ENIG/ENEPIC bond pads
  - Cu or Cu/Ni/Sn microbumps
  - 40um pitch
  - Cu or Cu/Ni/Sn pillars

- **Phase 2**: Digital High Density Interconnect Interposer
  - TSV (via-middle Cu)
  - 5 x 50um or 10 x 100um
  - Cu pillar (backside)
  - C4 Flip Chip Bumps (backside)
  - 50um dia. x 50um tall
  - 60-120um pitch

- **Phase 3**: High Bandwidth, High Speed, Digital Interconnect Interposer
  - Cu Power Plane
  - Cu Ground Plane
  - RDL (backside)
  - MIM decoupling caps

- **Phase 4**: RF Interposer
  - Low-dielectric polymer RDL
  - High Q inductors
  - Lower loss interconnect
  - Coplanar waveguide
  - Microstrip lines

2022 | 2023
Si Interposer Development
Heterogeneous Integration & Advanced Packaging

**Technology Details**
- Max reticle size: 22mm x 22mm
- TSV size: 10um x 100um (10:1 AR)
- TSV metal: Electroplated Cu
- Topside metallization: 4 layers
- Backside: RDL & Solder Bumps
- Daisy chain and functional hardware designs
- Assembly of topside components and interposer to substrate (via assembly partner)
- Design rule manual (beta version currently)

**Roadmap**
- Phase I – Qualified Q2/2022
- Phase 2 & 3 – Qualified Q4 2022/ Q1 2023
- Phase 4 – Target qualification date Q3 2023
Hybrid Wafer Bonding
Heterogeneous Integration & Advanced Packaging

Adeia ZiBond® technology: hybrid bonding **without** electrical interconnect

Adeia DBI® technology: hybrid bonding **with** electrical interconnect

SkyWater licensed the Adeia ZiBond® and DBI® wafer-to-wafer bonding technologies in May 2022

Proprietary
Hybrid Wafer Bonding
Heterogeneous Integration & Advanced Packaging

Technology Details
• Bonding performed at room temperature to eliminate CTE-driven misalignment
• Support for high density interconnect at small pitch
• Enables extremely small interconnect length

Roadmap
• Zibond® & DBI® tech transfer – Q2/Q3 2022
• Initial customer engagements active in Q3/Q4 2022

1µm pitch

W2W ZiBond®  W2W DBI  D2W DBI Ultra

2022  |  2023 & beyond

SkyWater DBI 4µm pads 8µm pitch
Fanout Wafer Level Packaging
Heterogeneous Integration & Advanced Packaging

Fan-Out Wafer Level Packaging:
- Enables IO extended beyond Si
- Chips-first, chips-up fan-out technology with fully encapsulated active region

Why Deca M-Series:
- Highest volume FOWLP technology deployed today
- Superior reliability and yield
- Supports multiple die integration in a single package
- Forward looking Gen 2 incorporates additional RDL layers, smaller RDL line/space dimensions, and 20um I/O pitch die
Fanout Wafer Level Packaging
Heterogeneous Integration & Advanced Packaging

Technology Details

• M-Series process supports
  • 2 RDL layers, min. 10um line/space
  • 55um die bond pad pitch, min.
  • Multiple die in package with 100um die spacing (min)

• M-Series Gen2 extends to
  • 4+ RDL layers, min. 2um line/space
  • 20um die bond pad pitch, min.
  • <75um die spacing

Roadmap

• 200mm demo test vehicle completed Q1 2023
• Gen 2 technology development in 2023
• Initial customer processing engagements in late 2022 – early 2023
Enable turn-key solutions for HI in a secure environment

Future Advanced Packaging Capability
- UBM and C4 Solder bumping
- Cu pillar micro-bump
- Sn-Pb and Pb-free alloys
- Die assembly to interposer or substrate
Solder Bumping & Assembly
Heterogeneous Integration & Advanced Packaging

Future Capabilities
• C4 and Cu pillar bumping
• UBM/solder bump bond pads
• NCP/NCF and capillary underfill
• Thermal compression bonding (TCB)
• Mass reflow
• Ultra fine pitch DBI® (≤10um pitch)
• Die to wafer assembly

Roadmap
• Current external partners for
  • UBM & solder bumping
  • Cu pillar bumping
  • Assembly: TCB & mass reflow (partner)
Are you working on an idea? Let’s talk. Get in touch today!

For more information:
www.skywatertech.com

Contact SkyWater:
swfoundry@skywatertehcnology.com