Intel’s Embedded Multi-Die Interconnect Bridge (EMIB)

First Consumer application in the Intel Core 8th generation i7-8809G

PACKAGING report by Stéphane ELISABETH
October 2018 – Version 1
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Executive Summary

- This full reverse costing study has been conducted to provide insight on technology data, manufacturing cost and selling price of the Intel Core i7-8809G with EMIB technology.

- We have analyzed the Intel Core i7-8809G which is the eight generation of Intel core i7 processor. The Processor features a computer processor unit (CPU), a discrete graphics processor unit (GPU) and a second generation of high bandwidth memory (HBM2) on the same package. The GPU has an 4GB high bandwidth cache assembled from one 4-Hi HBM2 stacks giving almost 200 GB/s of bandwidth.

- Focusing on the GPU and HBM integration, the report shows that in a small package area 29x19 mm 12-layer flip-chip ball grid array (fcBGA) package, the component uses almost 700 mm² of silicon, an impressive silicon-to-package ratio. Regarding the HBM2, only one stacks of 1GB are used to obtain the 4GB capacity. As for NVIDIA’s GPUs, Samsung is the provider of the HBM2 stacks. The 4GB HBM2 consists of four 1GB HBM2 dies and a buffer die at the bottom of the stack, which are all vertically interconnected by TSVs and microbumps.

- Compared to NVIDIA or AMD which uses Interposer, with via-middle Through Silicon Vias (TSVs), the Intel product uses EMIB technology which consist in a silicon bridge buried in the PCB substrate making the interconnection between the HBM2 stacks and the GPU. This approach has some inherent advantages such as the ability to implement high density interconnect without requiring TSVs and to support the integration of many large dies in a high area. The only other application available on the market is into a high-end FPGA, the Stratix X.

- The report includes a complete physical analysis of the packaging process, with details on all technical choices regarding processes, equipment and materials. Also, the complete manufacturing supply chain is described, and manufacturing costs are calculated.

- The report compares the Intel solution with AMD’s Radeon Vega Frontier solution and NVIDIA’s Tesla P100, highlighting the integration choices made by both companies.
CPU Supply Chain

Overview / Introduction

Company Profile & Supply Chain
- Intel
- Intel Core 8th Generation
- Hetero. Integration
- CPU Supply Chain
- Intel EMIB

Market Analysis

Physical Analysis

Physical Comparison

Manufacturing Process Flow

Cost Analysis

Selling Price Analysis

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Package Manufacturing Supply Chain:
- The **HBM stack** (memory dies, Driver die and 3D interconnection) is made by **Samsung**.
- The **GPU die** is manufactured by **Global Foundry**.
- The **Silicon Bridge** is produced by **Intel**.
- The **PCB package substrate** is made either by **Global Foundry**.
- The **final assembly** (HBM and GPU, Interposer in PCB, passives assembly and BGA balls) is realized by **Intel**.
Overview / Introduction

Company Profile & Supply Chain

Market Analysis

Physical Analysis
- Module Disassembly
- Package Assembly
- Views & Dimensions
- Cross-Section
- GPU Die
- Views & Dimensions
- µBumps
- Die Cross-section
- HBM2 Dies
- DRAM & Driver Views & Dimensions
- Die Cross-section
- Silicon Bridge
- View & Dimensions
- Die Cross-Section
- Die Process

Physical Comparison

Manufacturing Process Flow

Cost Analysis

Selling Price Analysis

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Intel NUC8i7HVK Teardown

Mini PC Overview – Front, Back, & Side View

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Package Overview

- Single package with Radeon Vega GPU and 4GB HBM2 Memory on a PCB substrate.

Metal Frame

HBM2 Stack
4 stacked memory dies (4GB) + 1 Driver die

Laminate substrate (12 layers PCB)
Package Cross-Section

- Package Total thickness:
- Package thickness without ball:
- Metal frame thickness:
- PCB Substrate thickness:

Package Cross-section plane
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GPU Die
CPU Board

Package Cross-section – Optical View
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Memory Die

Package Cross-section – Optical View
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Package Cross-Section – Laminate Substrate

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Package Cross-section – SEM View
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Package Cross-section – SEM View
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Package Cross-Section – HBM2 Memory – TSVs

- **HBM dies thickness (excepted top die):**

- **HBM stack TSV & micro-bumps pitch:**

- **Underfill thickness:**
Package Cross-Section – Silicon Bridge – HBM Memory

Physical Analysis
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Intel Core i7-8809G with EMIB Technology

Package Cross-section – Silicon Bridge – Optical View
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Package Cross-Section – Silicon Bridge – Metal layers

- Metal Layer number:
- Metal Line/Space Width:
- Metal Space Height:
PCB Substrate – EMIB Process Flow

- Core Laminated Substrate
- SAP Process

PCB Substrate

Manufacturing Process Flow
- Global Overview
- GPU FE Process & Fab. Unit
- HBM2 FE Process & Fab. Unit
- HBM2 Stacking Process Flow
- Silicon Bridge FE Process & Fab. Unit
- PCB Substrate Process Flow
- PCB Substrate Fab. Unit
- Final Test & Assembly Unit

Cost Analysis
Selling Price Analysis
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## GPU Wafer & Die Cost

### Cost Analysis
- Cost Analysis Summary
- Yields Explanation & Hypotheses
- GPU Wafer & Die Cost
- HBM2 Wafer & Die Cost
- Silicon Bridge FE Cost
- Silicon Bridge Die Cost
- PCB Substrate Mnf. Cost
- EMIB cost per process steps
- Component Cost

### Selling Price Analysis

### Related Reports

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- **Front-End Price**
- **Probe Test Cost**
- **µBump Cost**
- **Total Wafer Cost (including foundry margin)**
- **Nb of potential good dies per wafer**
- **Nb of good dies per wafer**

### Die Cost Breakdown (Medium Yield)

- Front-End Cost
- Probe Test Cost
- µBump Cost
- Yield Losses Cost

The **wafer cost** for the GPU is estimated to:

The number of **good dies per wafer** is estimated to range from **** according to yield variations, which results in a **GPU die cost** ranging from ****.
### HBM Stacking Cost (TSV + μBump)

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<td><strong>HBM Stacking Cost Breakdown</strong></td>
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The HBM stacking cost with thermocompression bonding and wafer molding is estimated to [ ]

The largest portion of the manufacturing cost is due to the [ ]
## Silicon Bridge Wafer & Die Cost

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<td>BE : Dicing Cost</td>
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The number of **good dies per wafer** is estimated between **die cost** between...
PACKAGING
- AMD Radeon Vega Frontier Edition
- NVIDIA Tesla P100 GPU with HBM2
- Second Generation of TSMC’s Integrated Fan-Out (iFO) Packaging for the Apple A11 found in the iPhone X

MARKET AND TECHNOLOGY REPORTS - YOLE DÉVELOPPEMENT

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- Status of the Advanced Packaging Industry 2018
- Status of Advanced Substrates 2018: Embedded Dies & Interconnects, Substrate Like PCB Trends
- 3D TSV and 2.5D Business Update - Market and Technology Trends 2017

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