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Executive Summary

This comparative review has been conducted to provide insights into the structures, processes and costs of the main permanent wafer bonding technologies.

Among these technologies, we have identified two main groups. One, bonding wafers without intermediate layers, includes fusion, copper-copper hybrid and anodic bonding approaches. The second group involves bonding wafers with intermediate layers using an insulator like a glass frit, or a metal in eutectic and thermocompression approaches. In this report, we show examples of each wafer bonding approach in different applications. We analyze and compare each wafer bonding process type to show the benefit in terms of cost and space used.

By switching from glass frit bonding to metal bonding thermo-compression, a manufacturer could reduce component area by up to 30%, reclaiming lost space around the active surface and cutting cost. However, some bonding technologies are currently used only in some market segments. For example, hybrid copper-copper bonding is only used in CIS and glass frit technology is found only in products in automotive and some consumer MEMS applications.

In the comparison, we have analyzed each component’s wafer bonding process, including component dimensions, cost and manufacturing approach. We provide an overview of technology costs and manufacturer choices by application and range. We offer buyers and device manufacturers a unique possibility of understanding permanent wafer bonding technology, evolution, and comparing process costs.
Wafer Bonding

- Permanent Wafer Bonding:
  - Wafer bonding consists of joining two wafers surfaces with or without an intermediary layer, depending on the bonding technology.
    - Direct bonding is the process of bonding without an intermediate layer:
      ```
      Cleaning step
      Joined + annealed
      Bonding process
      ```
    - Indirect bonding is the process of bonding with an intermediate layer:
      ```
      Cleaning step: surface preparation
      Joined + annealed External activation
      Bonding process
      Intermediate layer
      ```
Technology Description

- Wafer Bonding Technologies
  - Direct Bonding
    - Without intermediate layer
    - Fusion bonding/direct or molecular bonding
    - Cu-Cu/oxide hybrid bonding at RT
    - Anodic bonding
  - Indirect Bonding
    - With intermediate layer
    - Insulating interlayer
    - Glass frit bonding
    - Adhesive bonding
    - Eutectic bonding
    - Metal bonding
    - Thermo-compression
**Wafer Bonding Technology**

**Wafer Bonding Definition and Process Description**

- Without intermediate layer
  - Fusion bonding
  - Anodic bonding
- With intermediate layer
  - Insulating interlayer
    - Glass frit bonding
    - Adhesive bonding
  - Metal Bonding
    - Cu-Cu/oxide hybrid bonding
    - Eutectic Bonding
    - Thermo-compression

**Schematic of the fusion bonding process:**

- Hot pressure plate
- Si wafer
mCube Accelerometer - Package Cross-Section

Overview / Introduction

Wafer Bonding Technology

Wafer Bonding Definition and Process Description

- Without intermediate layer
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  - Anodic bonding
- With intermediate layer
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  - Metal Bonding
    - Cu-Cu/oxide hybrid bonding
    - Eutectic Bonding
    - Thermo-compression

Physical Comparison

Cost Comparison

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mCube Accelerometer – Process Flow

- Front-End Process:
  - Substrate: x-inch (xxxmm) Silicon wafer
  - Process type: xxxxxxx
  - Metal layers: x (xxx)
  - Special features: DRIE, fusion & xxxx bondings + TSV xxxxx in MEMS Cap
  - Lithography steps: xx
  - MEMS Area: xxxmm²

MEMS Accelerometer structure
Overview / Introduction

Wafer Bonding Technology

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Fusion Bonding – mCube Accelerometer - Process Flow

Fusion Bonding Process

MEMS on CMOS
- IC wafer

MEMS on CMOS
- Fusion bonding
PHYSICAL COMPARISON
Glass frit bonding to Thermo-compression bonding

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Glass frit bonding to Eutectic bonding

Glass-Frit Sealing Cross section
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AlGe Sealing Cross section
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C O S T
COMPARISON
# Permanent Wafer Bonding Comparison

## Overview / Introduction

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**Wafer Bonding Cost**

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**MARKET AND TECHNOLOGY REPORTS - YOLE DÉVELOPPEMENT**

**ADVANCED PACKAGING**

- Bonding and Lithography Equipment Market for More than Moore Devices
- Status of the MEMS Industry 2018
- Equipment and Materials for 3D TSV Applications 2017
- Status of the CMOS Image Sensor Industry 2018
- MEMS Packaging 2017

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**REVERSE COSTING ANALYSES - SYSTEM PLUS CONSULTING**

**PACKAGING**

- MEMS Packaging: Reverse Technology Review
- MEMS Pressure Sensor Comparison 2018

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More than Moore devices fueled by megatrend applications will strongly drive the growth of the lithography, permanent bonding, and temporary bonding and debonding equipment market.

**KEY FEATURES OF THE REPORT**

- Wafer-to-Wafer (W2W) permanent bonding, lithography, temporary bonding and debonding tools for More than Moore (MtM) markets (advanced packaging, MEMS & sensors, CMOS Image Sensors (CIS), RF, LED and power applications) volume and value metrics forecasted for 2017–2023
  > by MtM device
  > by technology type
- Key technical insights into each equipment type covered, including trends, requirements and challenges
- Competitive landscape and 2017 market shares for each bonding and lithography equipment manufacturer by MtM device
- Technology roadmap for W2W permanent bonding, temporary bonding and debonding and lithography for each MtM device

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