Packages... continued

• SCM and MCM
• Why packaging at all?
• Packaging requirements
• Types of single chip packages
TYPES OF PACKAGES

- Plastic Packages
  - DIP
    - DIL
    - PDIP
    - CDIP
    - CerDIP
    - MDIP
    - FDIP
    - SDIP
  - JLCC
    - PLCC
  - QFP
    - PQFP
    - HQFP
    - RQFP
    - CQFP
    - MQFP
    - TQFP
    - VQFP
    - LQFP
    - SQFP
  - SO
    - SOP
    - HSOP
    - SSOP
    - HSSOP
    - TSOP
    - TSSOP
    - HTSSOP
  - SO (CONTD)
    - VSOP
    - CSOP
    - QSOP
    - MSOP
    - SOIC
    - SSOIC
    - SOJ
  - PGA
    - PPGA
    - CPGA
  - BGA
    - PBGA
    - CBGA
    - MBGA
    - FBGA
    - FTBGA
    - FPBGA
    - FMBGA

- Ceramic Packages
  - BGA (CONTD)
    - UBGA
    - SBGA
    - FLIP CHIP
    - CSBGA
    - CSP
Packages Commonly Used

DIP --- Dual In Line Package

DIL --- Dual In Line Package

PDIP --- Plastic Dual In Line Package

CDIP --- Ceramic Dual In Line Package

CerDIP --- Ceramic Dual In Line Package

MDIP --- Molded Dual In Line Package

FDIP --- Windowed Frit-Seal Dual In Line Package

SDIP --- Shrink Dual In Line Package
Packages Commonly Used

JLCC --- J-Leaded Chip Carrier

PLCC --- Plastic J-Leaded Chip Carrier

CLCC --- Ceramic J-Leaded Chip Carrier

Figure Source: Wikipedia Commons
Packages Commonly Used

Dual Row Plastic Packages

- **PSOP** Plastic Small Outline Package (Gull wing)
- **TSOP** Thin Small Outline Package (Gull wing)
- **SSOP** Shrink Small Outline Package (Gull wing)
- **SOJ** Small Outline J-lead

Figure Source: Wikipedia Commons
Packages Commonly Used

**Quad Row Plastic Packages**

- **Quad Row**
- **PLCC** Plastic Leaded Chip Carrier
- **PQFP** Plastic Quad Flat Pack
- **QFP** Quad Flat Pack

*Figure Source: Wikipedia Commons*
Packages Commonly Used

QFP --- Quad Flat Pack

PQFP --- Plastic Quad Flat Pack
HQFP --- Heat Sink Quad Flat Pack
  (PQFP with metal plate)
RQFP --- Plastic Power Quad Flat Pack
  (similar to HQFP)
CQFP --- Ceramic Quad Flat Pack
MQFP --- Metal Quad Flat Pack
MQFP --- Metric Quad Flat Pack
BQFP --- Bumpered Quad Flat Pack
TQFP --- Thin Quad Flat Pack (typ. height 1.40mm)
VQFP --- Very Thin Quad Flat Pack (typ. height 1.00mm)
LQFP --- Low Profile Quad Flat Pack
  (0.30/0.40/0.50/0.65mm)
SQFP --- Shrink Quad Flat Pack (similar to LQFP)
SOP --- **Small Outline Packages**

HSOP --- **Heat Sink Small Outline Package**

SSOP --- **Shrink Small Outline Package**

HSSOP --- **Heat Sink Shrink Small Outline Package**

TSOP --- **Thin Small Outline Package**

TSSOP --- **Thin Shrink Small Outline Package**

HTSSOP --- **Heat Sink Thin Shrink Small Outline Package**

VSOP --- **Very Small Outline Package**

CSOP --- **Ceramic Small Outline Package**

QSOP --- **Quarter Size Outline Package**

MSOP --- **Mini Small Outline Package**

SOIC --- **Small Outline Integrated Circuit**

SSOIC --- **Shrink Small Outline Integrated Circuit**

SOJ --- **Small Outline Integrated Circuit with J-leads**
Packages Commonly Used

PGA --- Pin Grid Array

PPGA --- Plastic Pin Grid Array

CPGA --- Ceramic Pin Grid Array

- Size of the package is much bigger than the die itself
- Large-sized interconnects (pins, leads, solder balls etc) means lower I/O density

Figure Source: J Fjelstad, Tessera
High I/O Density Packages

- BGA --- Ball Grid Array (typ. 1.50mm / 1.27mm pitch)
- PBGA --- Plastic Ball Grid Array (typ. 1.50mm / 1.27mm pitch)
- CBGA --- Ceramic Ball Grid Array (typ. 1.50mm / 1.27mm pitch)
- MBGA --- Metal Ball Grid Array (typ. 1.50mm / 1.27mm pitch)
- FBGA --- Fine Pitch Ball Grid Array (typ. 1.00mm pitch)
- FTBGA --- Fine Pitch Thin Ball Grid Array (typ. 1.00mm pitch)
- FPBGA --- Fine Pitch Plastic Ball Grid Array (typ. 1.00mm pitch)
- FCBGA --- Fine Pitch Ceramic Ball Grid Array (typ. 1.00mm pitch)
- FMBGA --- Fine Pitch Metal Ball Grid Array (typ. 1.00mm pitch)
- FBGA --- Fine Line Ball Grid Array (typ. 1.00mm pitch)
- UBGGA --- Ultra Fine Line Ball Grid Array (typ. 0.80mm pitch)
- SBGA --- Super Ball Grid Array (typ. 0.80mm pitch)
- Flip Chip BGA --- Flip Chip Ball Grid Array (typ. 1.27mm / 1.00mm pitch)
- CSBGA --- Chip Scale Ball Grid Array (typ. 0.80mm / 0.50mm pitch)
- CSP --- Chip Scale Package (typ. 0.80mm / 0.50mm pitch)

MicroBGA (μBGA)

Figure Source: J Fjelstad, Tessera
High-Density Packages with Area Array

- BGA - Ball Grid Array
  - PBGA (Plastic BGA) - Summary
    - Routable Laminate Substrate (Many Layers)
    - High Pin Count (Over 2000 pins)
    - ASICs, DSPs, PC Chipsets
    - Wirebond, TAB or Flip-Chip (Build-Up) attach
    - Build-Up Technology Requires Special Via Structures

Figure Source: Wikipedia Commons
BGA Continued…

• BGA- Ball Grid Array
  – CBGA (Ceramic BGA)- Summary
    – LTCC- Low Temp Co-Fired Ceramic
    – MLC- Multi Layer Ceramic
    – Good Thermal and Electrical properties
    – Usually Flip-Chip and SiP (MCM)
    – Supports Smaller Feature Sizes (Interconnect Density)
    – Supports Via in Ball
    – Support for Die Cavities
    – More Expensive, high pin count possible; cost decisions

Military, high-end

Ceramic
BGA Continued…

• BGA- Ball Grid Array
  – TBGA (Tape BGA)- Summary
    – 1 or 2 Layer Tape (Usually 1)
    – CSP- Chip Scale Packaging ✓
    – Very Low Profile ✓
    – Good Thermal and Electrical Performance (Short Vias)
    – Smaller Pin Count, low density
    – Cavity Down
**Types:**
- PBGA (Plastic BGA)
- TBGA (Tape BGA)
- CBGA (Ceramic BGA)

**Assembly Technologies:**
- Wire bonding
- Flip chip

<table>
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<tr>
<th>Ball Grid Array</th>
<th>Pin Count</th>
<th>Min. Pitch</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>PBGA</td>
<td>&lt; 800</td>
<td>1.00</td>
<td>Desktop computers</td>
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<tr>
<td>FC-BGA</td>
<td>&lt; 1700</td>
<td>1.00</td>
<td>Networking, Set-top boxes</td>
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<tr>
<td>CBGA</td>
<td>&lt; 800</td>
<td>1.00</td>
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</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Chip Scale Package</th>
<th>Pin Count</th>
<th>Min. Pitch</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plastic (CSP,μBGA)</td>
<td>&lt; 356</td>
<td>0.50</td>
<td>Cell phone, PDA, Notebook, Camcoders</td>
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<tr>
<td>Ceramic (CSP)</td>
<td>&lt; 356</td>
<td>0.50</td>
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</table>
CSP- Chip Scale Packaging

- Definition: A Package is considered a CSP when the package area is no greater than 1.2 times that of the die area; when the ball pitch is equal to less than 0.5mm
- Usually Flip-Chip Attachment
- Common for Wireless Handsets and Handheld Electronics.
- Stacked die support (S-CSP- Stacked CSP); WL-CSP
- Laminate and Ceramic Substrates

Cross-section of a CSP

Figure Source: Amkor
### TYPES OF CSP

<table>
<thead>
<tr>
<th>Category</th>
<th>Type</th>
<th>Example</th>
<th>Devices</th>
<th>Applications</th>
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<tbody>
<tr>
<td>Flex Interposer</td>
<td>TAB/ flip chip</td>
<td><img src="example1.png" alt="Example" /></td>
<td>Flash, SRAM, ASIC, Microcontroller, DSP</td>
<td>Camcorder, cell phone, memory card, computer</td>
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<td>Wirebonding</td>
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<tr>
<td>Rigid Substrate</td>
<td>Flip Chip</td>
<td><img src="example3.png" alt="Example" /></td>
<td>Processor, Controller, DSP, SRAM, ASIC</td>
<td>Cell Phone, camcorder, PDA</td>
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<tr>
<td></td>
<td>Wirebonding</td>
<td><img src="example4.png" alt="Example" /></td>
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<td></td>
</tr>
<tr>
<td>Lead Frame</td>
<td>Wirebonding</td>
<td><img src="example5.png" alt="Example" /></td>
<td>Flash, DRAM, analog IC</td>
<td>Cell phone, memory card, notebook</td>
</tr>
<tr>
<td>Wafer-Level Assembly</td>
<td>Redistribution</td>
<td><img src="example6.png" alt="Example" /></td>
<td>Memory, controllers, ASICs, sensors, op-amp, power devices</td>
<td>Computers, communications</td>
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<tr>
<td></td>
<td>Substrate</td>
<td><img src="example7.png" alt="Example" /></td>
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<td></td>
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</tbody>
</table>

Types of CSPs. (Source: TechSearch International, Inc.)

Source: "Fundamentals of MSP" – Rao Tummala
Lead-frame material and Solder ball material

• Typically, for lead-frame material used in DIP and QFPs, the following materials are used:
  • Alloy 42: Fe, Ni 41, Mn 0.8, Co 0.5
  • Cu with Fe, P and Zn in very low quantities
  • Cu with Fe, Sn and P
  • Cu with Ni (3%), Si (0.65) and Mg (0.15)
  • Lead-frames can be further plated with noble metals or just tin-plated

• For solder balls used in BGA/CSP, the following materials are normally used:
  • Standard Type - Sn63%Pb37% (183 °C)
  • High Electrical Conductive Type - Sn62%Pb36%Ag2% (179 °C)
  • Lead Free Type
    - Sn96.5% Ag3.5% (221 °C)
    - Sn96.5% Ag3% Cu0.5%
    - Sn95.5% Ag4% Cu0.5% (217 °C)
Materials in Packaging

• Ceramic
  – Good heat conductivity
  – Hermetic
  – Expensive (often more expensive than chip itself!)

• Metal
  – Good heat conductivity
  – Hermetic
  – Electrically conductive (must be mixed with other material)

• Plastic
  – Cheap
  – Poor heat conductivity
  – Can be improved by incorporating metallic heat plate.