به نام خدا

سمینار درس تئوری و تکنولوژی ساخت

Wire Bonding

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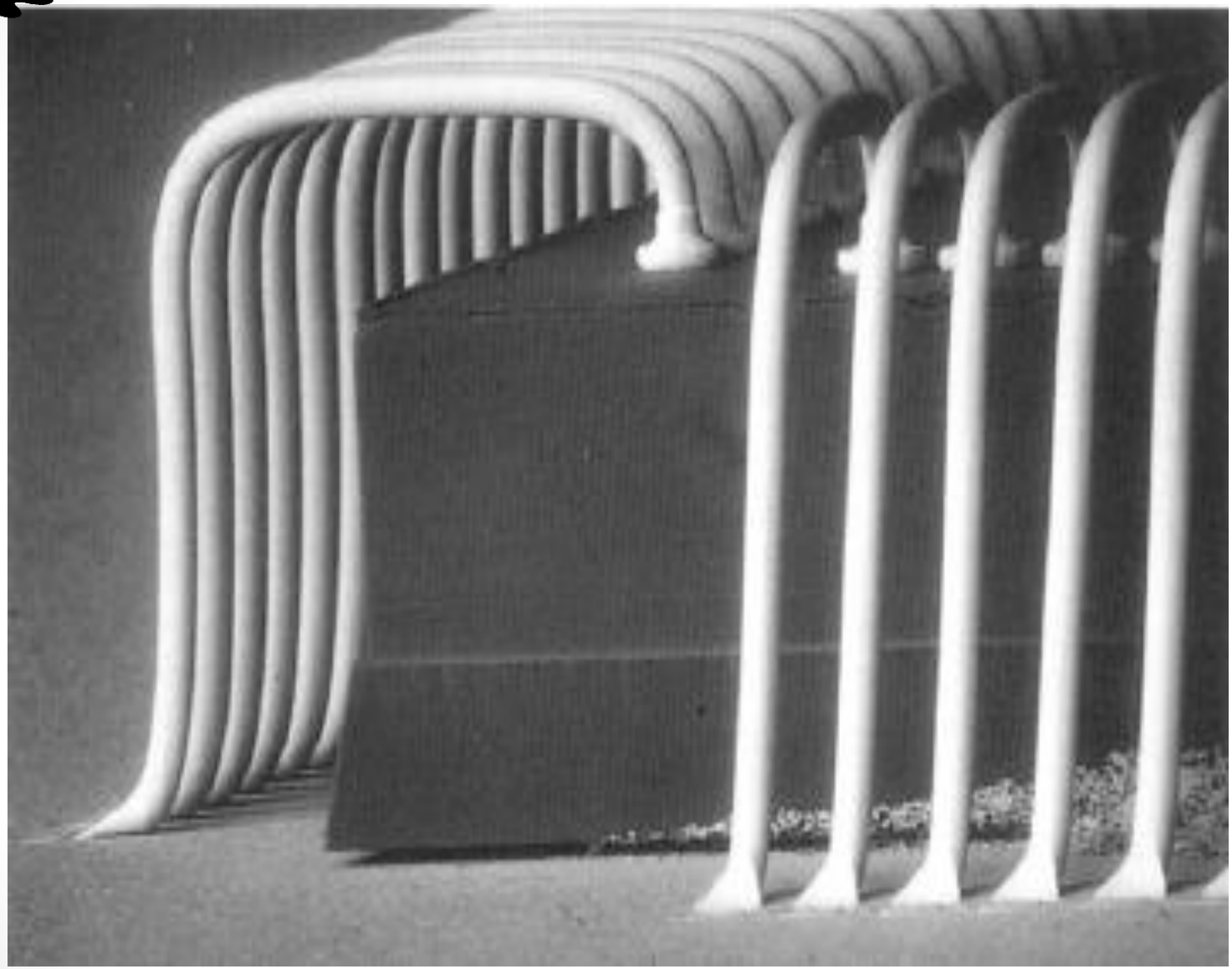
اردیبهشت ۹۳



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Preface :

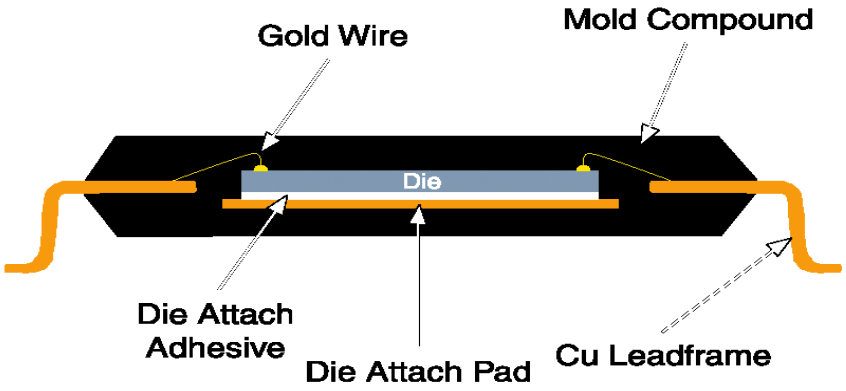
IC assembly is the first step (after wafer singulation into individual die) enabling the IC to be packaged, involving:

1.Metallurgical bonding to IC bond pad (Al);

2.Metallurgical bonding to package bond pad;

3.Electrical connection between these two.

Wirebonding is the earliest technique of device assembly, whose first result was published by Bell Laboratories in 1957.



IC interconnection technologies

- **Wire Bonding**

–The chip is attached to the substrate with the bonding pads facing away from the substrate.

–Connecting wires (bond wires) made of Au or Al are then attached by welding on the chip pads, pulled to the substrate pads and again attached by welding.

- **Tape Automated Bonding**

–The chip is attached to a polyimide tape prepared with Cu conductors.

–The Cu wires are attached to the pre-bumped chip by thermo-compression bonding.

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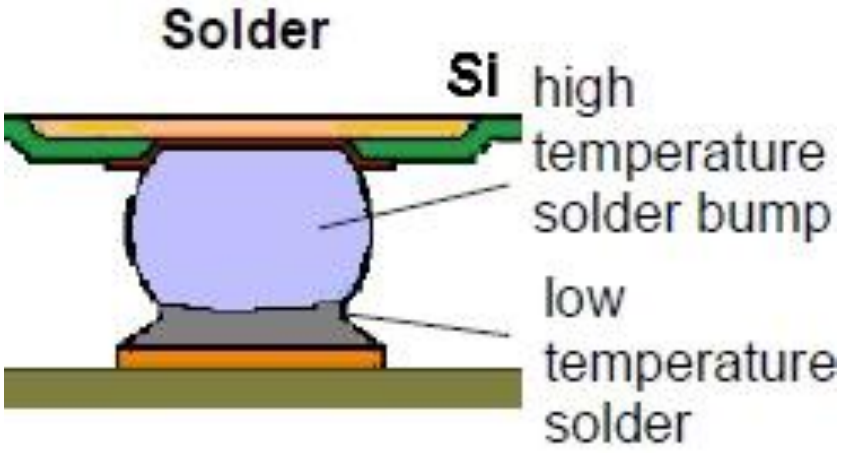
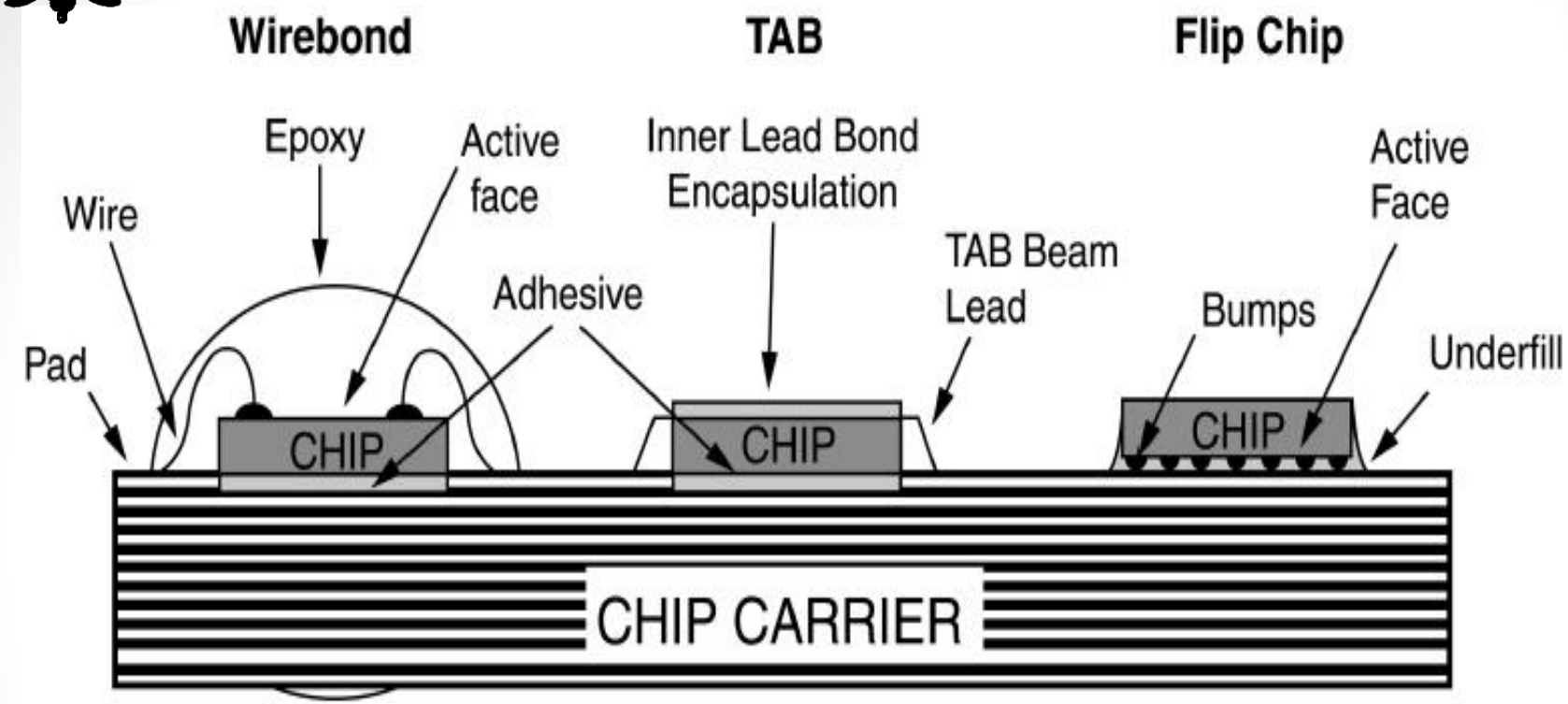
- **Flip Chip**

–The chip is placed upside down on the substrate, which have the same pattern as the chip.

–This technique requires the formation of bumps onto the chip pads (solder alloy balls, copper bumps, adhesives).





Two options:

- Ball bonding
- Wedge bonding

Two options:

- Face up chip
- Face down chip

Three options:

- Metallurgical bond
- Metallurgical and adhesive bond
- Adhesive bond

What is wirebonding

–Wirebonding is an electrical interconnection technique using thin wire and a combination of heat, pressure and/or ultrasonic energy.

–The chip is attached to the substrate with the bonding pads facing away from the substrate.

–Connecting wires (bond wires) made of Au or Al are then attached by welding on the chip pads, pulled to the substrate pads and again attached by welding.

Wire Bonding Processes:

- Wirebonding process begins by firmly attaching the backside of a chip to a chip carrier (Die Attach).
- The wires are welded using a special bonding tool (capillary or wedge).
- the bonding process can be defined to three major processes: thermocompression bonding (T/C), ultrasonic bonding (U/S), and thermosonic bonding (T/S).

Wirebonding	Pressure	Temperature	Ultrasonic energy	Wire	Pad
Thermocompression	High	300-500 °C	No	Au,	Al, Au
Ultrasonic	Low	25 °C	Yes	Au, Al	Al, Au
Thermosonic	Low	100-150 °C	Yes	Au	Al, Au

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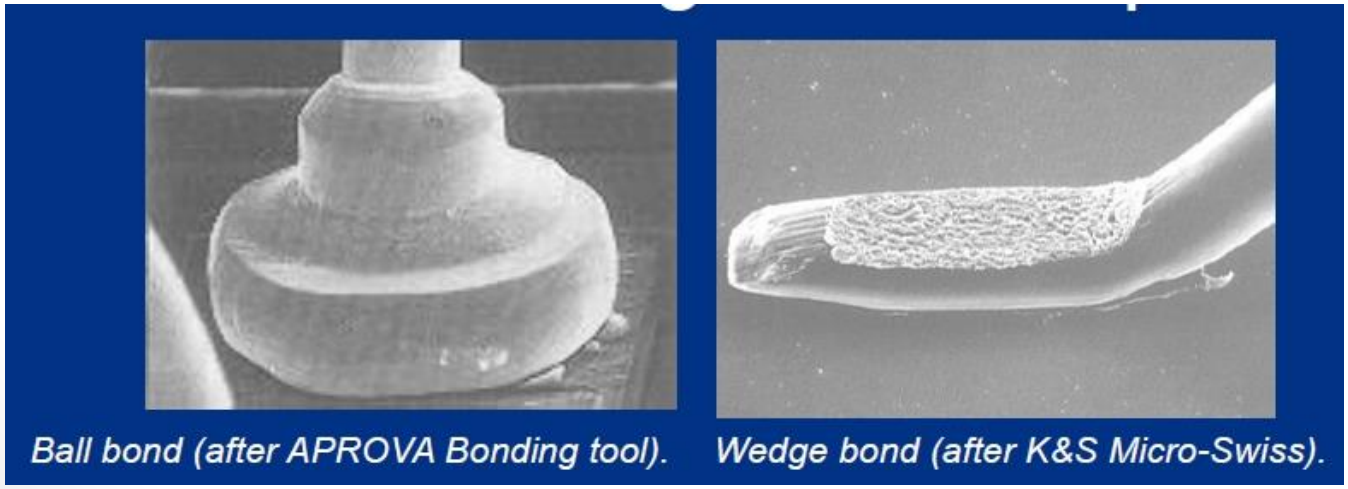
- **Chip Metallization:**
  - Aluminum
  - Gold
  - Copper
- **Bond Wires:**
  - Aluminum (Ø: 32, 125, 250 µm)
  - Gold (Ø: 32, 125, 250 µm)
  - Copper (Ø: 32 µm)

Wirebond forms

There are two basic forms of wirebond: ball bond and wedge bond.

ball-wedge bonding: A ball is remelted at the tip of a wire and bonded via thermo-compression or thermo-sonic subsequently.

Wedge-wedge bonds have the same geometry for the first and the second interconnection with either thick wire (Al) or thin wire (AlSi1, Au)



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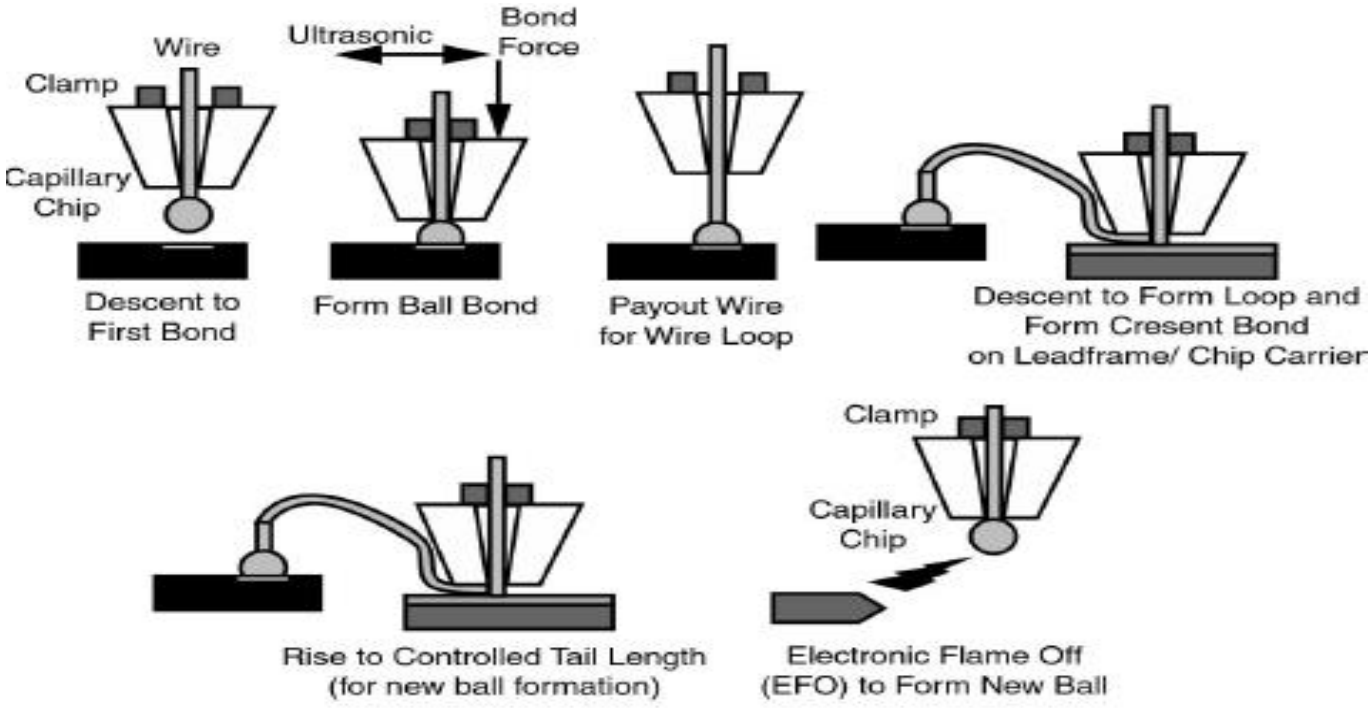
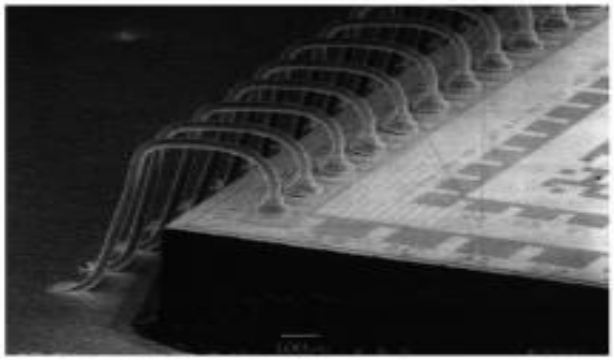
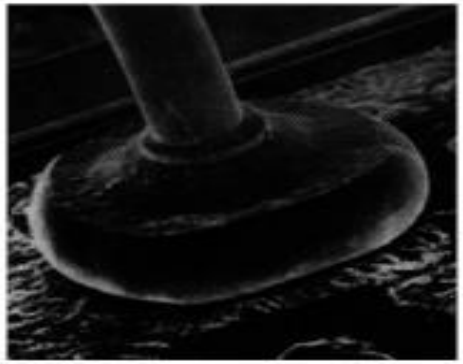
Wirebond	Bonding technique	Bonding tool	Wire	Pad	Speed
Ball bond	T/C, T/S	Capillary	Au	Al, Au	10 wires/sec (T/S)
Wedge bond	T/S, U/S	Wedge	Au, Al	Al, Au	4 wires/sec

Thermosonic Ball Bounding Process







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- **Ball bonding**

–95% of all wire bonding

–Wire: normally Au

–Thermosonic welding technique:

- Moderate temperatures 150-200°C
- Ultrasonic excitation (capillary and wire) 60-120KHz

–Full bond cycle can be <20 ms per bond

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- **Wedge bonding**

–Finest pitch bonding capabilities

–Higher yield compared to ball bonding

–Wire: normally Al

–Controlled wedge bonding force

–Thermosonic welding technique:

- Moderate wire temperature (for Au, 125-150°C)
- Ultrasonic excitation (capillary and wire) 60-120KHz

–Full bond cycle can be <80 ms per bond

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Ball Bonding

- High bonding speed
- Usage of Au or Cu wire
- Higher loops
- Large height steps
- Easier fan-out (no rotation)
- High yield

Applications

- High volume semiconductor
- High volume - high wire count lead frames
- Ceramic hybrids for automotive industry, aviation & defence

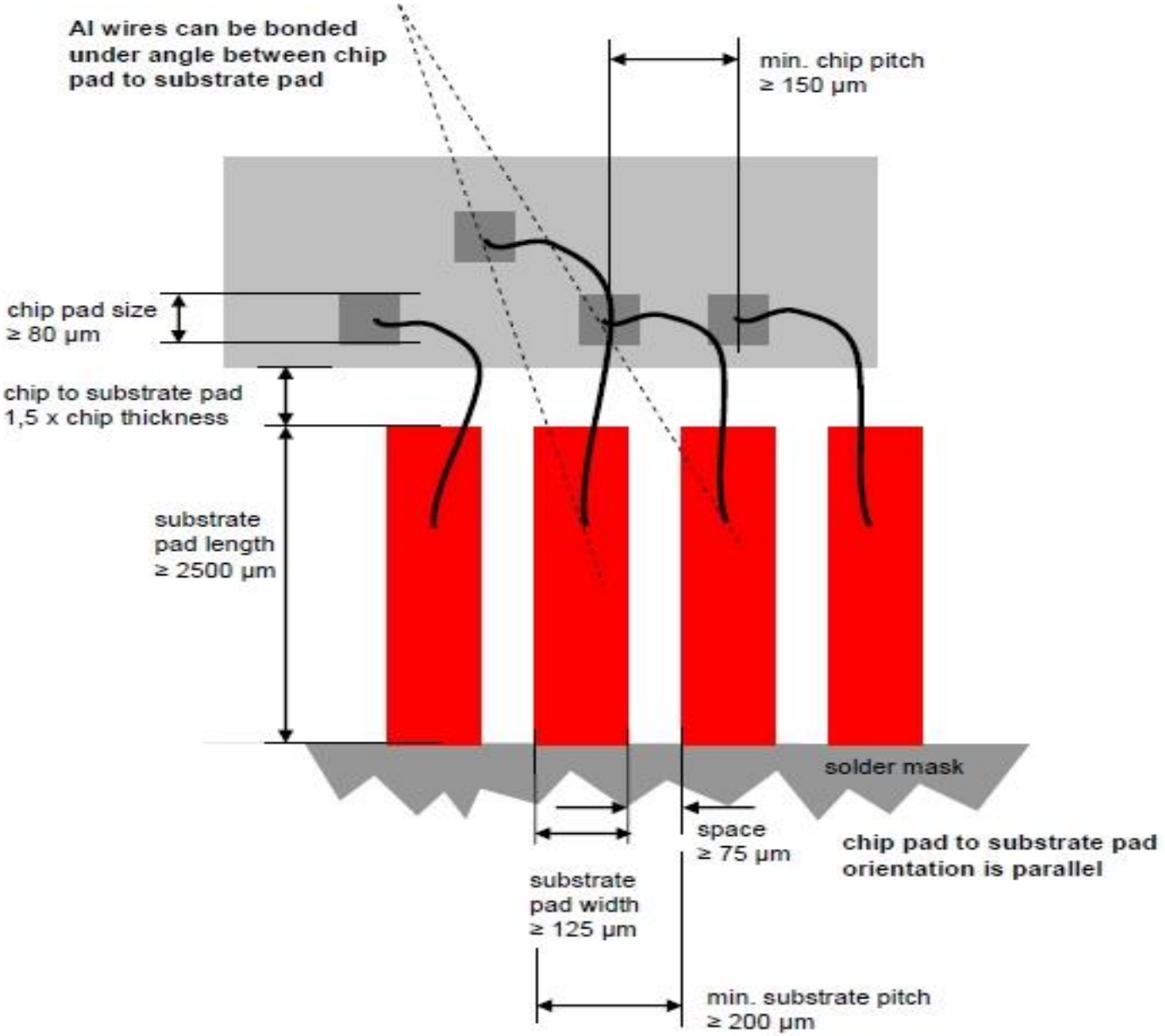
Wedge Bonding

- Higher degree of flexibility
- Smaller pitches/smaller pad size
- Lower loop shapes
- Possibility to use different materials (Au, Al, ribbon, ...)
- No requirement for part heating
- Capability of chip-to-chip connections

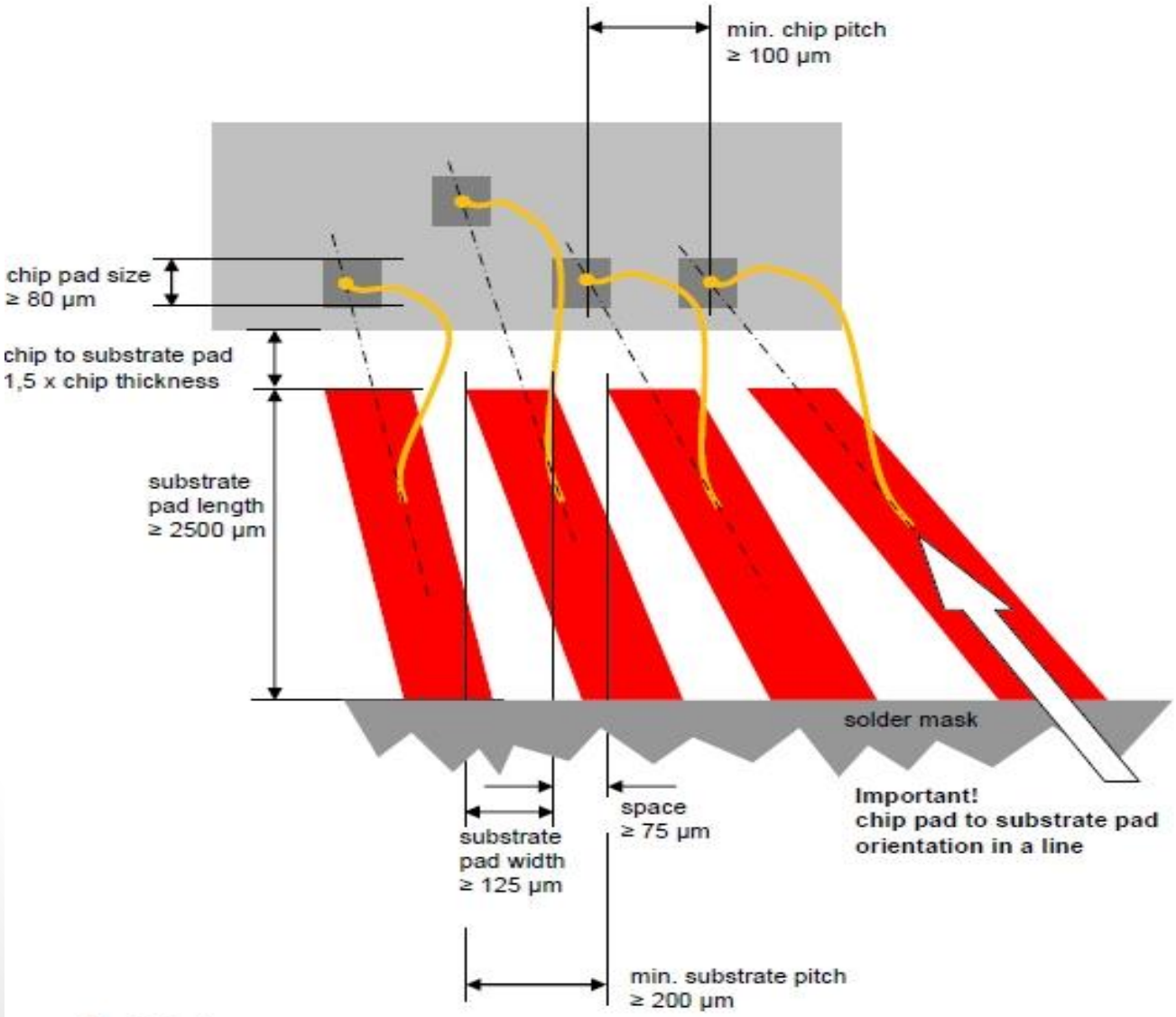
Applications

- Chip-on-board applications (COB)
- High frequency applications: radar, telecom, wire-less
- Fine pitch - high wire count
- Low wire count applications
- Special material requirements(T..

Standard design rules for Aluminium (Al) wire bonding wedge / wedge



Standard design rules for Gold (Au) wire bonding ball / wedge



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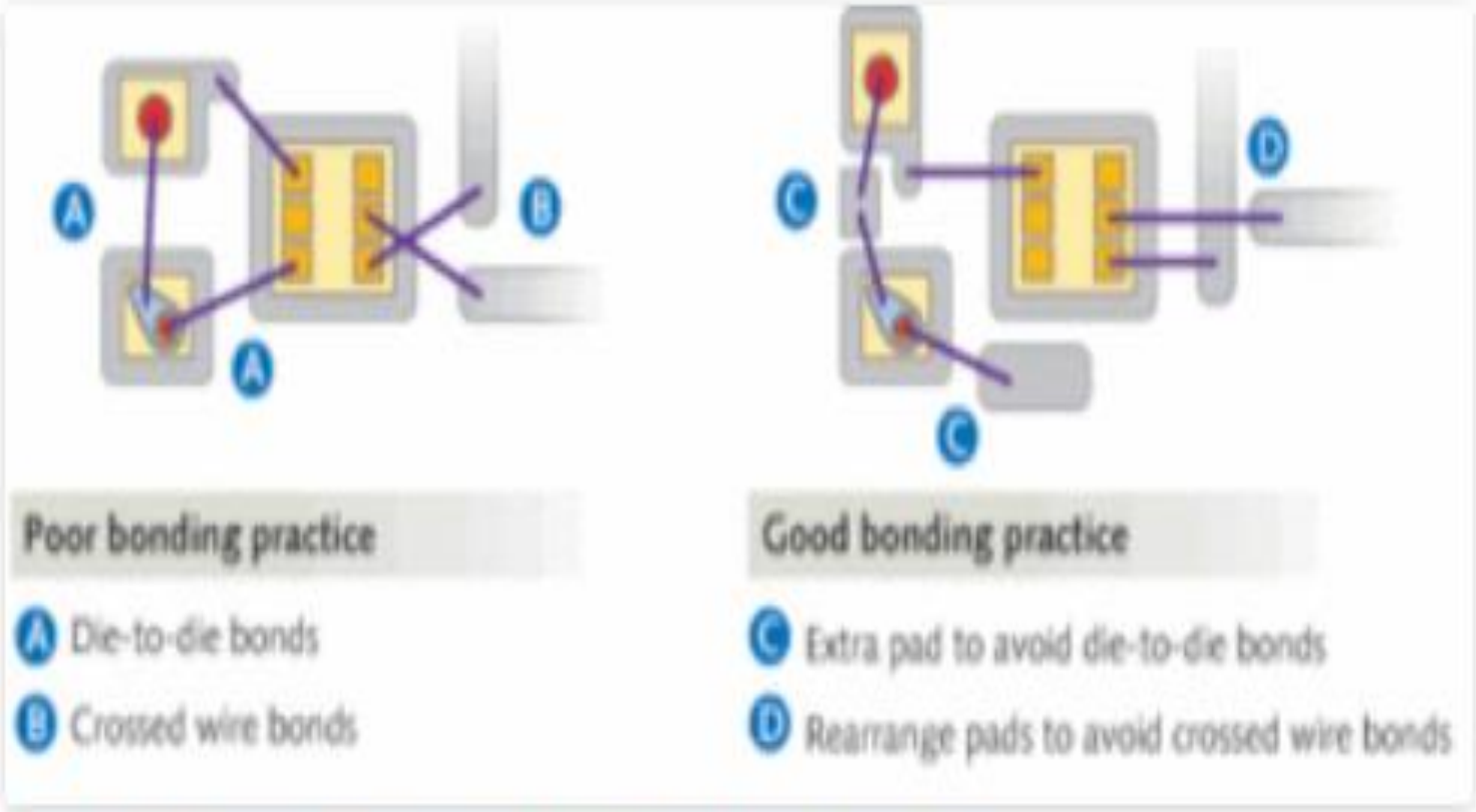

Figure 3. General guidelines for wire bond pad locations.

Cost

The main cost of wirebonding method includes:

· Wirebonder.

· Die attach equipment.

· Support equipment, such as wire pull and shear stations, plasma etchers, as well as storage facilities.

· Materials including tool, wire, die attach materials.

· Engineering

Wire bond machine

F&K Delvotec 56xx series of desktop wire bond machines

Wire bonding is a semiconductor device fabrication method that uses very fine gold, copper or aluminum wire—often less than 100 micrometers in diameter—to make electrical interconnects between a microchip and other electronics. While many automatic wire bond machines are designed for high volumes with minimal product variants, there is also demand for smaller "desktop" bonders that can be used for laboratory, small-scale production and testing applications.

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AUTOMATIC WIRE BONDERS

Manual Wire Pull Test Machine

Thank you…