# Flip Chip Technology
# Vendor Overview

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**Abstract:** Advancements in the packaging of semiconductor devices traditionally use wire bonds to provide the interconnect from device to substrate or to other active devices. Flip chip offers advantages over traditional interconnect schemes. A smaller overall footprint can be realized, better thermal heat transfer, and improved performance especially at higher frequencies are all enabled through the use of flip chip technology.

Over the past ten years major advancements have been made in flip chip development in the commercial silicon industry and in many cases the manufacturing infrastructure has been put in place and is being exploited. DELCO was a pioneer in silicon flip chip in the eighties. Virtually every automobile in the world contains flip chip devices for the various electronic functions. Flip chip at higher frequencies has been slower to gain acceptance. This is beginning to change as now the design community, the packaging community and the manufacturing engineers all have knowledge gained from the lower frequency silicon world.

Several types of flip chip technologies are available today and can be readily adapted to higher frequency applications. Hard and soft solder bumps used in industry are examples of commercially available processes. Several vendors will also supply hard metallic bumps of various material sets including gold, copper and silver. As lead free solders enter into the market new binary and tertiary alloys are now offered for flip chip bumping.

Flip chip usage in RF products is on the rise. Several vendors offer bumping and die rerouting as services using wafer processing techniques are compatible with other materials used in microwave packaging. Flip-chip die attachment of GaAs MMICs is claimed to improve the repeatability and reliability of microwave modules. Repeatability is said to be improved by eliminating the inconstancies associated with the wire bonding and die attachment. Reliability of the MMIC is improved by enhanced cooling though high-thermal-conductivity metal bumps plated directly above the FET source pads. This presentation will offer an overview from the user perspective based on experiences and offer desired technology for future RF applications.

The development of microwave electronics for Radar systems have permitted the deployment of fully functional active array antennas. Key to this development has been the compaction of microwave integrated circuits, MMICs. However, the cost of these components and associated packaging has limited proliferation to only a few Military high performance systems. Fewer than 100 arrays have been deployed to date. A higher level of integration and fewer parts must be realized to make active arrays more affordable. Flip chip MMICs help move towards this goal. Offering smaller footprints, better isolation and inherent ease of environmental protection over wire bonded versions. It is envisioned that new array technology in the future will take active arrays from the $1000's of dollars per element down to under $100 per element.

Active array architectures typically must place all the functional blocks of the TR Module within the grating lobe free spacing for a given frequency and scan angle. Usually the spacing is half wavelength at the highest frequency of operation. The space for an X Band system is limited to approximately 0.5 inches square. At higher frequency say 18 GHz the spacing for full scan volume is reduced to 0.35 inches square. Within this area both transmit and receive functions must be accommodated. Generally the TR functions include a phase shifter, variable attenuator, gain blocks, low noise amplifier and a power amplifier. Historically the MMICs are housed in hermetic enclosures and signals interconnected in ceramic substrates and metal housings mounted perpendicular to the array face. While these have proven reliable, have high performance and are realizable with present infrastructure the cost has become to be asymptotic.

New array technology is moving towards thinner profile antennas sometimes known as panel arrays. This puts surface area at a premium as now the functions must all fit within the lattice unit cell on a single layer. Arrays vary in component count from a few hundred MMICs to nearly 1 million per antenna for satellite applications.

The area on the interconnect unit cell is some 15 % larger for face up devices than flip chip devices. Making flipped devices desirable for use in panel array. Further at higher frequencies the variation in parasitic effects demands extreme precision in the alignment of the MMIC to the interconnect medium and accurate placement of the wire bonds both on the MMIC and the substrate. With the flip chip this at a minimum and in some design cases the MMIC has some self aligning properties as well.

The MMIC design itself for flip chip has been realized using standard microstrip or Co-Planar Waveguide, (CPW). CPW eliminates source via etching and back side thinning. The CPW structure carries the RF ground with the signal for transition into the substrate. The elimination of source vias reduces the inductance that must be matched out for high frequency applications. In the future it tighter bump pitch, higher bumps and compatibility with organic board metallization are desirable.

These of course come with some concerns. Critical issues include: Reducing bump pitch to further shrink flip chip foot prints causes issues with attach reliability. Tighter pitch can lead to solder bridging requiring tighter control of pad geometries and solder volumes. Bump heights if too low will cause MMIC interactions with the host substrate and must be accounted for. The use of underfills result in degraded performance due to dielectric losses, dispersion in wider bandwidth systems and de-tuning of circuits typically design for air.

While the MMIC itself is only marginally lower cost than the face up equivalent, the impact is felt at the higher levels of assembly. Continued infrastructure investment and wide industry use will expand the active array market providing opportunity to grow the number of chips purchased by the military.

Flip chip MMICs at higher frequencies permit new, low cost array's making the technology available for insertion into more applications. Not only radar applications but communications antennas as well. The thin profile panels enable truly "SMART SKIN" structures as thinner antennas allow them to conform to the outline of the mounting vehicle.

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Acronyms:

TR Transmit Receive

CPW Co-planar Waveguide