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Application Note – AC10-001
Die Attach and Assembly Considerations for the AC3030 and AC3050 Series Low-Pressure Sensor Die

This Application Note presents general considerations for die attach and die picking of the AC3030 and AC3050 series low-pressure die. This die is used in a variety of products and packages using a number of different approaches. Hence, this document should only be used to highlight packaging considerations.

General Description of Acuity Pressure Die

The AC3030 and AC3050 are "next generation" low-pressure piezoresistive silicon pressure die.

The die is a multiple thickness three dimensional MEMS structure. Detailed design and modeling is used to provide stable zero-performance, optimum performance as at very low pressures and minimal sensitivity to package and assembly stress.

The piezoresistive sensing element is fabricated in a CMOS grade wafer fab. Additional process steps are incorporated to ensure zero stability and reduce humidity sensitivity.

The pressure cavity is formed using high-speed Deep Reactive Ion Etching. This provides several advantages over the older technology including precision etch stopping because of an SOI layer, no exposure to salt-based contaminants such as KOH, and better structural strength than offered by conventional wet-chemical etching.

Much smaller die size is used to significantly reduce the effects of die attach variations and substrate stress. Traditional low-pressure die are in the range of 3.3 to 3.6 mm in size. In comparison, the area of the AC3030 is less than ¼ and the area of the AC3050 is less than $^1/_3$ the area of traditional low-pressure die. This smaller size greatly reduces the effect of substrate bending and die attach on the sensor output. The improvement is shown both by modeling and qualification tests. This is because a much shorter bending moment arm is developed from die center to edge.

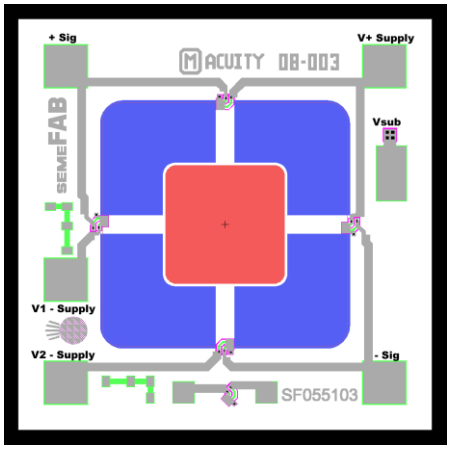


Figure 1- AC3030 Top View

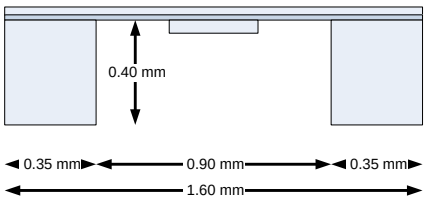


Figure 2 – Cross-section of AC3030

While the die is smaller than traditional parts, vertical DRIE cavity etching results in considerably less bond area reduction than KOH etched structures. Note that the die-attach area as shown in Figure 2 of about 0.35 mm is actually slightly larger than the frame width of typical disposable medical pressure die.

The standard AC3030 and AC3050 series parts are designed with no additional back-side constraint. Pressure die traditionally have used a glass constraint, which introduces a second material with differing temperature coefficients and are amorphous. This contributes to long-term zero drift.

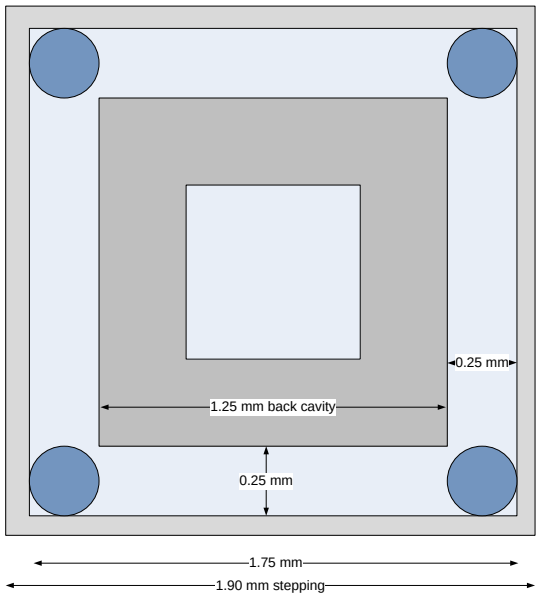


Figure 3 – Location of Ejector pins for AC3050. These are 1.5 mm center-to-center spacing. For the AC3030 the die is 0.3 mm smaller and thus the ejector pins need to be placed at 1.2 mm center-to-center.

Die Picking from Tape

Die are provided diced and mounted on blue tape over grip-rings ready to be ejected and picked for substrate placement. Differential pressure, by design, typically have a rear port for the backside pressure. Hence, a center ejector pin can cause damage to the diaphragm area. The AC3030 and AC3050 die are no different. Instead of a port in the back glass plate, the effective port is in the back of the wafer. The same die pick considerations apply.

The primary approach to eject differential pressure die from the blue tape and rings is to use a 4-pin ejector under the tape to push up on the corners of the die. This technique has been routinely used for many years with unconstrained medical disposable blood-pressure sensors as well as with smaller glass constrained differential pressure die. An approximate pin location is shown for the AC3050 in Figure 3.

There are also special considerations for picking up very-low-pressure die. They are highly sensitive to vacuum pressure and any vacuum pick--up on the diaphragm surface should ideally operate below 100 mBar applied vacuum (pick-up with over 200 mBar (3 PSI) vacuum on the diaphragm is not recommended). To assist in pick-up, many assemblers use a pick-up collet that applies vacuum only to the edge of the die. A donut shaped annulus is created and the center of the diaphragm is vented to atmosphere. In this case, pressure is not applied to the diaphragm. Such a picking tool is depicted in Figure 4.

Die Attach

Die attach is one of the keys to long-term stability of the sensor. The AC3030 and AC3050 parts are being assembled in a wide variety of packages with stable results. Several characteristics are important to assemble a stable sensor.

First, the substrate needs to be relatively stiff. Ceramic substrates should typically be at least 0.5 to 1.0 mm thick (heavily influenced by the remainder of the package design).

A printed-circuit board is not nearly as stiff as ceramic and thus, for optimum performance, it may be necessary to use a thicker printed circuit. Again, this will depend on the design of the balance of the package.

The die may also be assembled into pre-mold-lead frames. Die pad design and overall structure should be designed similar to other low-pressure parts.

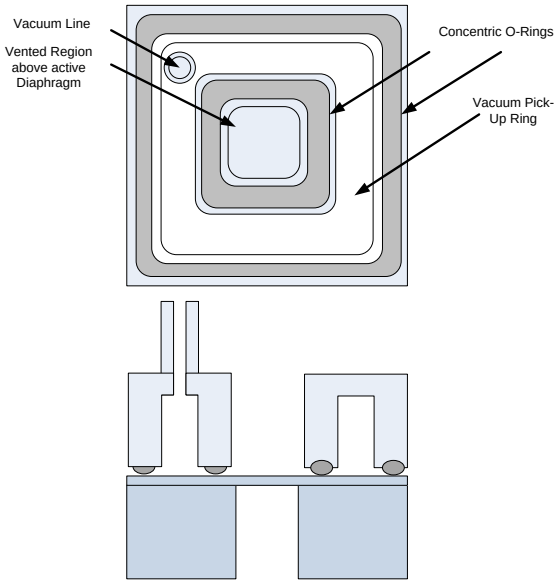
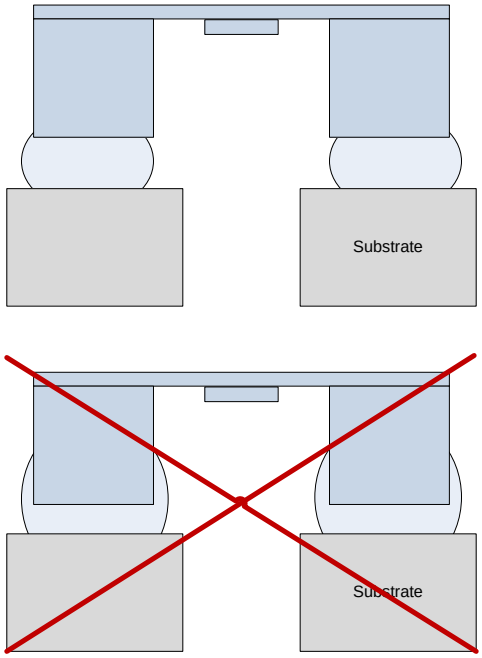


Figure 4 – Vacuum Pick-up collet to eliminate direct pressure on the sensor's Diaphragm.

As with all low-pressure parts, over-molding should only be attempted with very careful package design. Gels or overcoat of the diaphragm may result in a change in sensitivity and a change in zero reproducibility.

Second, the die-attach needs to be compliant. This is because most substrates have a different thermal expansion from Silicon. Because of that, the die-attach needs to be an effective buffer between the substrate and the sensor. A thick die attach provides mechanical isolation. However, this is good from stress-decoupling but bad from a wire-bonding standpoint. Similar to traditional low-pressure parts, the wire-bond parameters must be adjusted according to the die-attach. However, the thinner die structure of these parts relaxes the wire-bond constraints.

In general, die attach with a silicone-based elastomeric adhesive should be a minimum of 0.175 mm, with thicknesses in the 0.20 to 0.25 mm range preferred. Even thicker die attach has been reported with excellent performance.



Ideal Die Attach

- Adhesive compressed slightly but does not wick up side of Die.
- Adhesive is 0.200 mm or thicker between the die and substrate
- Die should move visible when viewed under a microscope if pushed gently from the side

Not Recommended Die Attach

- Adhesive wicks up side of by more than 0.130 mm (1/3 height of die) or
- Adhesive under Die is less than 0.175 mm or
- Die Attach is hard epoxy

Figure 5 – Die attach cross-section

Third, the die-attach should not absorb water if the device is going to be used near freezing. If it does, then water crystals may form at freezing and cause radical change in compliance of the die-attach adhesive. Hard die attach such as epoxies is not recommended for very low-pressure applications. Without very careful package design, they will cause a non-linear and non-repeatable zero error.

Fourth, the die attach must be properly cured. Incomplete curing or accelerated curing may trap stress from the adhesive, which cannot properly escape due to an outer skin-over on the material.

Finally, several methods of applying the die attach, from printing the die attach pattern to dispensing a die attach ring are used. While manual die placement is used in some cases, automated placement is highly recommended for uniform material thickness. As with all differential parts, care must be assured that the adhesive does not wick up the inside of the diaphragm cavity and touch the active diaphragm area or constrain the outside of the die (figure 5). If that happens, nonlinearity will be increased. Both zero stability and temperature performance may also be compromised.

A wide variety of soft die attach materials have traditionally been used to assemble low-pressure parts. Considerations are generally chemical and media compatibility, and compatibility with the substrate, package and the dispense / assembly technique used. The same materials have been used to assemble the AC3030 and AC3050 series die.

For further information

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