Sealing Hermetic Packages Using the Gold-N-Flo™ Process

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Historically the sealing of hermetic packages has been a costly operation with precious metals such as Au/Sn or Au/Ge needed as the solder. This is typically done with a separate lid and preform frame introduced to the sealing process or by first weld attaching the lid and preform frame. Both of these approaches lead to yield losses attributable to poor alignment or cracked performs. This contributes to higher cost of manufacturing since these losses are often the cause for the rejection of a completed package.

Au/Sn, whose phase diagram is shown in Figure 1, is a perfect choice for most device sealing insofar as its melting temperature is concerned, melting as a eutectic at 280 degrees C. However Au/Sn is very expensive to produce. Additionally rolling, stamping, packaging and handling are difficult due to the brittleness of the material. Further, because of the configuration of a window frame, material utilization is very low causing high scrap rates and correspondingly high refining costs. Last, but not least, the price of gold is at approximately $650.00 per ounce and will probably go higher.

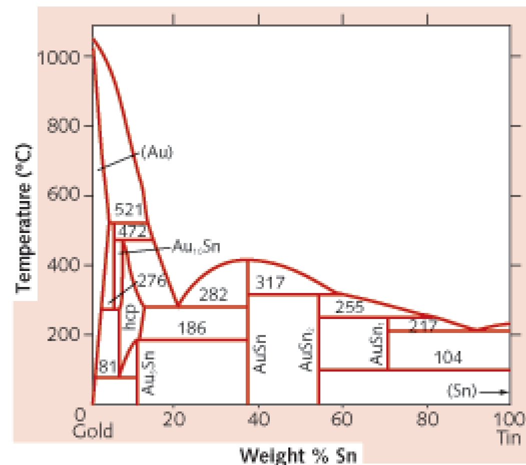

Fig. 1 Au/Sn Binary Phase Diagram

What is Gold-N-Flo™?

Gold-N-Flo™ is a patent pending process for accurately applying molten Au/Sn, Au/Ge and certain other braze materials to specific areas of a lid, package, substrate or lead frame.

The following are two examples of the cost of material needed to make the Au/Sn preforms for a weld attach assembly.

Lid - .500 X .400 X .010
Preform - .490 X .390 X .040 wall X .0021 thick
Ribbon needed with gold @$600.00
(7.66oz/in^3)(.55in)(.43in)(.0021in)(.8wt%Au)($600/oz)=$1.82 each
Gold in preform
(7.66)((.490)(.390)-(.410)(.310))(.0021)(.8)(600)
(7.66)(.073)(.0021)(.8)(600)=$0.56 each

Lid - .250 X .190 X .010
Preform - .240 X .180 X.025 wall X .0021 thick
Ribbon needed with gold @$600.00
(7.66)(.375)(.210)(.0021)(.8)(600)=$0.61 each
Gold in preform
(7.66)((.240)(.180)-(.190)(.130))(.0021)(.8)(600)
(7.66)(.0185)(.0021)(.8)(600)=$0.143 each

As you can see from the examples cited, generally three to four times the value of the gold on the finished part is required to manufacture each piece. Although in many cases this “scrap” can be recycled, the cost of casting, rolling and stamping, plus some inherent manufacturing losses contribute to the cost of the final piece.

If a welded lid-preform assembly is used, the cost of the welding, which is a relatively slow process, plus yield losses during this operation greatly increase the cost of the assembled lid and preform. These yield losses are due to poor alignment, cracked preforms, poor welds causing voids or dewetting and non-hermiticity due to fibers or foreign materials trapped between the preform and the lid. Figures 2 – 5 show some of the typical defects with this approach.

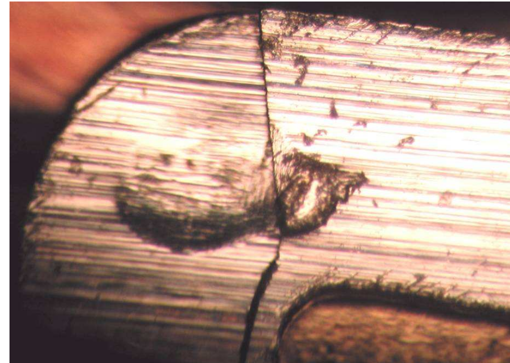
Fig. 2 Au/Sn preform crack due to tack welding

These defects are usually due to wear and carbon or oxide deposits on weld tips or poor handling (packaging).

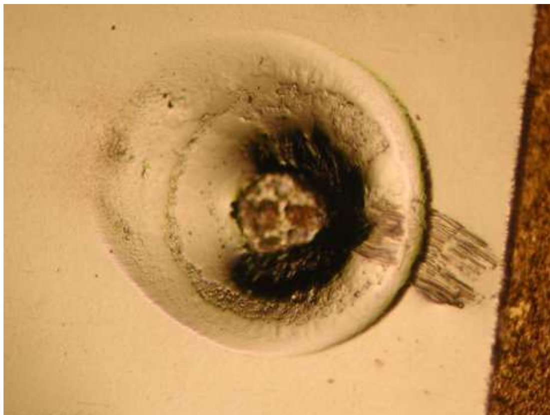
Fig.3 Poorly formed weld area

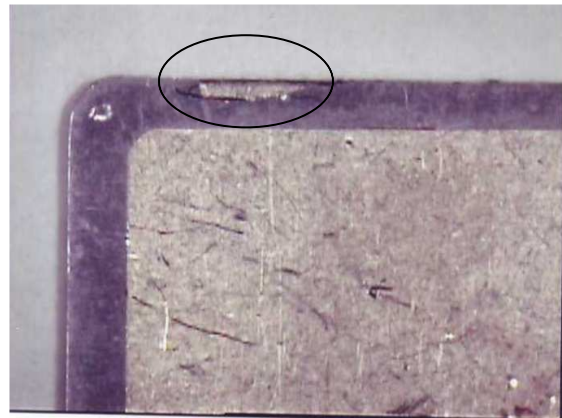
Fig. 4 Missing Au/Sn solder

Gold-N-Flo™ eliminates many of these cost factors since the Au/Sn is accurately placed, and forms a void free metallurgical bond with the lid.

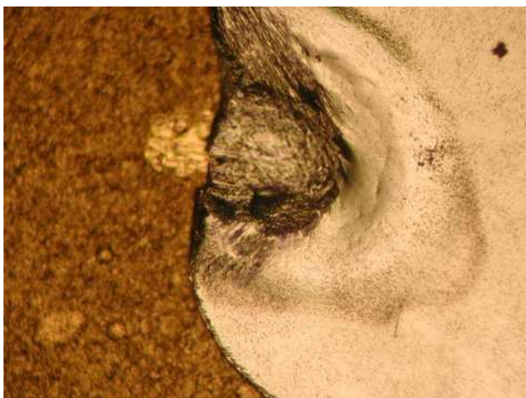
Fig. 5 Misaligned tack weld

Other cost factors that are reduced using the Gold-N-Flo™ process are packaging and cleaning. Whereas the standard welded lid or the two piece assembly system need special packaging to prevent breakage of the Au/Sn preform, the Gold-N-Flo™ parts can be bulk packaged, waffle packed or put into tape on reel. This further reduces the cost. Solvent cleaning of the welded lid is not practical and the two piece system cumbersome. The Gold-

N-Flo™ parts can be cleaned easily in any solvent system including those that use ultrasonics.

Gold-N-Flo™ Process

At SPM we have done extensive testing using X-ray analysis, cross section analysis, and package sealing. During beta site testing, it was found that temperature and bond pressure may require some nominal adjustments from those used with a weld-attach lid since half the wetting has already been accomplished with the Gold-N-Flo™ process.

We have worked with various types of lids at SPM, some are as follows:

Recessed Lid (Coined or Etched)

In this application the Au/Sn had to be accurately placed with the proper volume of solder so that none flowed to the center recessed portion of the lid. As you can see in Figure 6 this was accomplished with Gold-N-Flo™.

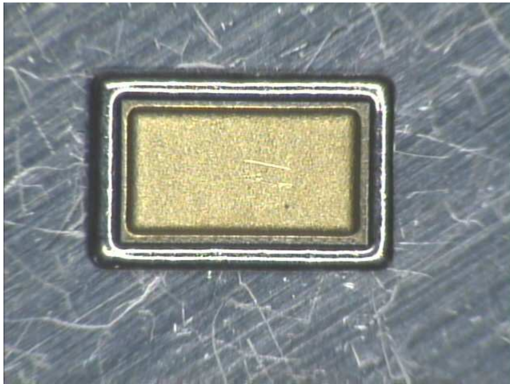

Fig. 6 Recessed lid with Gold-N-Flo™

The lid with Gold-N-Flo™ shown is for a MEMS device and any foreign material in the cavity would be cause for rejection. Our challenge was to position the Au/Sn away from the center cavity keeping a volume that would be consistent with perfect wetting. An additional problem the Gold-N-Flo™ process was able to resolve was a reduction of the voiding rate between the lid and Au/Sn on the weld assembly.

The following X-ray analyses in Figure 7 were focused at various depths of the Au/Sn. As you can see at the levels we tested (approximately 1/3rd deep and close to the bottom) the assembled part is void free. Also note that the Au/Sn has been kept far from the inner cavity.

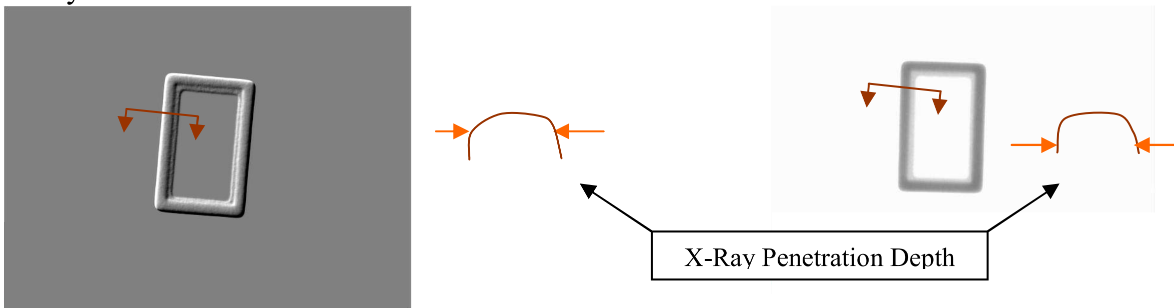

Fig. 7 X-Ray analyses of recessed lid with Gold-N-Flo™ applied

The cross section in Figure 8 shows that in addition to no voids in the Au/Sn there are no dewet areas between the lid and the Au/Sn. The interface between the Au/Sn and the gold plated kovar are well defined.

The fact that the bond between the lid and Au/Sn is robust increases the chances that there will be optimal hermetic sealing on the package. One half the potential problem area for non-hermeticity has been eliminated further insuring overall cost savings using Gold-N-Flo™.

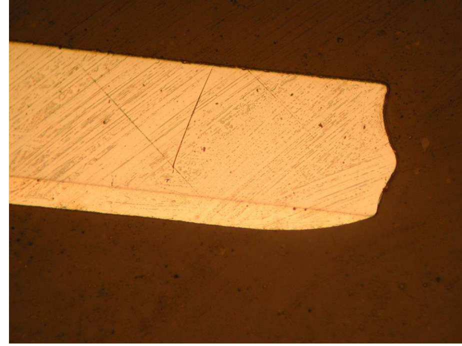

Fig. 8 Cross section of recessed lid with Gold-N-Flo™

Standard Lid – (Flat)

Far simpler than the recessed lid is the standard flat lid that is more prevalent in package sealing. However the same challenges of void free, complete Au/Sn are present.

As you can see from the cross section in Figure 9 the Au/Sn grain structure is pronounced, the interface layer is uniform and unbroken and most importantly it is void free. Also note the uniformity of the Au/Sn thickness.

Fig. 9 Cross section showing grain structure

Once again since we are able to achieve ideal wetting between the lid and the Au/Sn the chances of a non-hermetic seal are greatly reduced, obviously increasing the final assembly yield.

A major benefit of the Gold-N-Flo™ process could be the reduction of the actual Au/Sn needed to seal a package. A welded lid-preform assembly generally requires a certain wall width where the weld is made and a thickness of .0021" is considered standard. Since Gold-N-Flo™ is placed in molten form a narrower wall and a thinner seal could be made, thereby reducing the cost of materials. If in the example of the .500" square lid discussed earlier if the thickness was of the Au/Sn .0015" and the wall width was .020" the cost of the Au/Sn for soldering would be reduced to $0.18 each from $0.56 each.

Drawn Lid

These lids also lend themselves nicely to the Gold-N-Flo™ process with all of the benefits noted previously. An example of this approach is shown in Figure 10. With a drawn lid, packaging of the weld assembly becomes increasingly expensive. Again with Gold-N-Flo™, bulk packaging is acceptable and less expensive.

Fig. 10 Drawn lid with Gold-N-Flo™

Die Attach

We have experienced success depositing Au/Sn and Au/Ge using the Gold-N-Flo™ system for die attach. The two systems we have worked with require either very thin layers of die attach material, for example, in attaching gallium arsenide devices where the meniscus along the edge must be kept to a minimum. We have

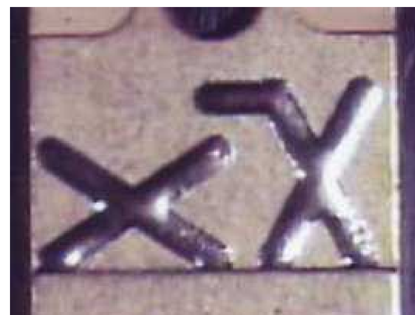

Fig. 11 Gold-N-Flo™ for die attach

been able to wet the Au/Sn in confined areas with thicknesses as low as .0001" which may be of interest in MEMS and optoelectronic packaging applications. Figure 11 shows a typical solder deposit configuration for die attach utilizing Au/Sn.

Lead Frame

We have been successful placing Au/Sn, Au/Ge and Ag/Cu braze alloy (72Ag/28Cu) on lead frames using the Gold-N-Flo™ Process. This eliminates the need for very expensive inlay material or the handling of individual performs. One example of this application is shown in Figure 12.

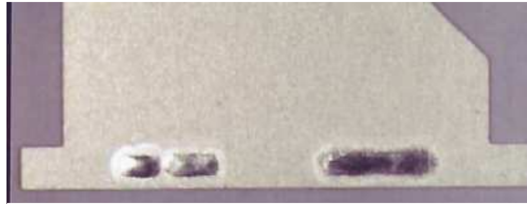

Fig. 12 Gold-N-Flo™ on leadframe with Au/Ge

Conclusion

Gold-N-Flo™ has been shown to be a viable hermetic sealing method with distinct technical advantages over the standard welded-lid assembly or the two piece soldering method. The reduced volume of Au/Sn required could result in significant cost savings. With Gold-N-Flo™, handling issues are reduced, and most importantly, yields are increased since voiding at final seal is significantly reduced or eliminated.