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Ultrasonic Cleaning

Q-Tech Corporation builds crystal oscillator hybrids in accordance with MIL-PRF-55310, which is the industry standard specification for high reliability clock oscillators. We strongly suggest that our customers DO NOT employ any ultrasonic cleaning process.

The use of ultrasonic cleaning methods has been known to cause damage to hybrid devices and has been documented for a number of years. Q-Tech, with years of collective experience, has both witnessed and heard of many "horror stories" of damaged devices due to ultrasonic cleaning processes. There appears to be loss of this 'historical' process information which is a documented problem plaguing all manufacturing concerns, especially small wire hybrid devices in hermetic packages.

While the use of 'intelligent' microprocessor controlled ultrasonic generation can certainly reduce the possibility of destructive effects, it is Q-Tech Corporation's belief that one can not categorically state that this process standardization will eliminate failures from resonances and stresses induced by ultrasonic vibration. Indeed the multitude of process variables (tank loading and configuration, reflections and standing waves, transducer and monitor placement, part orientation, cleaning fluid properties, etc.) make it impossible to characterize, or even bound, the possible energy and vibration levels at any individual part. The fact that a test, or group of tests, shows no damage to devices does not prove that different items would not be destructively affected by the same cleaning process.

1. **Metallurgical Failure Modes of Wire Bonds by George G. Harman**
   (Institute for Applied Technology, National Bureau of Standards – Washington, D.C. 20234)

3. BOND FAILURE MODES OCCURRING AFTER THE DEVICE IS SEALED, TESTED,AND SCREENED

3a.The Effect of Vibrations

Once the bonding process is finished, the package sealed, and various mechanical, thermal, and electrical screens are completed, the variety of possible bond failure modes is reduced considerably. Vibrational and centrifugal type forces that occur in the field are seldom severe enough to cause metallurgical fatigue or other bond damage. In general, large components of assembled systems will fail before such forces are sufficient to damage the bonds. Schafft (15) has calculated the resonant frequency as well as centrifuge-induced forces for gold and aluminum wire bonds having various geometries. The minimum excitation frequencies that might induce resonance and thus damage gold wire bonds, having typical geometries, would be above the 3 to 5 kHz range. Centrifugal forces would have to be greater than about 30,000 g to produce significant stress. For most aluminum wire bond geometries, the resonant frequencies and centrifugal forces required to damage bonds are much higher, being typically greater than 10 kHz and 100,000 g, respectively.

Only one situation has been reported in which bonds in sealed devices mounted on circuit board subassemblies have been subjected to vibrations of high enough frequency and intensity to cause what appears to be fatigue failure. Beall [5] and Ramsey [16] both reported gold thermocompression wire-bond failures in one class of packages (flat packs) after immersing the assembled circuit boards

in ultrasonic cleaning baths. Beall reported that within a single integrated circuit, some bonds were broken while others remained undamaged, apparently depending on the geometrical resonant frequency of each individual bond. Fig. 13 gives two examples of such metallurgical damage to the wire. Ramsey stated that very long immersion times (ti30 minutes) in laboratory-type ultrasonic cleaners were necessary to damage the bonds.

However, Beall reported that failures occurred in high power industrial cleaning baths in less than 1 minute immersion time. The difference may be attributed to different ultrasonic energies, operating frequencies, or focusing within the various cleaning baths. Under these circumstances, the only safe course is to avoid ultrasonic cleaning processes unless careful study has verified that these processes cause no bond damage in each particular situation.

It should be pointed out that ultrasonic excitation under more controlled conditions have previously been suggested as a nondestructive bond screen by Knollman, et al. (17]. Such a test may be subject to the same problems as described above, particularly with respect to differing wire-bond geometries within the same package."

2. Ultrasonic Cleaning – by John Tuck, Associate Editor - Circuits Manufacturing

"Yet doubts about the effects of ultrasonic cleaning remain." Will ultrasonics destroy `old (bonding) wires?" asks Thomas Thill of Branson about ICs. His colleague Mike Tamas notes that risk of damage does increase with smaller diameter wires. While certain components may be affected by particular frequencies, in Bud's opinion most of today's components will withstand ultrasonics, and no general hazards exist for assemblies cleaned that way. No one has investigated industry-wide which components are sensitive, he says.

Meanwhile, until such a study is made, you can take several courses of action. "It is incumbent upon the user to check with the component manufacturer to make sure that a given component is guaranteed for an ultrasonic environment," says Joe Keller, Manager of Advanced Manufacturing Technology, and Motorola. "And then in all cases the user should run his own test to make sure that ultrasonic energy has not degraded the gold wire bonds or the chip within the semiconductor," he adds. If high energy levels in the tank are a problem, Branson for example, will add the option of reducing RF power to the transducers. Keller has developed ultrasonic processes for various ICs, and in most cases the safe energy level is less than 40 watts per gal. He says design of the PCB holder/basket is a critical consideration."

3. Cleaning Hybrid Circuit Assemblies with Fluorocarbon Solvent Systems from Insulation/Circuits, February 1982

"Typically these fluorocarbon solvents are used in conjunction with ultrasonic cleaning equipment. This manufacturer (Branson Cleaning Equipment Company) uses ultrasonics in several areas during circuit component manufacturing. When there are wire bonds to the chips, however, the ultrasonic cleaning is too vigorous a process for the delicate connections."