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The 7,000 Year Cycle

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What's at the top of your "Worry List"? RoHS and lead-free, right? But everyone is making progress and freedom from lead, or at least lead reduction, is in sight. How long did it take to get the lead out? Just a few years? Let's take a brief look at the history of solder assembly. Metallurgy is one of the most ancient arts. In previous articles[1,2] it was estimated that solder was used for about 7,000 years; Mesopotamians, Egyptians, and others in the region melted metals with blow-pipe-assisted flames hot enough to melt gold. Gold and silver were the metals of choice and naturally-occurring alloys of gold-silver are found in these locations. Almost certainly the natural alloy was melted and used to solder pieces of gold together. Au/Ag is probably the original lead-free solder developed in the name of art.

Thousands of years later, the practical Romans were faced with the challenge of joining two pieces of metal together and solved it with solder. Since the metal to be joined was lead sheet, the solder contained lead. Lead sheeting used to line the aqueducts was readily sealed by heating the joints with strips of tin to form a tin-lead eutectic joint giving birth to once-favored Sn/Pb solder. And thousands of years later, we are moving back to lead-free alloys. Ironically, the first solders contained silver just like the "modern" solders; we've replaced gold with tin and copper to come full circle in 7,000 years.

Electronics has made tremendous progress during the past century starting with vacuum tubes, moving to solid state, and now heading toward Nanoelectronic devices. The semiconductor industry can now fabricate 100's of millions of transistors on a single stamp-sized chip with nanoscale dimensions. Perhaps in 10 years, that industry will shift to Nanotechnology devices that may not even contain silicon. The electronic device field certainly represents the epitome of stellar technical progress. Circuitry, as well, is advancing; microvias are laser drilled, micron-dimensioned conductors are formed by additive processes, and direct write ink jetting is being developed. But what about circuit assembly?

Some boast that assembly has made great strides, but what are they? About 20 years ago, we moved the solder joint from the bottom of the circuit board to the surface during the surface mount "revolution". Today, we are at the threshold of lead-free, a 7,000 year old idea whose time has come round again. But what about the basic assembly process? It's still the same. We join metal "A" to metal "B" with solder "C". Granted, we are changing the solder alloy, but there is no fundamental difference. What might have happened if we applied the time and money of lead-free to modernizing the process to invent solderless assembly?

We do have solderless assembly today, but it's quite limited. There are plug-in packages like the pin grid array (PGA) and assembly materials like conductive adhesives[3], and even metal fusion bonding; wire bonding and ultrasonic flip chip.

But why not a universal solderless assembly? How about “Metal Velcro”, or a “Lego-Like” interconnect? These ideas have been discussed for years and limited work done, but not enough. Perhaps MEMS 3D fabrication techniques can now produce a connectable surface on chips or packages that readily mates to PCBs with complimentary bond pads. Or maybe something will emerge from the nano-particle field. But is there really any incentive after just about breaking the bank with lead-free? Will we still be soldering in 7,000 years, or even 70 years? Probably not!

There are two important fields that will bring fundamental change to components: optoelectronics and Nanoelectronics. A time will come, sooner than many realize, when devices will no longer be made with silicon-based transistors. Photons will begin to handle some of the signal transport tasks. Devices of the future could be based on carbon nanotube (CNT) materials, or something yet undiscovered and many signals will be transmitted over transparent, non-metallic conduits. Much of this is already on technology roadmaps and these are planned events, not speculation. It is quite possible and even probable, that metal conductors will not be needed as organic nanostructures are implemented with better electrical, thermal and mechanical properties; these CNT properties are extraordinary. When the device paradigm shift occurs, solder could well become a 7,000 year old relic. But before you dismiss the idea of organic devices and interconnects, consider that you are reading and comprehending at this very moment using the world’s greatest data processing and logic system and it doesn’t contain a single solder joint.

References

1. Gilleo, K., "The First 7,000 Years of Soldering, Part I", Circuits Assembly, pp. 30 - 34, Oct. 1994.

2. Gilleo, K., “"First 7000 Years of Soldering - Part II", Circuits Assembly, pp. 44 - 45, November 1994.

3. Gilleo, K., "Conductive Adhesives: The Clean and Safe Alternative to Solder", IVF Symposium, Sweden, Oct. 23, 1991.