SN100C Achieves 20 Years of Reliable Service

By Keith Howell, Technical Director, Nihon Superior USA

The implementation of the European Union's RoHS directive mandated the use of lead-free solders in the electronics industry by 2006. However, five years before, Japan's appliance recycling waste electronic and electrical equipment (WEEE) regulation went into effect. This regulation covered home electrical goods, air conditioners, refrigerators, freezers, TVs, washing machines, and clothes dryers.

A new category of waste type, a category that includes precious metals, as well as such toxic substances as lead (Pb) and polybrominated biphenyls (PBBs) was included in the WEEE regulation. For the solution to replace tin-lead solder, the industry looked to lead-free alloys, including tin-copper (SnCu).

SnCu (left) and SN100C (right).

But, the SnCu did not perform as expected as a eutectic solder. The industry was forced to research improvements to turn SnCu into a user-friendly solder.

The Birth of SN100C

In 1998, Tetsuro Nishimura, then Nihon Superior's technical manager, now CEO, in partnership with the audio and video division of Panasonic Corporation extensively investigated the causes of the poor performance of SnCu. Nishimura identified nucleation of the second phase of the eutectic Cu_6Sn_5 as the problem.

Adding a trace amount of nickel, 0.05 percent, was discovered as the most effective method of enhancing the performance of the solder. During solidification, nickel works by facilitating the nucleation of the intermetallic Cu_6Sn_5, making it possible to solidify as a eutectic, such as tin-lead solder.

With the microalloying of nickel to SnCu, SN100C was born. During the development, a germanium (Ge) addition was identified as the most effective way to control the oxidation that generates dross.

Nishimura was awarded "Best Inventor" by *SMT Today* magazine during the 2015 SMTA International conference and exhibition in recognition throughout the electronics industry as the inventor of SN100C and the pioneer of microalloyed solders.

This award recognizes an individual or team whose innovations have not only addressed a need and solved a problem, but also have been used to drive improved efficiency, productivity and performance within the electronics manufacturing industry.

"The small amount of nickel is like the effect of salt in a dish. A small amount has no taste, no effect, but a large amount overpowers the dish, ruining the taste. A good dish requires the right amount of salt, just as SN100C has the right amount of nickel. On the other hand, germanium is like pepper, which gives a good taste, but the amount may be varied," says Nishimura.

Commercial Debut

The first commercial use in mass production for the newly developed SN100C solder was in 1999 for a Panasonic VCR. Since then, SN100C has been widely accepted and has gained a reputation as a reliable solder.

The reliability of SN100C has been proven in a wide range of electronics assembly products, from appliances to industrial, automotive and aerospace. The alloy delivers a silver-free stable microstructure that can accommodate the long-term and impact strains to which a solder joint can be subjected. The eutectic character of SN100C alloy and the associated high fluidity provides faster wetting and increased spreadability over SAC305, which is beneficial in wave and hand soldering applications, as well as in reflow.

Due to the significant increase in eco-friendly hybrid and electric vehicles, the demand for solder joints to resist thermal fatigue is also growing. Vehicles are often exposed to extreme temperatures during service and the solder must function in a range of environments.

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Model-Based Engineering for Wire Harness Manufacturing

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knowledge. Tribal knowledge is information about processes, methodologies and more that is stored only in certain employees' memories. This information is unwritten, but is often critical to successfully implementing a process, creating a product or maintaining quality levels.

Employees that change roles or leave the company will take this information with them, undermining the process or product they once oversaw. This presents a real risk for many companies, harness manufacturers included. Ten thousand Baby Boomers retire every day in the U.S.

In Canada, from 2011 to 2016, there was a 20 percent increase in the number of Canadians that reached the age of retirement. In the U.K., it is predicted that between 2016 and 2020 the number of people between 16 and 49 will decrease by 700,000.

The workforce is shrinking. How can managers maintain productivity with a younger, less-experienced and smaller workforce? In particular, how can they capture the vital information and expertise held by their current employees to prevent a catastrophic loss of tribal knowledge?

In a typical, high-level, wire industry, manufacturing engineering flow, design engineering first releases initial designs or engineering changes for costing and to provide quotes to the customer. Next, the main formboard is designed, followed by production modules and subassemblies, which occasionally require their own assembly board. Then, the engineers will design a bill of process (BOP) for the entire harness, allocating wires, splices, twisted wires, and all remaining material to its designated equipment or workstation.

The BOP is then released into the enterprise resource planning (ERP) system. This is followed by balancing and optimization of the final assembly carousel and then creation of the work instructions.

Introducing Error

Errors from data reentry can occur at any of these stages, each of which requires great skill and experience. Adjustments and corrections made downstream in the flow must be fed upstream manually in order to achieve data coherency.

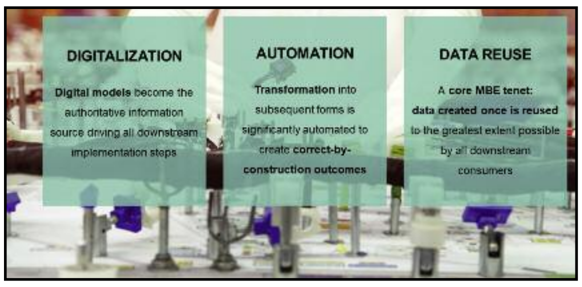
The conventional wire harness manufacturing methodology is vulnerable to errors from fragmented processes and the loss of tribal knowledge as engineers retire or leave their jobs. Other key issues include inconsistent or inaccurate costings, suboptimal formboard design or manufacturing process design, as well as misplacing key information on the shop floor. These can lead directly to inefficiency during production. As a result, manufacturing and overall costs can overshoot the quote made to the customer and production quality can suffer.

Model-Based Engineering

A model-based flow unifies the previously fragmented domains of design and manufacturing by automating data exchange and providing engineers with access to cross-domain decisions. Tribal knowledge, previously held by experienced engineers, is captured through integrated design rules that support automation, guide all engineers consistently and check designs for issues.

There are three key aspects to digitalization and the model-based enterprise in the wire harness industry. First are digital models of the wire harness product and the manufacturing process. The digital models of the harness and production process together create what is known as a "digital twin."

Automation is the second key aspect. Today's harness design and manufacturing solutions can consume design rules created by veteran engineers and use them to automate the transformation of the digital harness and process models into BOPs,



The three key tenets of a model-based enterprise: digitalization, automation and data reuse.

work instructions and other output formats. This simultaneously embeds tribal knowledge into the company's production flow, safeguarding it from employee turnover.

The third aspect is data reuse. Instead of recreating or reengineering data, in a model-based engineering flow, data is created once and reused to the greatest extent possible by all upstream and downstream consumers.

In a digital world, companies create a digital thread in which all of the functions, from architectural and functional design through to physical design, manufacturing engineering and after-sales service, can all use the same data. At each stage of the harness lifecycle, each stakeholder can use the same data models and have access to decisions that are made in other domains. Using a digital thread, design cycles are faster and issues can be caught and resolved earlier in the process when

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In a thermal cycling test, it was shown that there are significant differences in the reliability of SN100C versus that of the Sn-3.8Ag-0.7Cu alloy. After 2,000 cycles, cracks started to appear. At 4,000 cycles the alloy failed completely. In the solder joints made with SN100C, there was no significant cracking until 4,000 cycles.

Nihon Superior's Heritage

Nihon Superior has been a leader in soldering and brazing since it was founded in 1966 by Toshiro Nishimura and continues its tradition of developing lead-free joining materials with improvements in reliability, thermally stable joining and lead-free die attach. Toshiro's son, Tetsuro, now runs the company and Toshiro's grandson, Takatoshi, is also involved in the company, making Nihon Superior a third-generation family-owned business.

The company continues to develop highly reliable products and is committed to earning its customers' highest level of trust by taking full responsibility for every product delivered. The company remains ready to meet rising demands for diversification, increasingly sophisticated technologies and environmental protection.

Beyond SN100C

It is becoming increasingly apparent that the simple ternary SAC305 alloy cannot deliver everything that the electronics industry requires from a solder, in terms of cost and performance. The cost of the three to four percent silver required to get the 422.6°F (217°C) solidus temperature was one of the main reasons for choosing SnAgCu eutectic that had reduced silver content as low as 0.1 percent, or even without silver altogether.

Nihon Superior has now developed its SN100CV alloy that gains its strength from solute atoms in the tin matrix of the joint unlike silver-containing alloys that derive their strength from a dispersion of fine particles of eutectic Ag_3Sn. The addition of bismuth enables thermally stable solder joints, even after thermal cycling.

Another product the company has developed is the Alconano silver sintering paste, which is based on a patented technology that makes it possible to effectively join most metals, as well as silicon and silicon carbide at low sintering temperatures, in nitrogen if necessary, without the nitrous or sulfurous residues that are the byproducts of the sintering of some other nanosilver pastes. The highly active surface of the nanosilver particles and the consequent strong capillary forces make it possible to achieve strong bonds with high electrical and thermal conductivity at low temperatures, without the need for external pressure.

Three generations of the Nishimura family (from left): Takatoshi, founder Toshiro, and CEO Tetsuro.

Twenty years ago, when SN100C was invented, it was considered to be a reliable and stable alternative to SnPb solders. Now, its reputation has grown even stronger and has evolved to meet new industry challenges.

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they are much less expensive. By also reducing design rework, data reuse minimizes costs and enables superior manufacturing efficiency.

In order to survive and grow in this challenging environment, harness manufacturers must significantly change their methods. Digitalization is a key adaptation for harness makers, offering the tools needed to survive in an extremely dynamic industry. A digital model-based flow unifies the previously fragmented domains of design and manufacturing and captures tribal knowledge held by experienced engineers through integrated design rules. To meet the demands of an evolving industry, it is time for wire harness makers to become digital enterprises.

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