Column

Transitions in Bonding Technologies : from a Golden Mask to MEMS

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Throughout the history of humankind, technology has progressed slowly and, at times, rapidly. One technology that has advanced with the others is welding/bonding technology.

The history of bonding began with a golden mask that was discovered in the tomb of the Egyptian king Tutankhamen. The goldwork of the mask had been assembled around 1300 BCE using thermocompression. Bonding in Japan began with the repair of a bronze bell. Then in 747, the Daibutsu, or Great Buddha, of Nara was cast in block units and subsequently assembled using a brazing-like technique. Around 900, a technique for manufacturing Japanese swords was established. When guns arrived in Tanegashima in 1543, material processing techniques advanced so rapidly that guns could be manufactured domestically soon thereafter. These bonding and processing techniques were performed by combusting charcoal as a heat source, heating the materials in a reducing gas to prevent oxidation, and joining gold and iron alloys through forge welding and brazing with no melting.

When iron came to be produced in blast furnaces after the Industrial Revolution, iron and steel materials were bonded mechanically by forming holes in two iron plates and inserting rivets to join them together. This riveted construction can be seen in the Eiffel Tower, constructed in 1889, and the Komagata Bridge in Asakusa, Japan, shown in Photo 1. The heat source evolved from charcoal to electricity, then arcs, electron beams, and laser beams, as new heat sources were developed. These heat sources have been applied to welding/bonding techniques to develop a new fusion welding for melting the process points.

Recently, materials are gaining higher functionality; parts are being made smaller; and there is increasing demand for precision bonding and methods for joining dissimilar materials. There are numerous cases in which assembly is not possible with the conventional melt welding due to metallurgical problems. Thus, technologies have been sought and developed for joining materials in their solid phase without including a molten phase in order to decrease these metallurgical problems.

Fig. 2 shows a sample wound coil for use in a cell phone. The entire coil is smaller than a grain of rice. The coil is produced from a urethane-coated copper wire having a diameter of 30 μm, and this insulated copper wire is bonded to the silver electrode of a terminal by thermal compression.

Fig. 3 shows a sample microreactor having heat exchange circuits above and below the reactor circuit. A stainless steel leaf having a path no greater than 0.5 mm, is bonded using thermocompression (diffusion bonding) under a high vacuum so that the material does not deform.

The thermocompression in these bonding techniques was the same used to assemble Tutankhamen's golden mask, but remarkable advancements have been made in techniques for controlling the bonding process.

Various accelerometers have been manufactured in recent years. Many of these have been incorporated in automobiles and have helped improve riding comfort and safety. Accelerometers are parts formed by joining and assembling silicon and glass that have been micromachined according to photolithography. The method of bonding is anodic bonding, which employs electrostatic attraction in the glass interface that accompanies the migration of sodium ions. This method can be used at the relatively low temperature of about 300℃.

In addition to microreactors, devices having micromechanical structures (MEMS) include various accelerometers and optical switches. Assembled of micromechanical parts formed in silicon using photolithography, these devices have practical applications in combination with processing technologies from multiple fields.

I believe that complex micromechanical process and assembly technologies represented in devices having micromechanical structures should be one of Japan's focuses in the future.

Fig. 1 Rivet structure for the Komagata Bridge in Asakusa

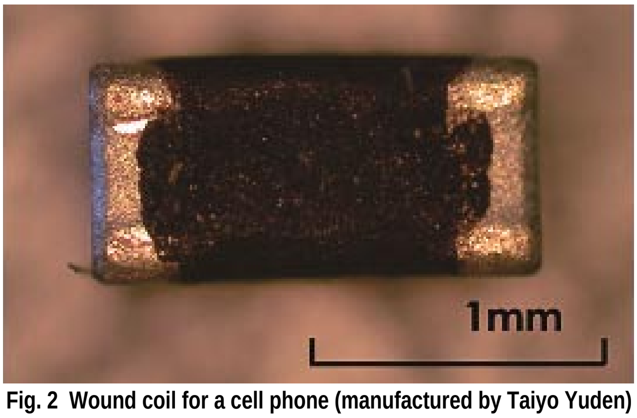

Fig. 2 Wound coil for a cell phone (manufactured by Taiyo Yuden)

Fig. 3 Layered heat exchanger cut to show the internal structure (manufactured by Yachida)