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Bringing Niche Technology to the Global Market

One Researcher, One Engineer: A Powerful Team

Developing the room-temperature wafer bonder from scratch

The Advanced Technology Research Center is responsible for developing MHI's key leading-edge technologies. Here, the staff conducts market intelligence activities and performs future-focused research, working with other divisions to drive the development of new, market-changing products. In 2004, Takayuki Goto, a researcher from the Center, and Kensuke Ide, an engineer from Machine Tool Division, began working to commercialize room-temperature bonding technology. Starting from square one, they worked closely to explore prospective products, gathered engineers whose skills they trusted, and established a completely new line of business — the first of its kind in the world. The product: a room-temperature wafer bonder* for semiconductor device manufacturers.

* Wafers are thin (1 mm) discs used as semiconductor substrate material. Several thousand semi-conducting devices are manufactured simultaneously on a single wafer. Room-temperature bonding, used in applications such as wafer packaging, has the advantages of avoiding thermal stress warping and making device miniaturization possible, among other benefits.

Diligently Uncovering Latent Needs

In 2005, MHI developed the world's first industrial-level room-temperature wafer bonder. Wafers made of silicon and other material, which are used in semiconductor devices such as computer memory and cell phone sensors, are irradiated with atom or ion beams. By activating the wafer's surface, the machine bonds at room temperature without the need for adhesives, heating or annealing. Since no heat is used — unlike current mainstream devices, there is no thermal stress after bonding, thereby improving device quality and manufacturing efficiency. Development of this product began when Goto brought room-temperature bonding technology to Machine Tool, where Ide worked.

At the time, neither of them knew what to create from this technology. As Ide says, "All we could do was go talk to customers. We called nearly 100 companies, and Goto and I visited about 20 who were willing to meet with us."

This was unfamiliar territory for them, but they pressed forward on their own. Goto was certain that if customers didn't hear about the technology from the people who knew it best, they would not understand. According to Ide, trekking around Japan to uncover customer needs paid off. "We'd been searching for a 'positive area' for this technology, but what we discovered was 'negative areas.' Viable business opportunities were virtually non-existent in fields where unit price of the final product – the chip itself – was low." These negative area discoveries, however, highlighted the positive area implications where profitability was high, and where value lay in achieving high-precision bonding at room temperature. As their target became clearer, the two met with the person in charge at a major MEMS*1 device manufacturer, and here found their 'positive area.'

Happy New Year! Happy New Bonding!

The customer was impressed by the subsequent bonding demonstration, and finally, in June 2004, product development began. In order to deliver their industrial room-temperature wafer bonder — the world's first — inside eight months, Goto gathered a group of highly skilled members from the Technology & Innovation Headquarters' 1,300 researchers. "To stay on the same page and move ahead decisively, seven select members pooled their knowledge and brainstormed ideas. We also created multiple safety nets, so that we wouldn't fall behind if something went wrong."

Despite this, a supplier's delayed delivery pushed back assembly. Nevertheless, the first bonding experiment had to be performed on January 2. To keep the promised delivery date, they even worked on New Year's Eve. After doing all they could, the members ended 2004 in the company cafeteria, eating traditional New Year's dishes Goto's wife had brought them.

Test day: January 2. Success on the very first try. This was the first time Ide saw bonding occur at room temperature. "We stuck two wafers together at room temperature, and they didn't peel apart," exclaimed Ide. "We hadn't used adhesive, we hadn't heated them, and they stuck. What a surprise." According to Ide, the elation he felt then still keeps him going. That day, he e-mailed his supervisor about the experiment: "Happy New Bonding."

Goto commented, "It took two months to complete the first bond with the earlier test unit. After that experience, I knew this might not be easy, so I was relieved when it worked so well." In February 2005, they delivered the product on schedule.

After that first success, the project received additional development funds and PR activities began in earnest. "I had the feeling that if we broke into one market, this business would expand," said Ide. "Room-temperature bonding can bond various materials; it's an extremely versatile technology. Besides, it originated in Japan: no overseas groups had beaten us to it. I really fell in love with this technology."

Ide's feeling was spot on: at the Micromachine/MEMS・Robotech exhibition*2, they attracted throngs of people, met sales partners and gained more customer connections. At this point, they have performed more than 4,000 bonding demonstrations on customers' in-development devices. According to Goto, "Room-temperature bonding is an unknown technology to our customers; they don't yet have methods for making devices or bonding preprocessing. So we go in deep, starting with the device development process, and solve the issues together. Sometimes it's necessary to seek out things the customer would rather keep hidden and tell them how to improve it." This attitude has paid off, and now customers hold them in high regard: "After looking at other companies, they tell us our skills are on a whole different level."

Bonding experiments are conducted in the clean room. Members regularly gather here to run tests.

Today, a New Market Tomorrow, Half the World

The enthusiasm of Goto and Ide took the Research Center's component technology and turned it into an advanced device that met customer needs. Goto reflects, "Having technology you researched become a product that sells is the goal of every company researcher. I started from nothing and took it all the way into sales. It was a truly valuable experience." This success is sure to motivate young researchers.

Having accomplished commercialization, the pair is already working on a new challenge. In 2012, they developed the world's first fully automatic 300 mm room-temperature wafer bonding machine for 3D integrated LSIs*3. As Ide says, "The market won't open until 2014, but we have inquiries from the world's major semiconductor manufacturers, and those will turn into orders. Ultimately, I'd like to bond half the world's wafers with MHI's product." The room-temperature wafer bonder is still relatively unknown overseas, but the day when MHI takes it global is obviously not far off.

*1: Micro Electro Mechanical Systems — devices that include mechanical elements. The category includes acceleration sensors, pressure sensors, inkjet heads, gyros, bio-devices, and more.

*2: World's largest trade fair for MEMS, ultra-precision and micromachining, nanotech, and bio, plus application systems and service robot component technology

*3: A next-generation device manufacturing method in which LSI (large-scale integration) circuits are stacked, and the upper and lower wafers joined with Through Silicon Vias (TSVs). Further integration in two dimensions is nearing its limit, and this is seen as a breakthrough solution.

BOND MEISTER MWB-12-ST, the room-temperature wafer bonder for 3D integrated LSIs developed in 2012. The world's first commercial room-temperature bonder is able to stack 300 mm-diameter wafers, the most common type for LSIs, in three dimensions.

Get a behind-the-scenes look at development from the seven elite researchers on the MHI website.
A Story of Innovating Challengers：Room-Temperature Wafer Bonder Edition "Taking a Dreamlike Bonding Technology to the Forefront of Manufacturing"

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