HELLER INDUSTRIES
Thermal Solutions Leader

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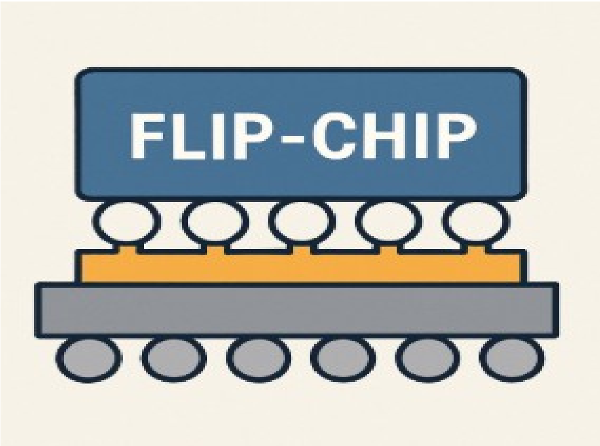
Solving Flip Chip Die Crack Issues with Heller's Reflow Oven Solutions

Executive Summary:

One of our global OSAT clients faced die crack issues during the flip chip reflow process, threatening production quality. Heller Industries resolved the die crack problem by fine tuning the reflow oven and implementing precise thermal control solutions. The result: defect-free production, a major customer win for the client, and over 300 ovens delivered to one of client's sites—demonstrating Heller's leadership in advanced semiconductor packaging solutions.



(AI generated picture)

Client Background:

A global OSAT (Outsourced Semiconductor Assembly and Test) client, with a long history of using Heller's reflow ovens, reached out to us after discovering die cracks in its flip chip manufacturing process in Korea. Given the client's trust in Heller's equipment and service, they sought immediate technical support.

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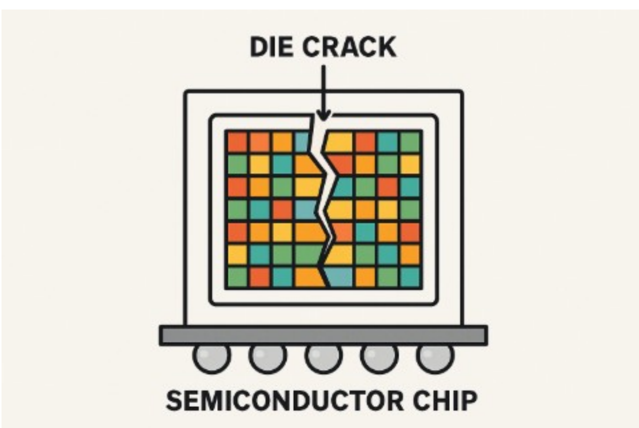
(AI generated picture)

Problem Statement:

The OSAT client was producing a device for a major fabless semiconductor company using the flip chip reflow process -- a stage where the semiconductor dies, mounted face-down with solder bumps, are heated to form electrical connections and then cooled to stabilize the package. During the cooling phase, the client observed die cracks, suspecting the cooling rate was too rapid, which induced thermal stress due to differing thermal expansion rates between the silicon die and the organic substrate. This issue was particularly unusual, even within the client's own production lines, where flip chip processes were already being used at scale.



(AI generated picture)

A simple reduction in cooling rate was not viable. Doing so without extending the cooling time would result in the board exiting the oven at temperatures well above the client's 65 °C threshold. The challenge, therefore, was to design a solution that could slow the cooling rate while also extending the cooling duration.

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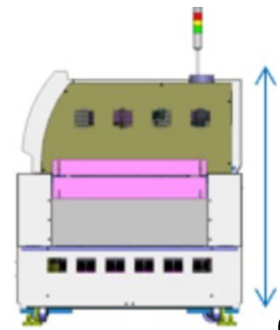
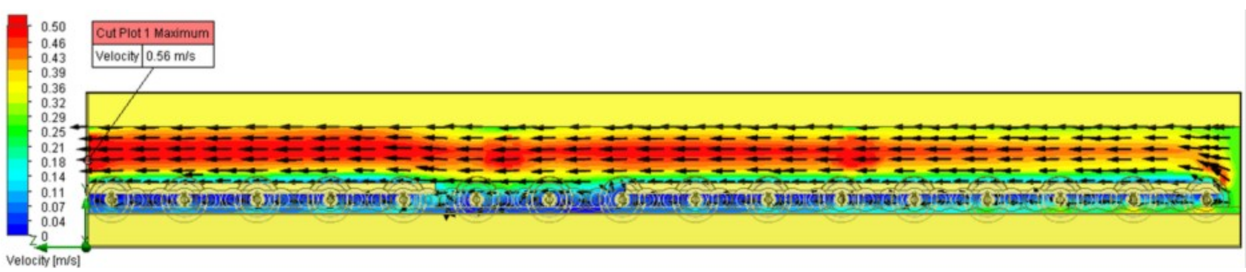
Heller's Solution:

Heller Korea quickly mobilized a cross-functional team. The Heller Korea sales team brought in the engineering team to investigate and develop a tailored solution.

To address the issue, we proposed switching to the 2020MKIII oven model, which offered more cooling zones than the client's existing oven setup, 1913MKIII. Moreover, an external cooling module was set up to extend the overall cooling length.


(external cooling module)

To facilitate easier maintenance, we designed a clamp type tunnel between the oven and the external cooling module. Nitrogen input was inserted across the oven to ensure full nitrogen flow while maintaining a low N2 ppm. To maximize energy efficiency, the Heller team created designs empowered by computerized fluid dynamics (CFD) to simulate air flow within the oven, allowing optimal use of nitrogen.



(Optimization of airflow)

A special design was also implemented to block external air from the beginning and the end of the oven tunnel, minimizing the chances of oxidation. To meet the high temperature profile requirement commonly used in semiconductor manufacturing, the experts at Heller used a high temperature application which can stand up to 400 degrees in operation.

The next challenge is to ensure smooth temperature control. To bring down the cooling rate by nearly fivefold, precise thermal control of the oven is crucial.

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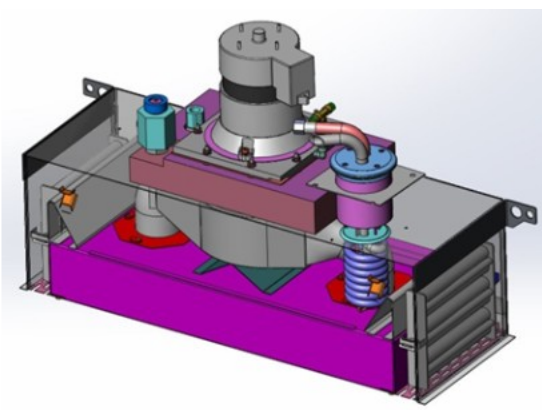
Heller's engineering team came up with several design modifications to the oven. They minimized the space between individual cooling modules to get a smooth cooling gradient.

To get the most precise temperature control in the cooling region, the engineers at Heller provided a set of antagonist temperature control mechanisms. Just like in human brains, excitatory and inhibitory neurotransmitters work together to maintain a precise and balanced control of body functions, Heller's cooling modules have heaters and cooling coils working together to achieve precise temperature control. Bottom cooling modules with heaters are added to force an all-rounded cooling airflow to the chips, and Heller's unique small coils filled with chiller water provide fast and responsive cooling if the temperature is too high.


(Small coils in cooling zones)

On top of it, the Heller team installed blower motor controllers to allow the client to fully control the wind speed, and thus, precise cooling performance. Additionally, the original mesh belt was replaced with a more lightly woven version and slightly elevated to minimize thermal interference between zones and for better profile uniformity. Lastly, the Heller team used its Gen5.1 Flux Management System which allowed maximum heat transfer to condense flux while blowing out highly efficient cool air to the cooling zone.

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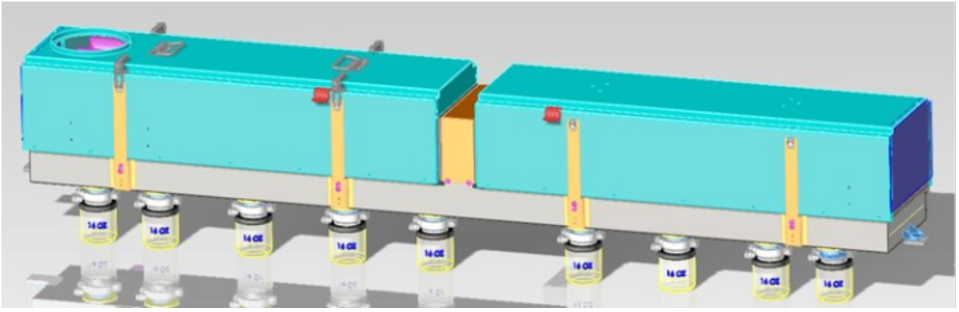
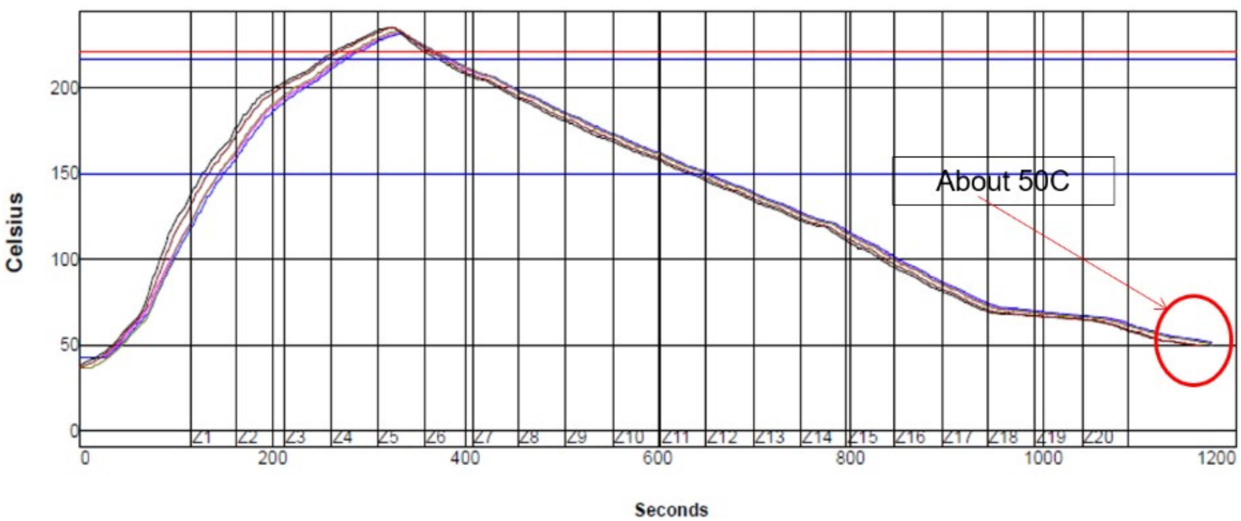

(Gen 5.1 Flux Management System)

With these changes in place, the team began testing. Heller Korea obtained sample boards from the client and ran profile tests to meet the client's profiling requirement.

The client hoped to achieve cooling rates below 0.3°C/s and 0.35°C/s for temperature changes from peak (around 240°C) to 100°C, and a board exit temperature around 50°C.

The Heller team fine-tuned the oven configurations, including temperature setting and belt speed adjustment to optimize the profile performance. As a result, the cooling rate was around 0.25°C/s, the board exit temperature at 50°C, well within the client's target range.



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Impact of Solving Flip Chip Die Crack Issues with Heller's Reflow Oven Solutions:

Thanks to the collaborative effort of Heller Korea, the client observed no more die crack issues and was able to ramp up their production to meet the demands of its fabless customer, who later became one of its major accounts, impressed by the reliable output.

To date, Heller has delivered over 300 ovens to this client because of the trust we have earned. The success also led to broader adoption of the 2020MKIII model for other semiconductor manufacturing companies with advanced package applications like not only Flip chip but also System-in-Package.