# FEM Simulations to optimize a micro mirror array package for a wide operating temperature range

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## ABSTRACT

Based on FEM thermo-mechanical simulations we propose a packaging concept for a micro mirror array (MMA) for holographic applications that is as stable as possible within the operating temperature range and throughout SLM lifetime despite the inevitably different coefficients of thermal expansion (CTE) of the various materials involved.

## PACKAGE DESIGN

The package consists of a stack of heat slug, the silicon crystal based MEMS SLM chip and a beam combiner (BC) window glued together as well as a package substrate for electrical connection, see Figure 1. To connect the package to the system PCB we plan to use Z-ray connectors.

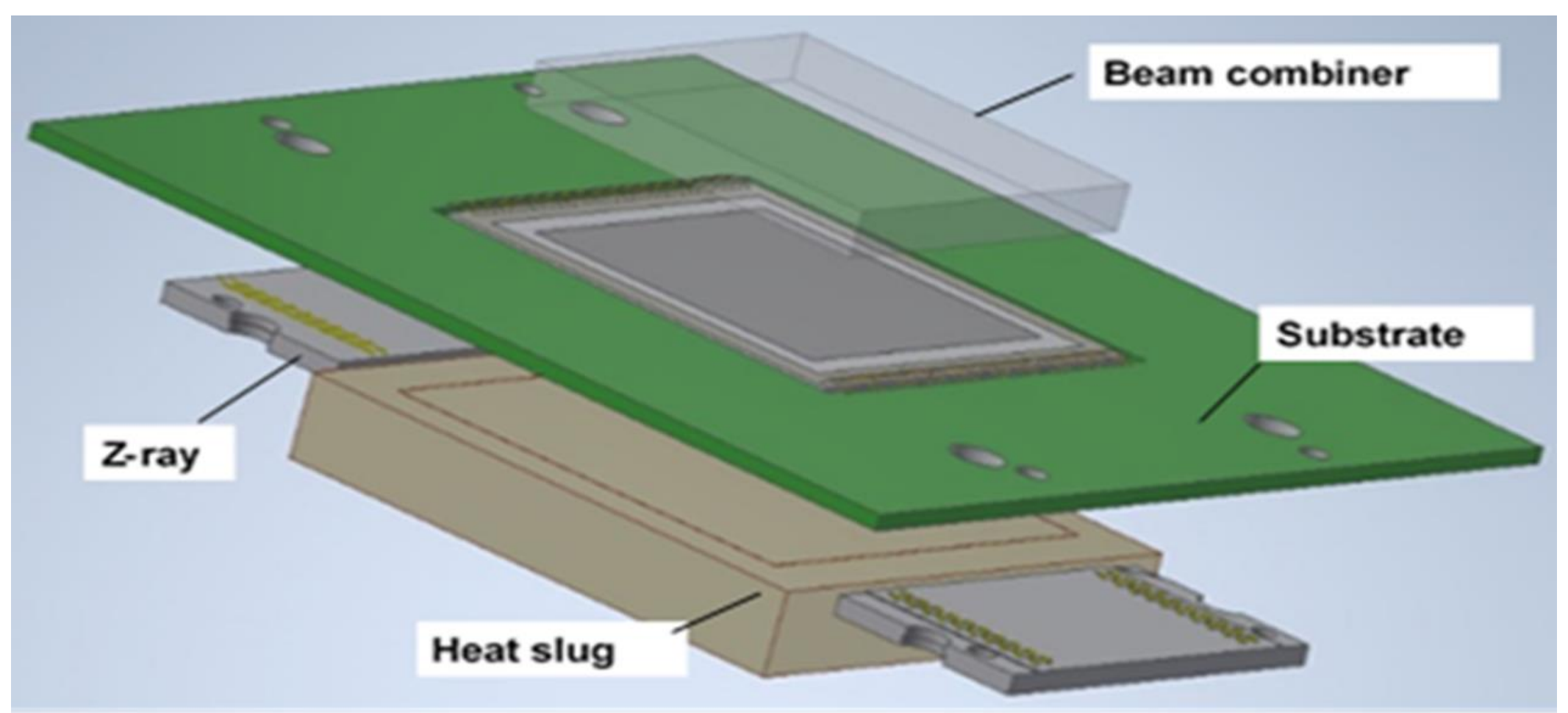

*Figure 1: Package assembly consisting of beam combiner (transparent), MEMS (SLM) chip, heat slug, substrate and Z-ray connectors*

For a reliable light modulator, the package needs to fulfil these specifications:

| Parameter | value |
|---|---|
| Placement accuracy of beam combiner window during whole lifetime | ≤ 0.3 µm |
| Global flatness change over operating temperature range | 45 nm |
| Operating temperature range | -20 - 85°C |
| Gap height (MEMS surface to beam combiner window) | 5µm – 10µm |

*Table 1: Key SLM package specifications*

## FEM SIMULATIONS

The FEM package model is 'assembled' at 22°C and heated up to the maximum operating temperature of 85°C, where the relevant package parameters are analysed. We started with a simplified model without substrate.

## FIRST RESULTS

The first approach was to reduce the stress in the BC glue by stretching the silicon chip to match to the free expansion of the BC using the influence of the heat slug. This can be reached using a 3.7mm thick heat slug, see Figure 2.

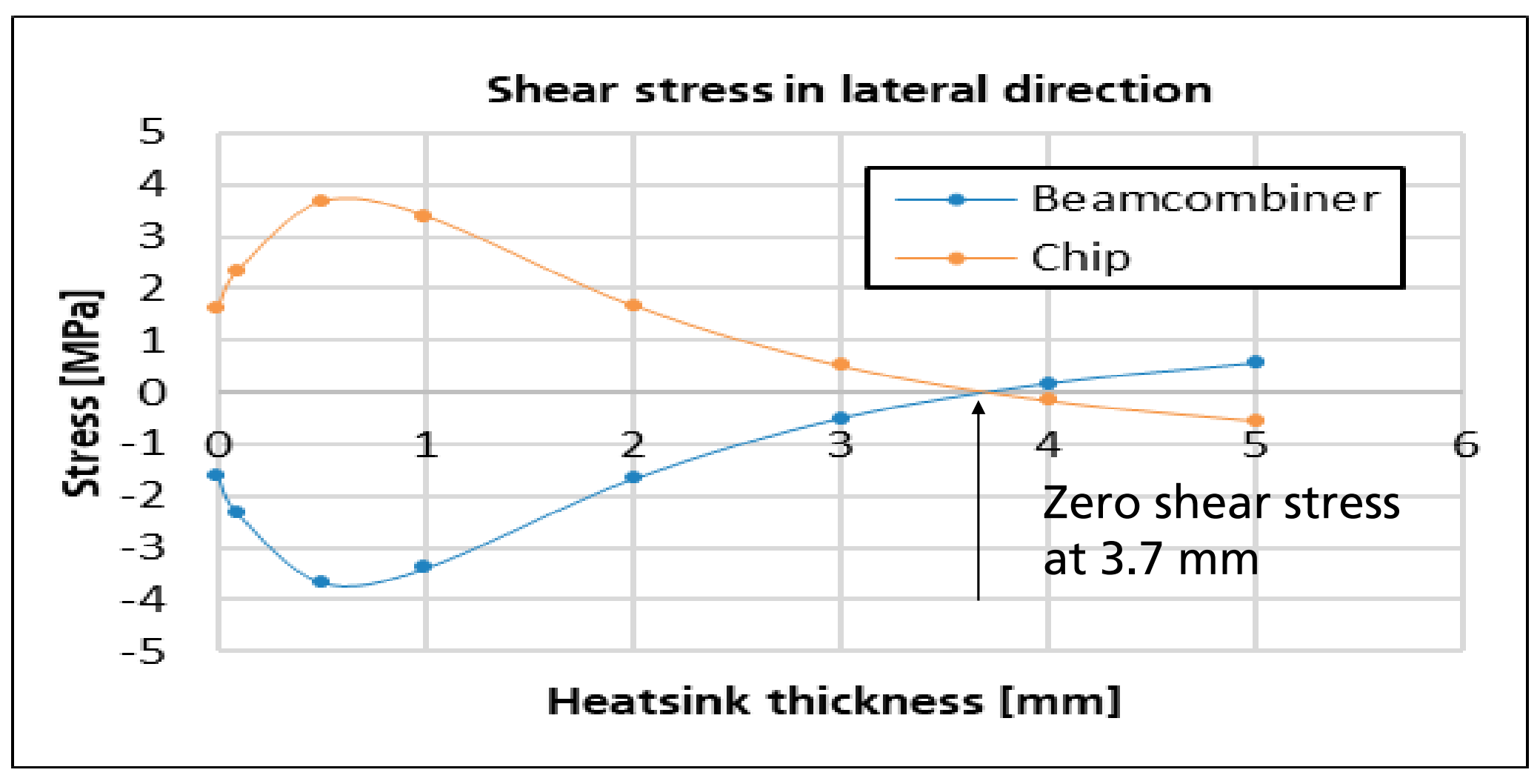

*Figure 2: Shear stress in BC glue for standard model vs. heat slug thickness*

With this heat slug the misalignment in the pixel area is acceptable (Figure 3). Unfortunately the change in MMA bow is much too large (Figure 4). We therefore have to use a much thicker heat slug and accept the non-optimum stress in BC glue. We also extend the model to include the substrate and molding, which is protecting the bond wires.

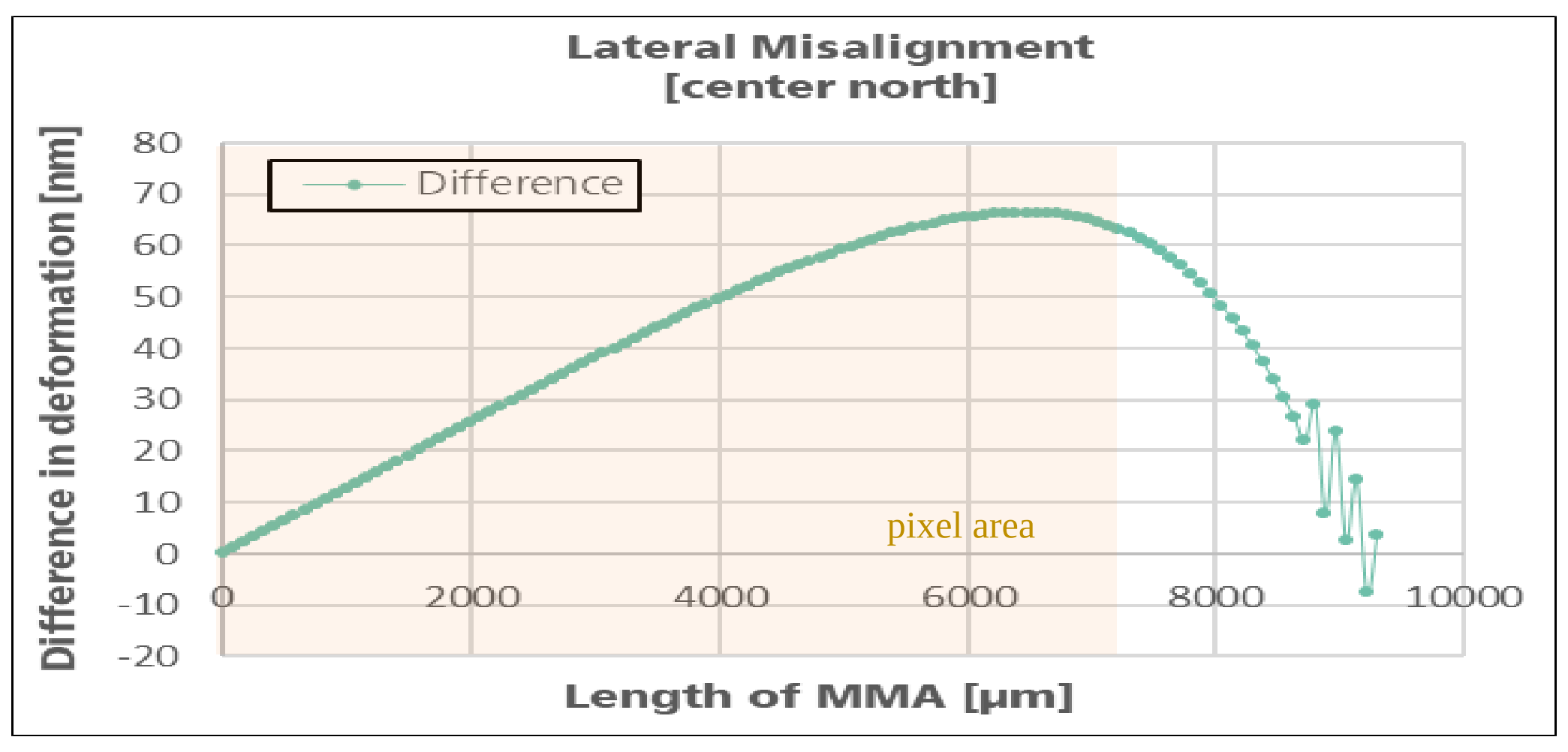

*Figure 3: misalignment in pixel area*

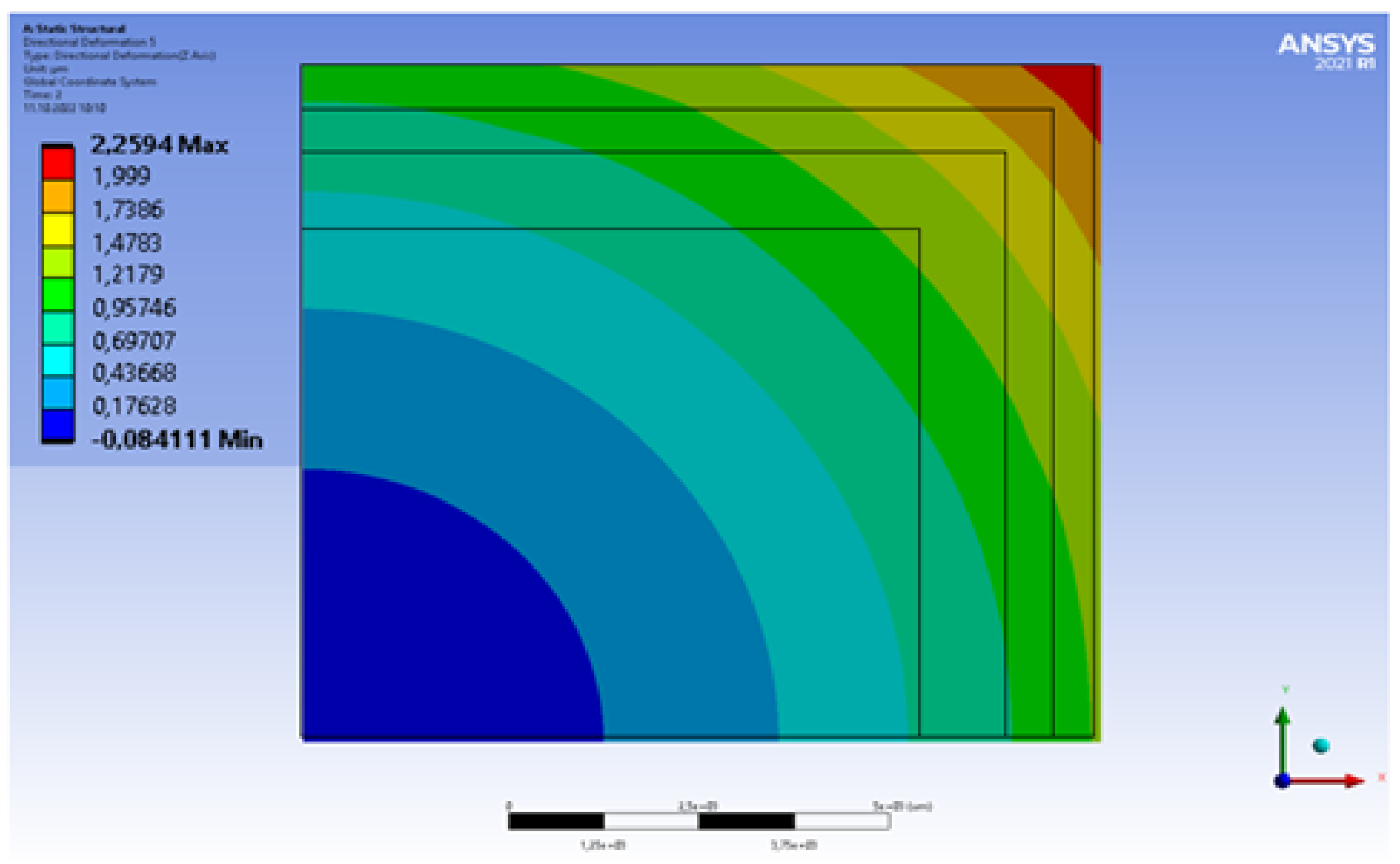

*Figure 4: MMA bow change for 3.7mm thick heat slug*

## FULL FEM MODEL

In the full FEM model (Figure 5) the die bond glue thickness is varied to be able to adjust the influence of the heat slug on the MEMS die stretching and thus the BC glue stress.

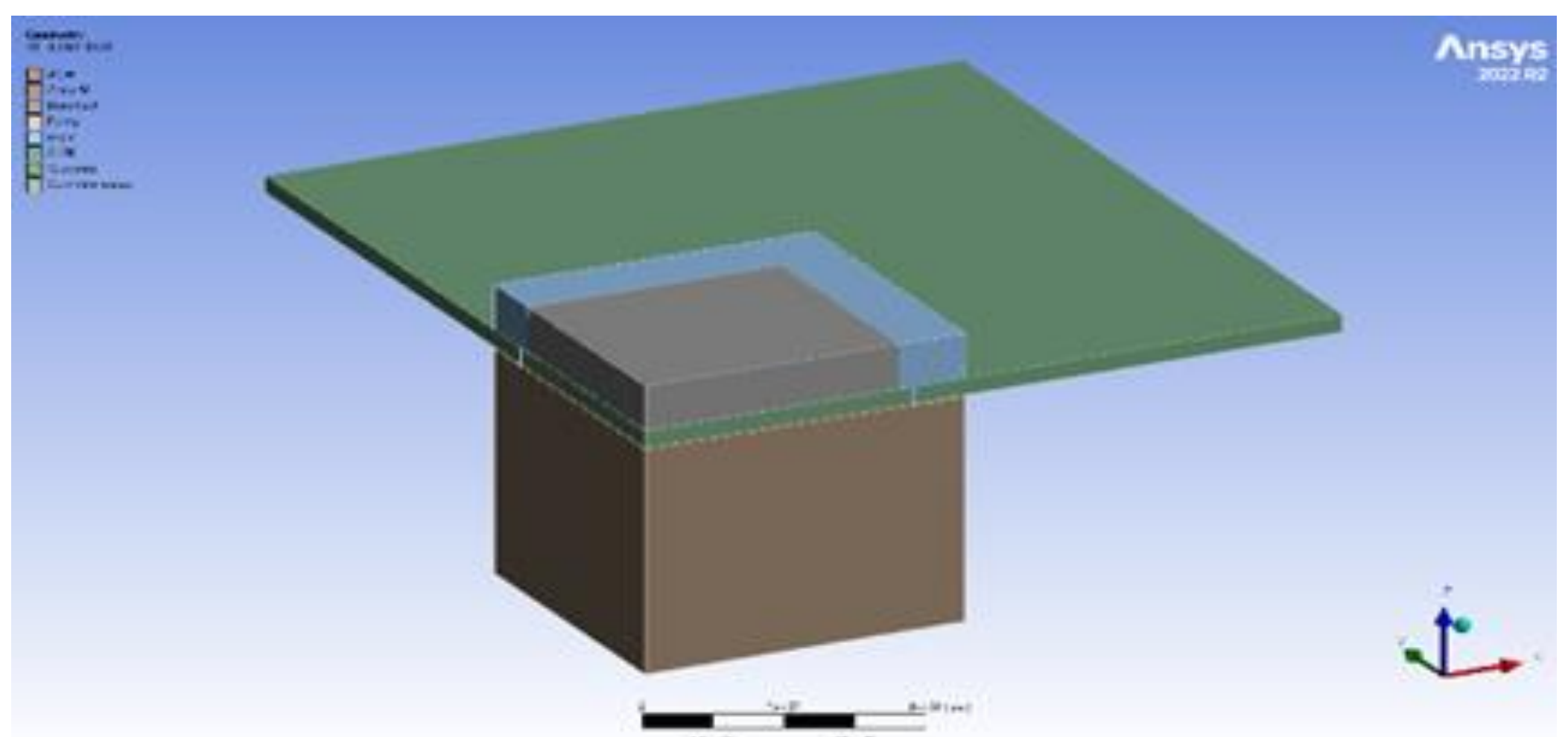

*Figure 5: one quarter of the package with thick heat slug, substrate, and mold*

We also compare the full model to the one without substrate to understand the sensitivity of the system to external forces. We find acceptable stress levels in the beam combiner glue and low enough alignment mismatch. The MMA bow is not ideal, but may be acceptable.

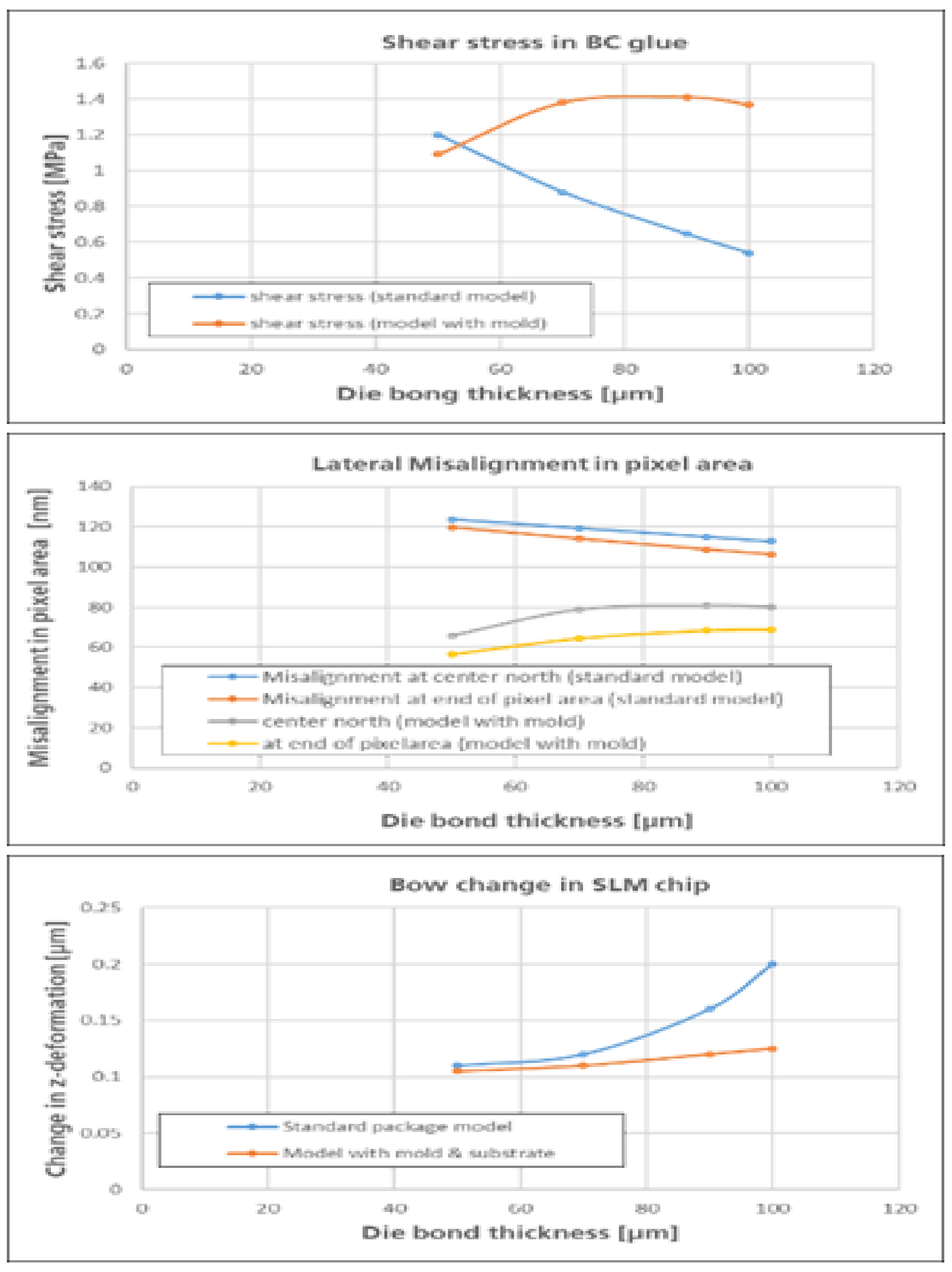

*Figure 6: comparisons of stress in BC glue (top), lateral misalignment (middle), and bow change in MMA chip (bottom) for various die bond thicknesses*

## CONCLUSION

We developed a packaging concept for a micro mirror array (MMA) that mostly meets the very challenging requirements to be usable in holographic applications. The bow change spec could not be met fully, but it can be met by stabilizing the MMA temperature by a Peltier element. The solution features a very thick heat slug and an optimized die bond glue thickness.

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