Thermally Induced Stress in a Glass-Silicon Bonded MEMS Micro-Structure

A Finite Element Analysis (FEA) using flexPDE

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The purpose of this numerical experiment is to learn about the field distribution of stress and strain in a MEMS microstructure.

This knowledge helps the engineer to better understand the stress on a bond line as will occur when anodic bonding of glass and silicon is attempted.

In this model, a high bonding temperature is impressed on all parts which subsequently cool to room temperature. As the material cools, it shrinks differing amounts in different materials and in different places within a given material, thus "freezing in" stress that, unless relieved, will exist for the life of the bonded part.

Depending on circumstances, the bond line may be sufficiently stressed to fail during the cooling process.

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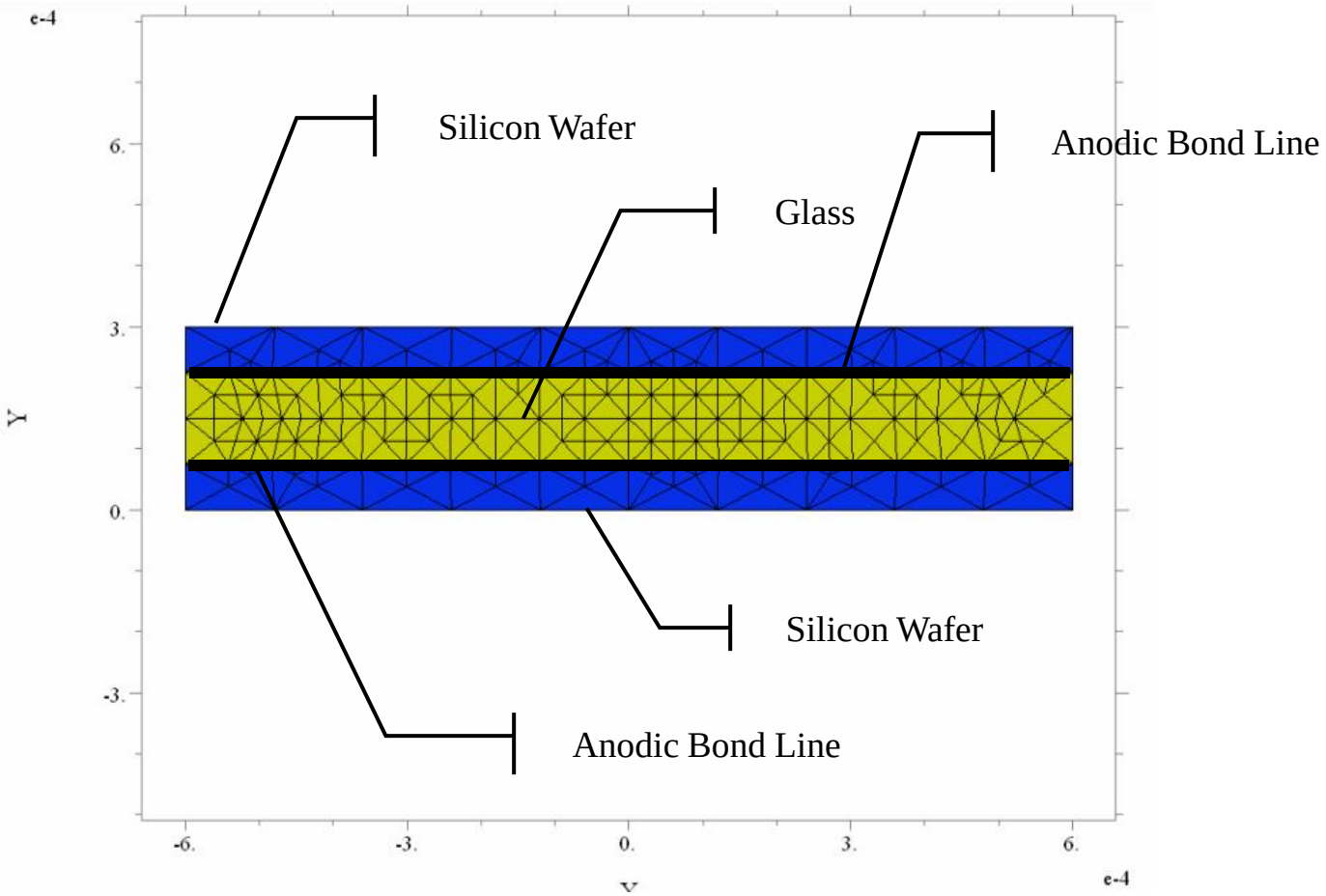

Model Geometry

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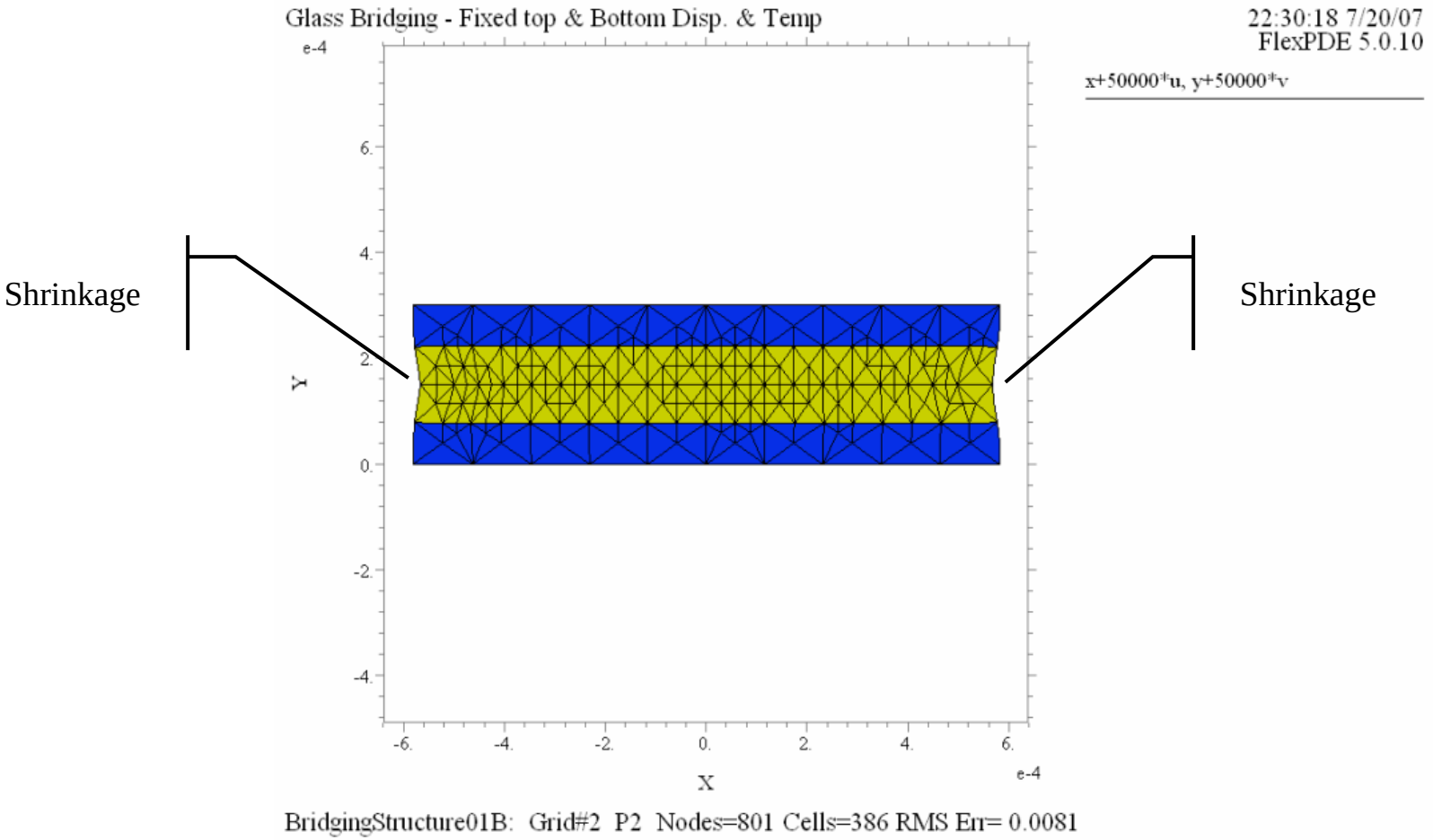

Strained Structure – Shrinkage is Greatly Magnified

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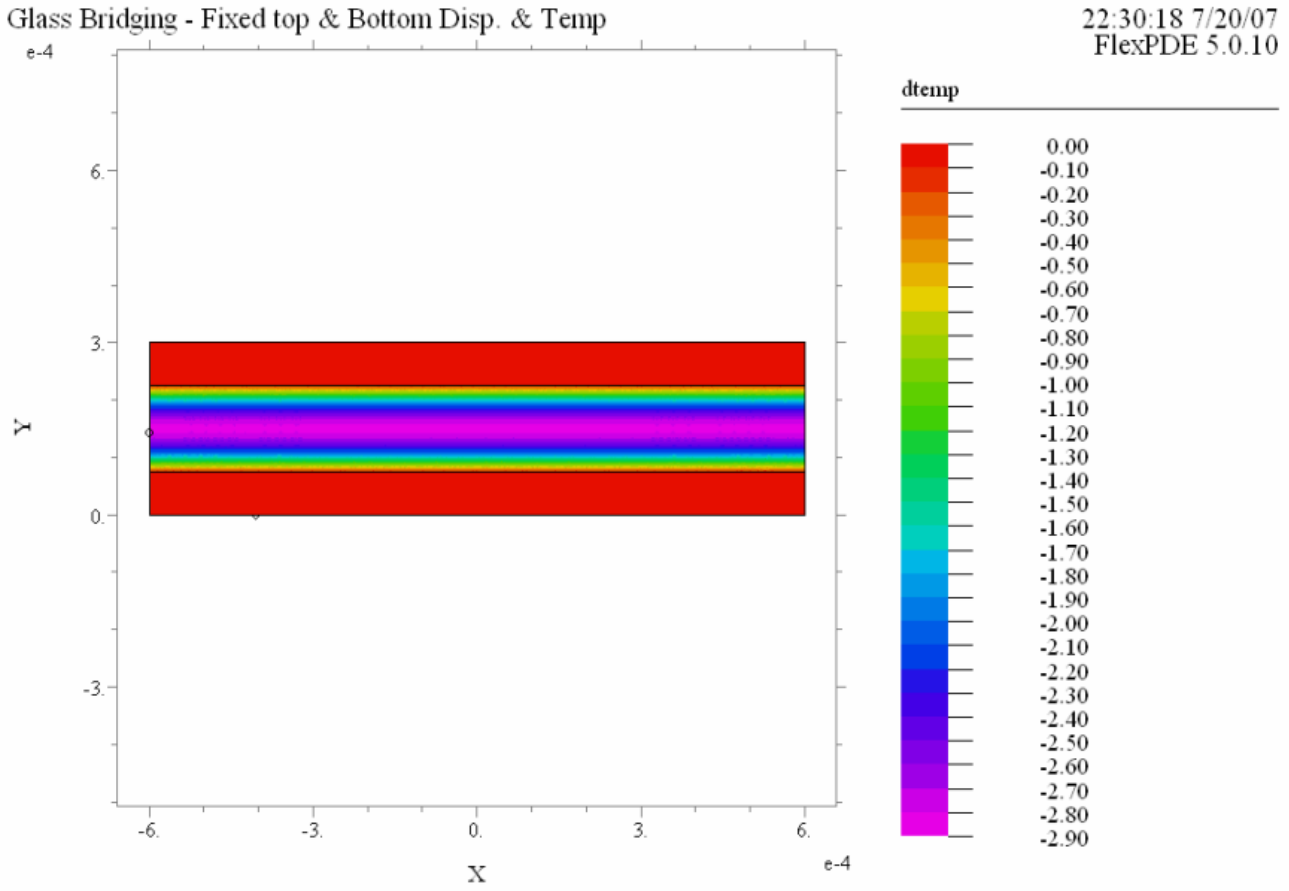

Temperature Gradient During Cooling

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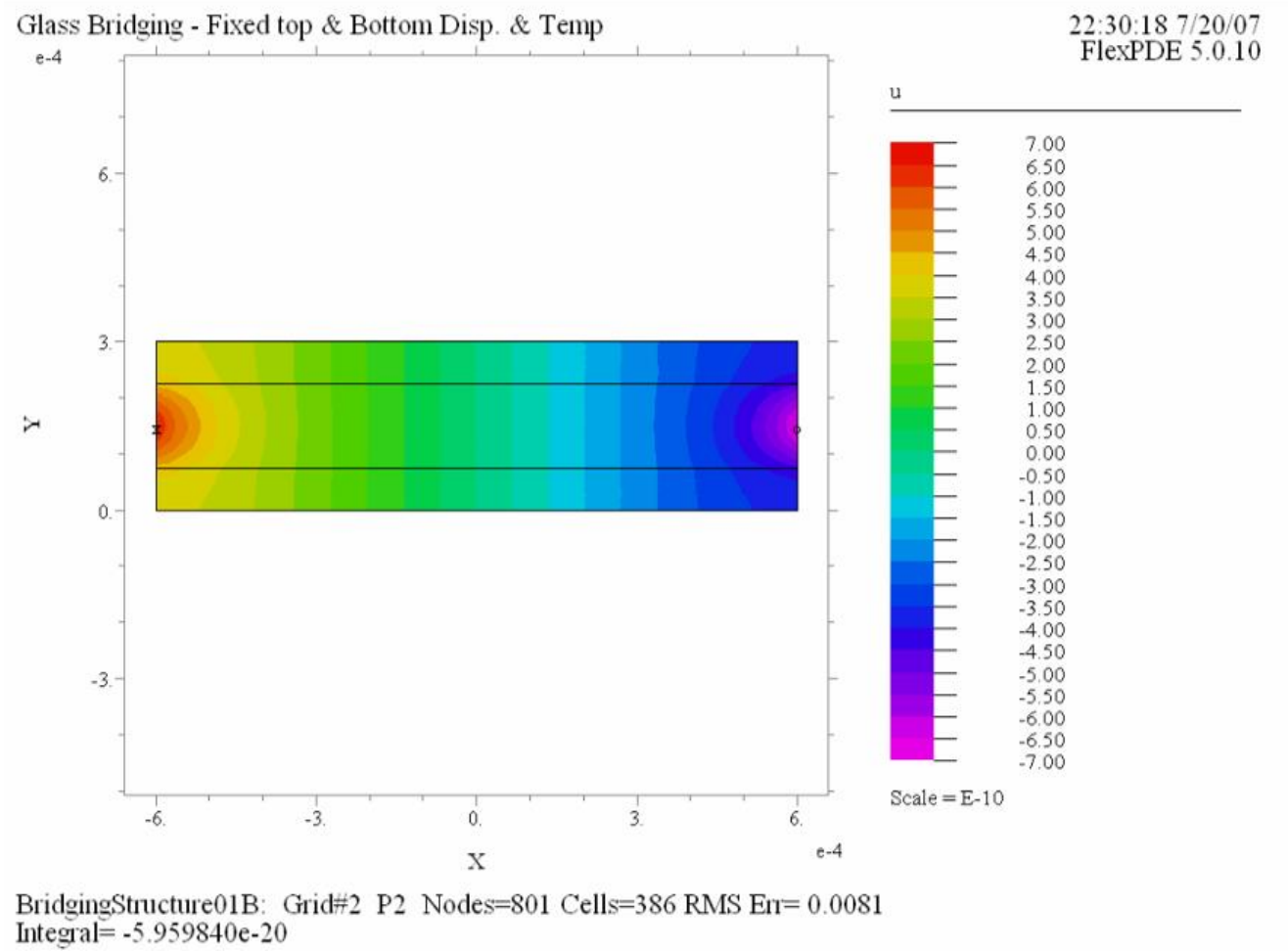

Strain Distribution Field – Horizontal Direction

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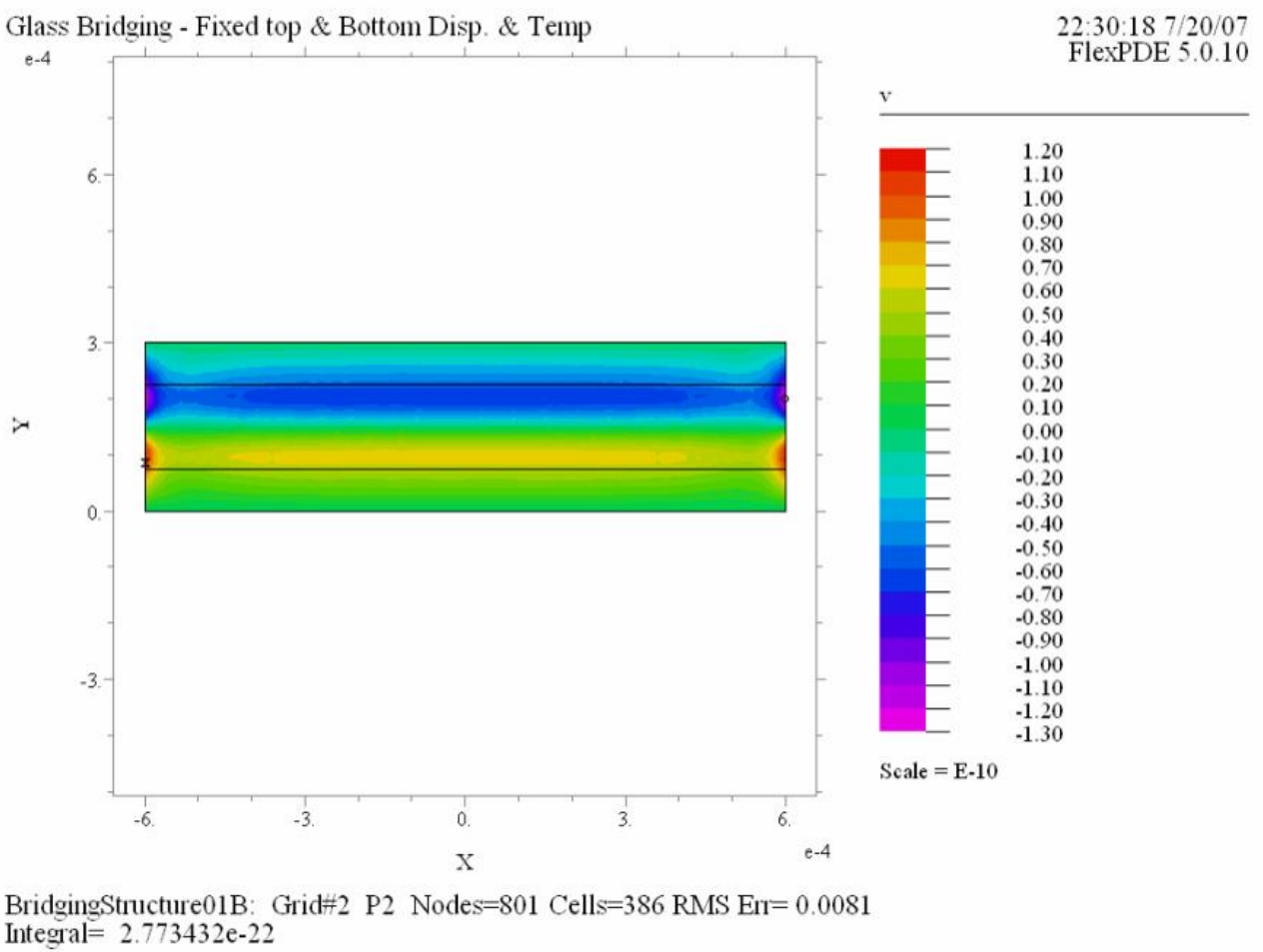

Strain Distribution Field – Vertical Direction

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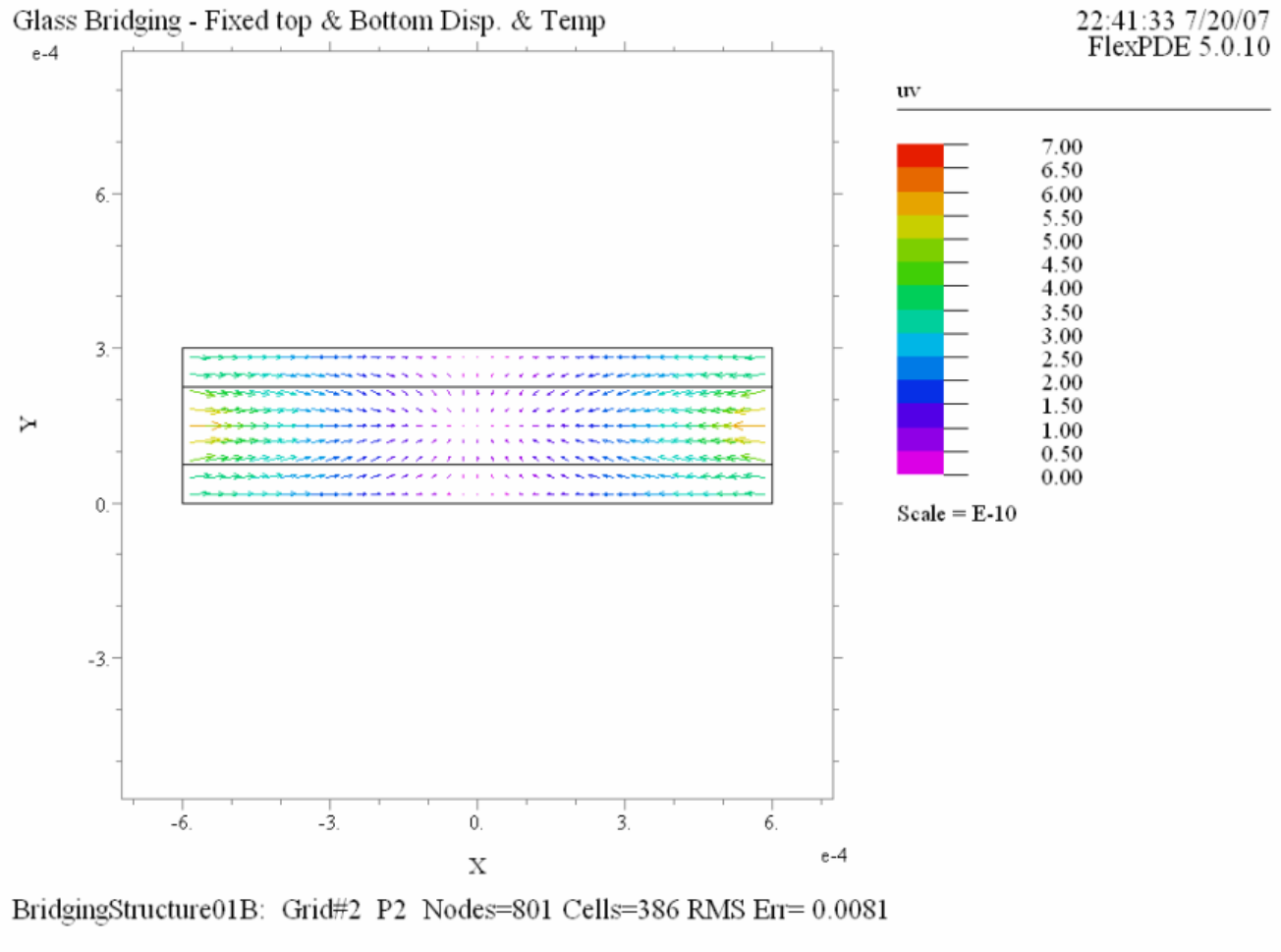

Strain Distribution Field – Vector Plot

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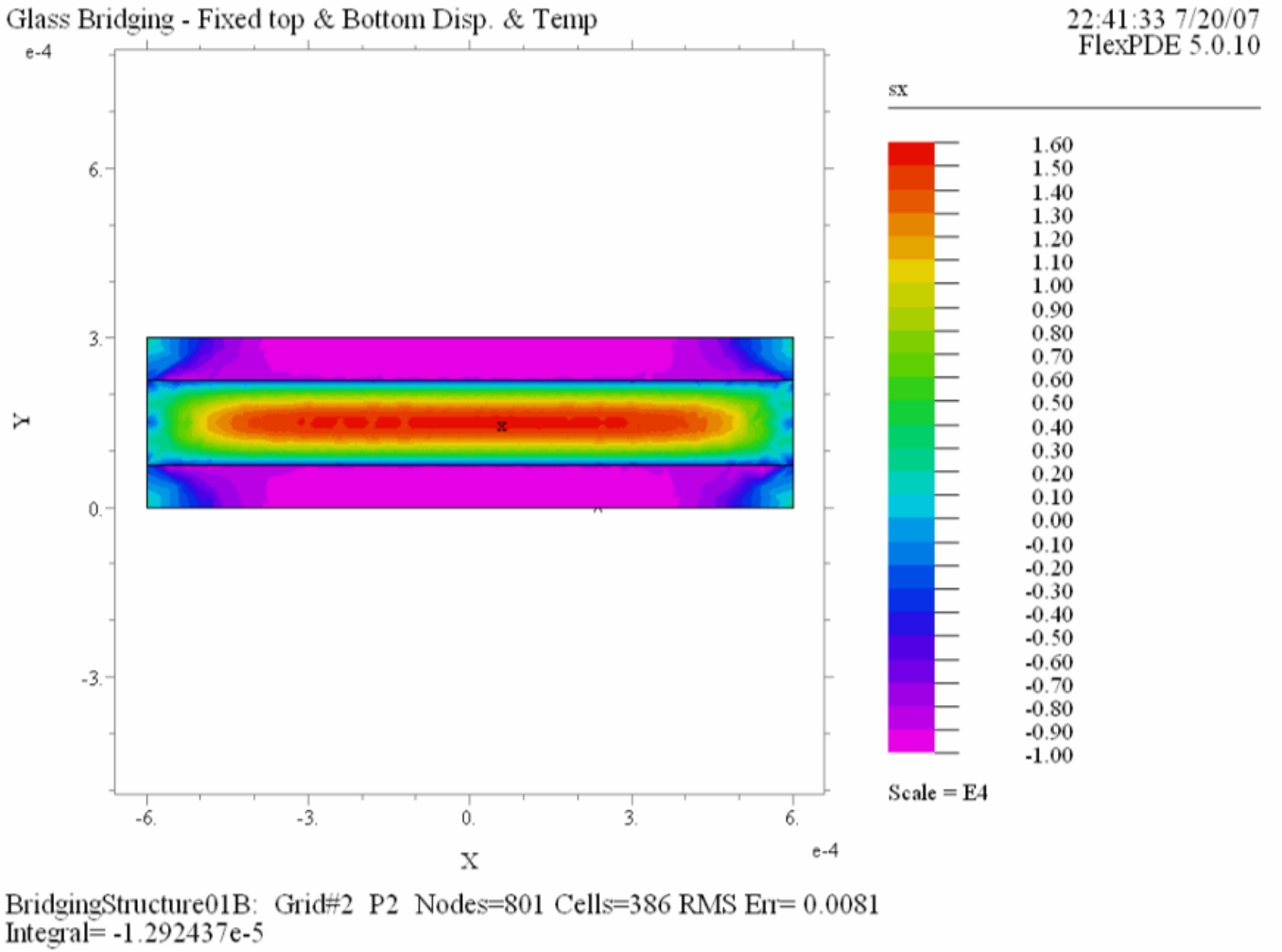

Stress Distribution Field – Horizontal Direction

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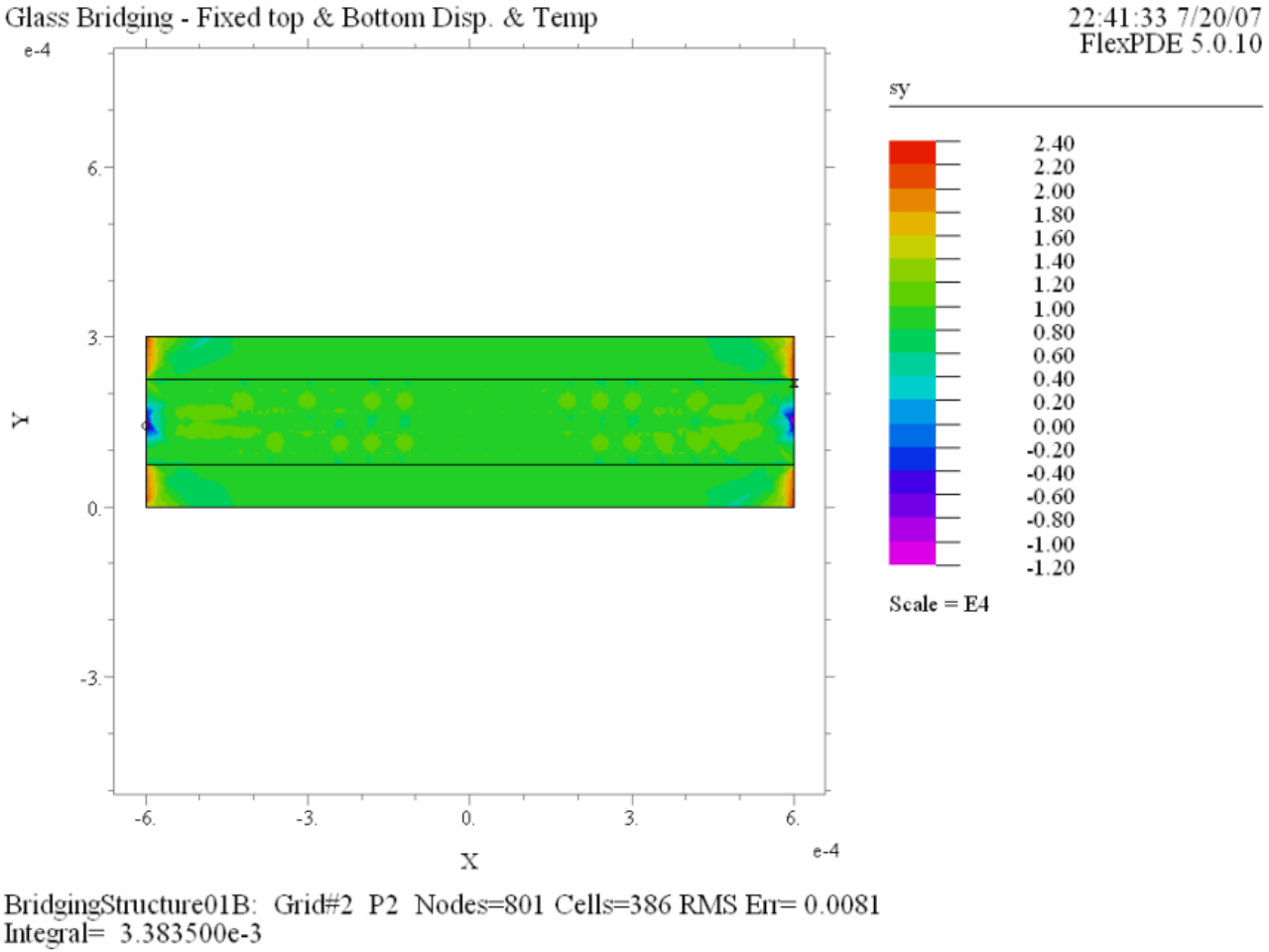

Stress Distribution Field – Vertical Direction

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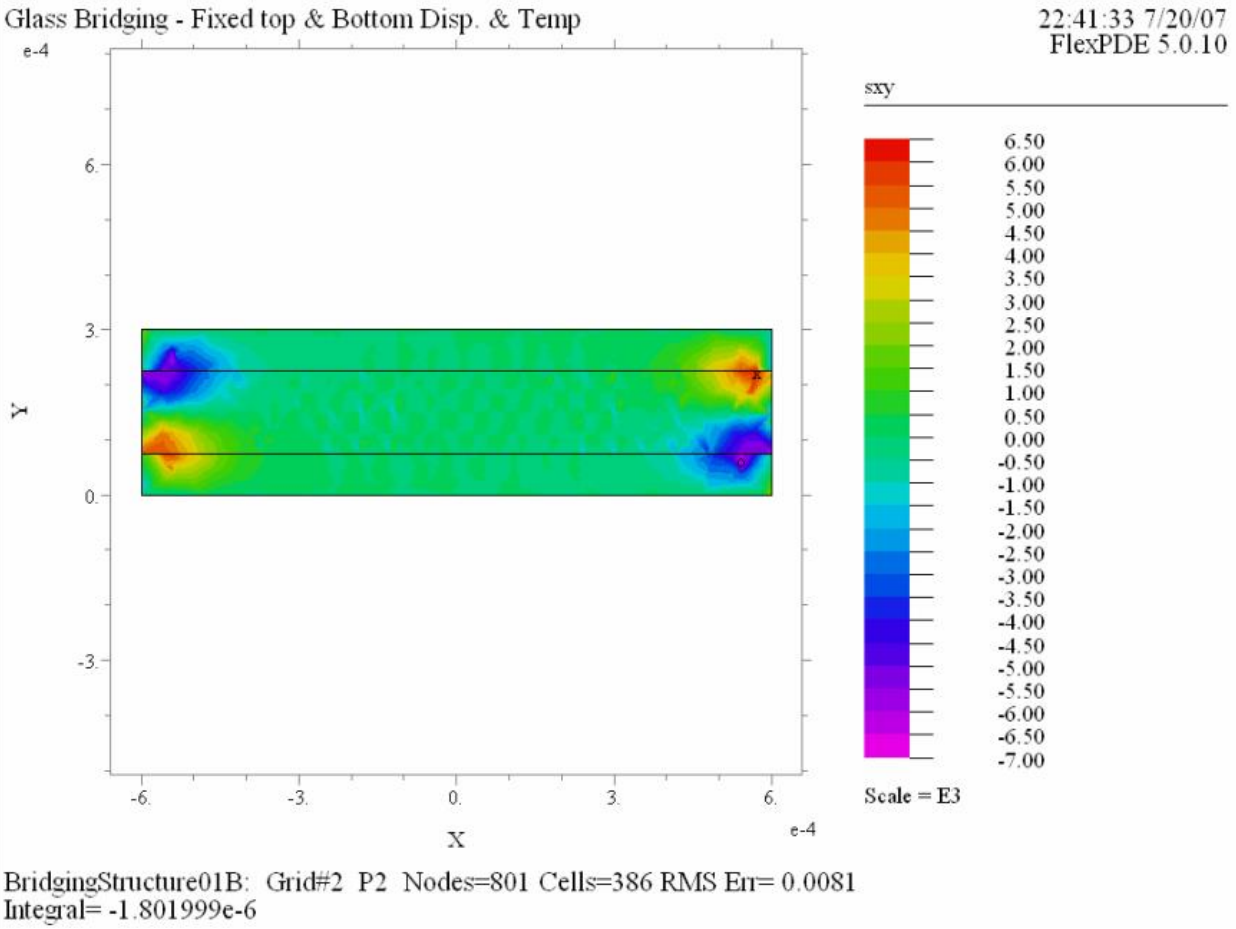

Shear Stress Distribution Field

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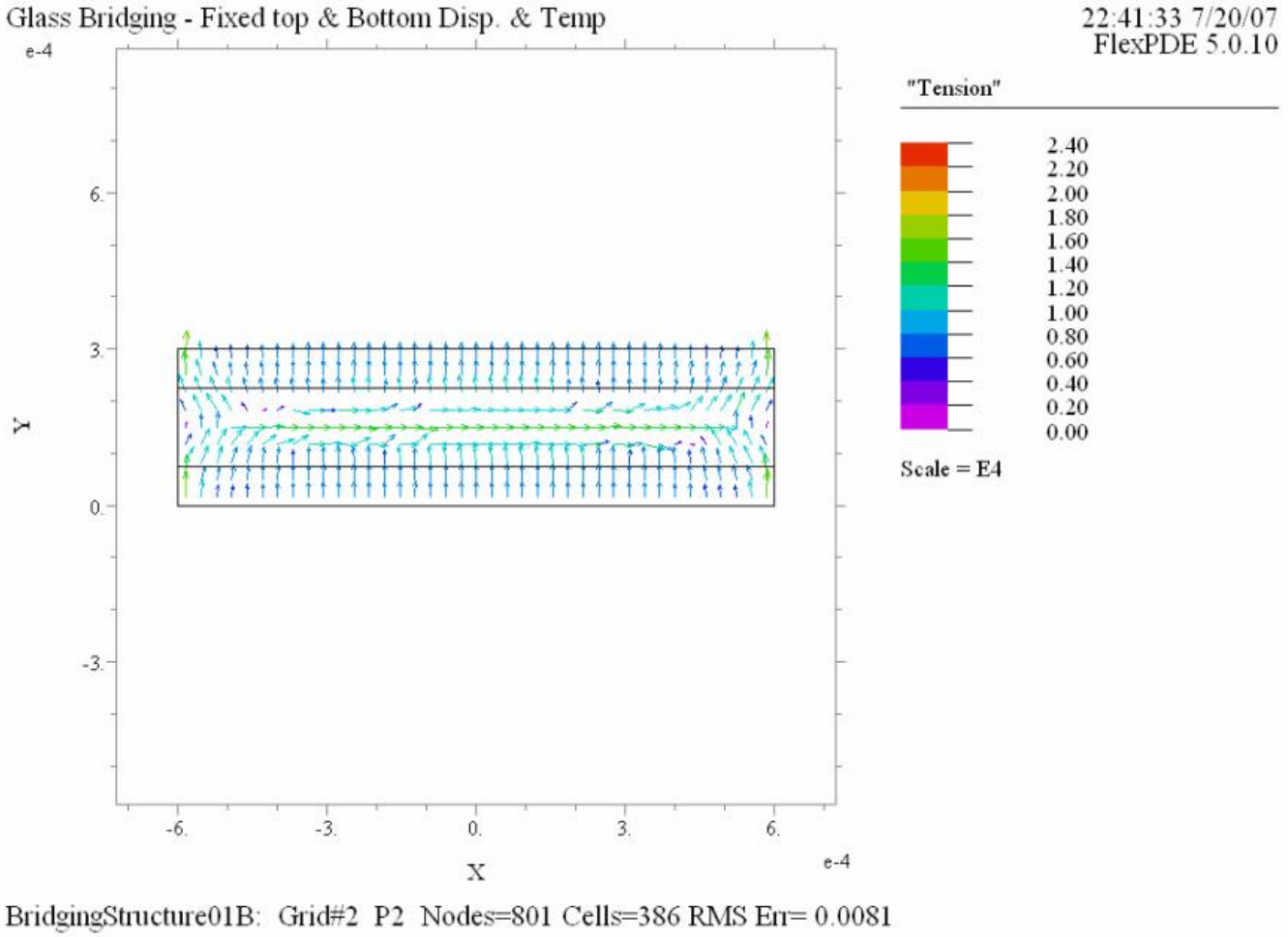

Stress Distribution Field – Tension

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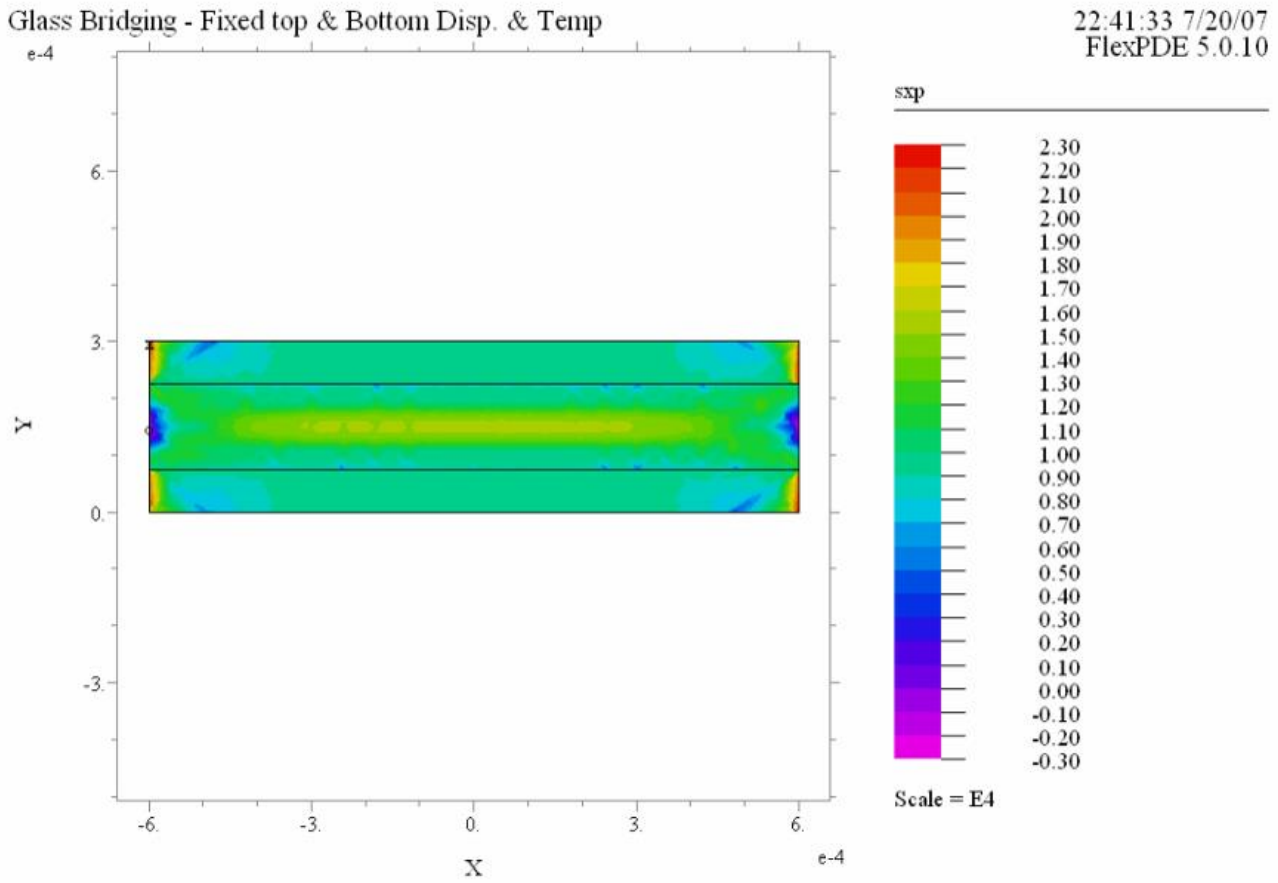

Principal Stress Distribution Field – Horizontal Component

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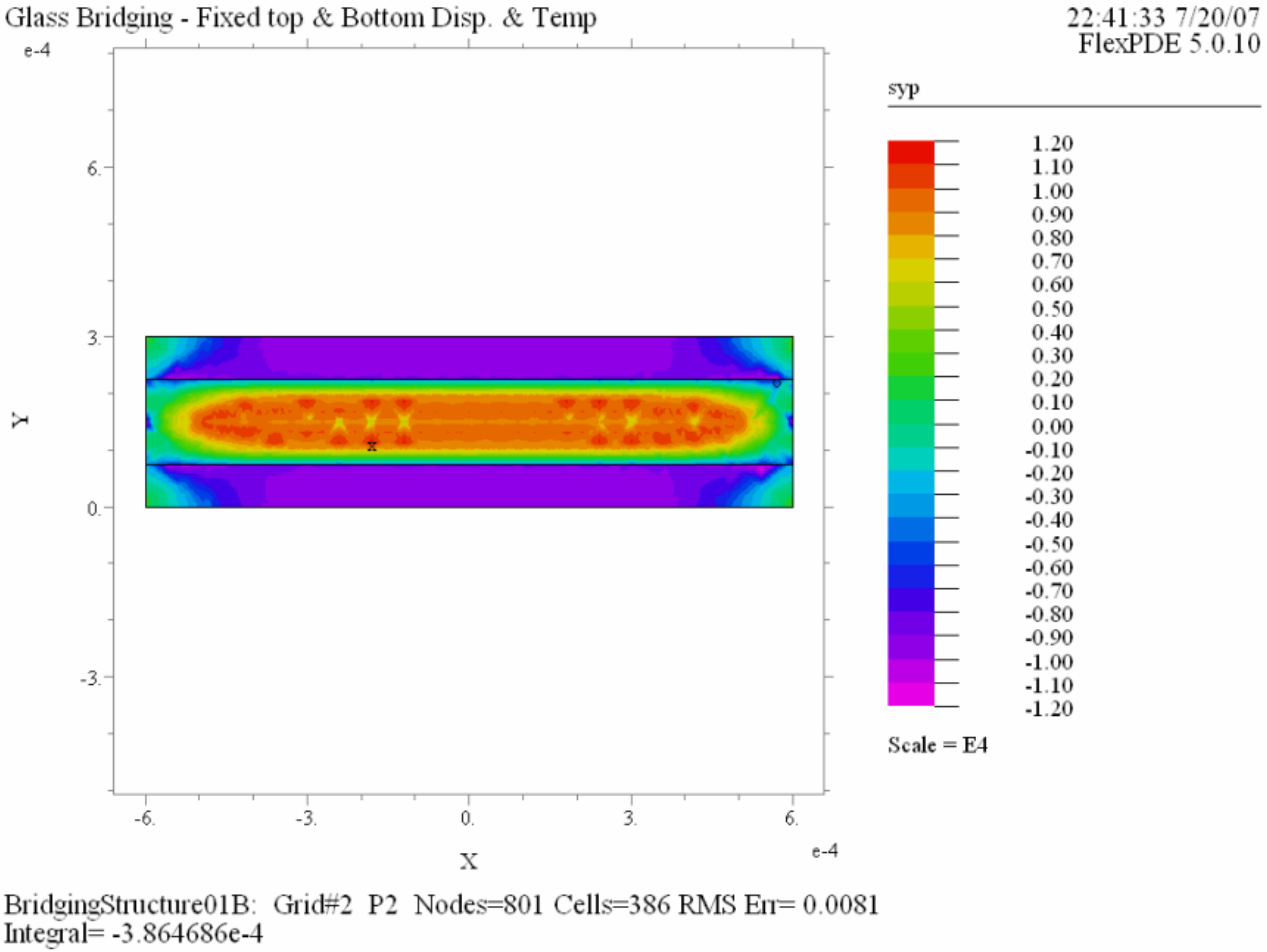

Principal Stress Distribution Field – Vertical Component

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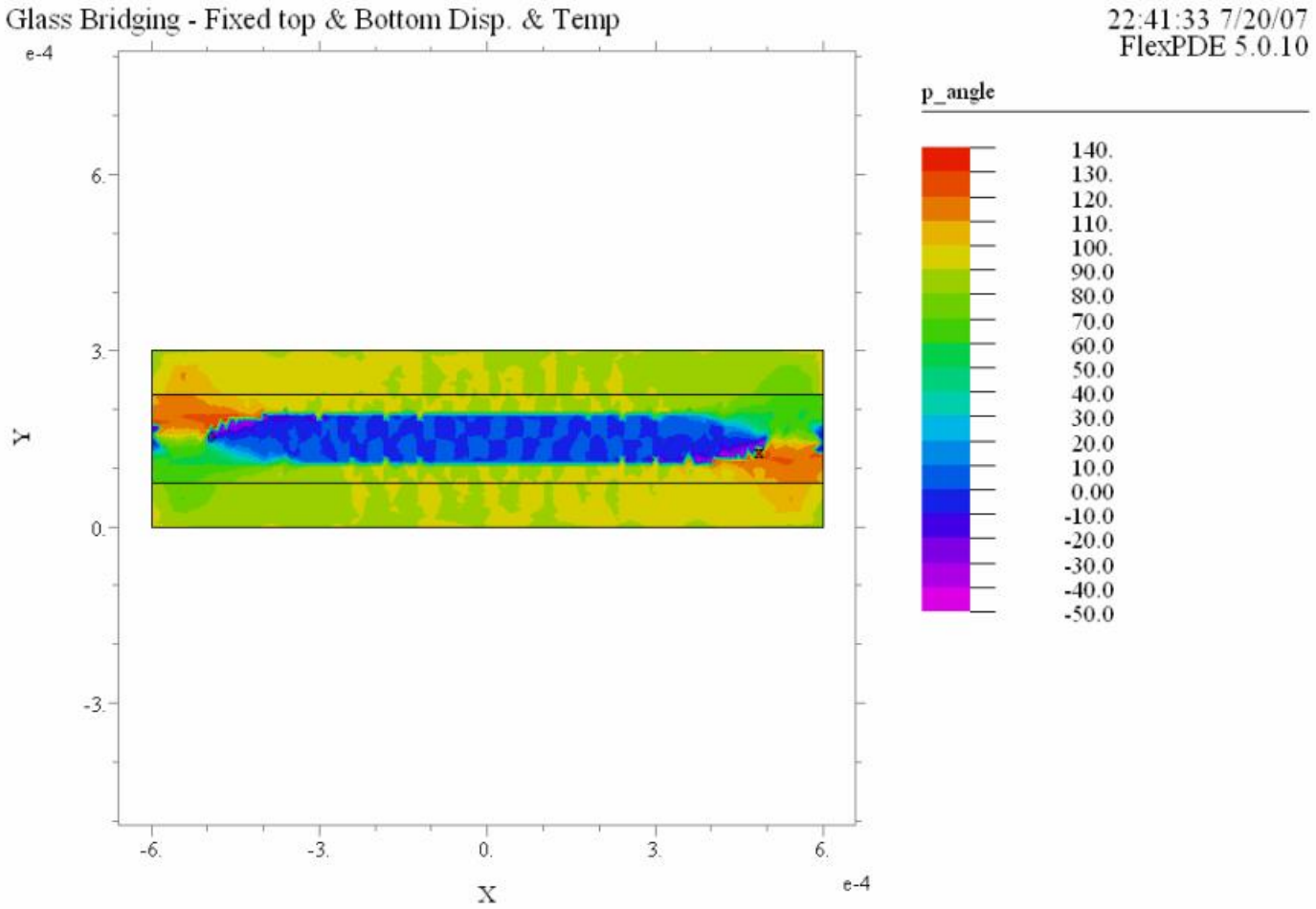

Angle of Principal Stress Distribution Field

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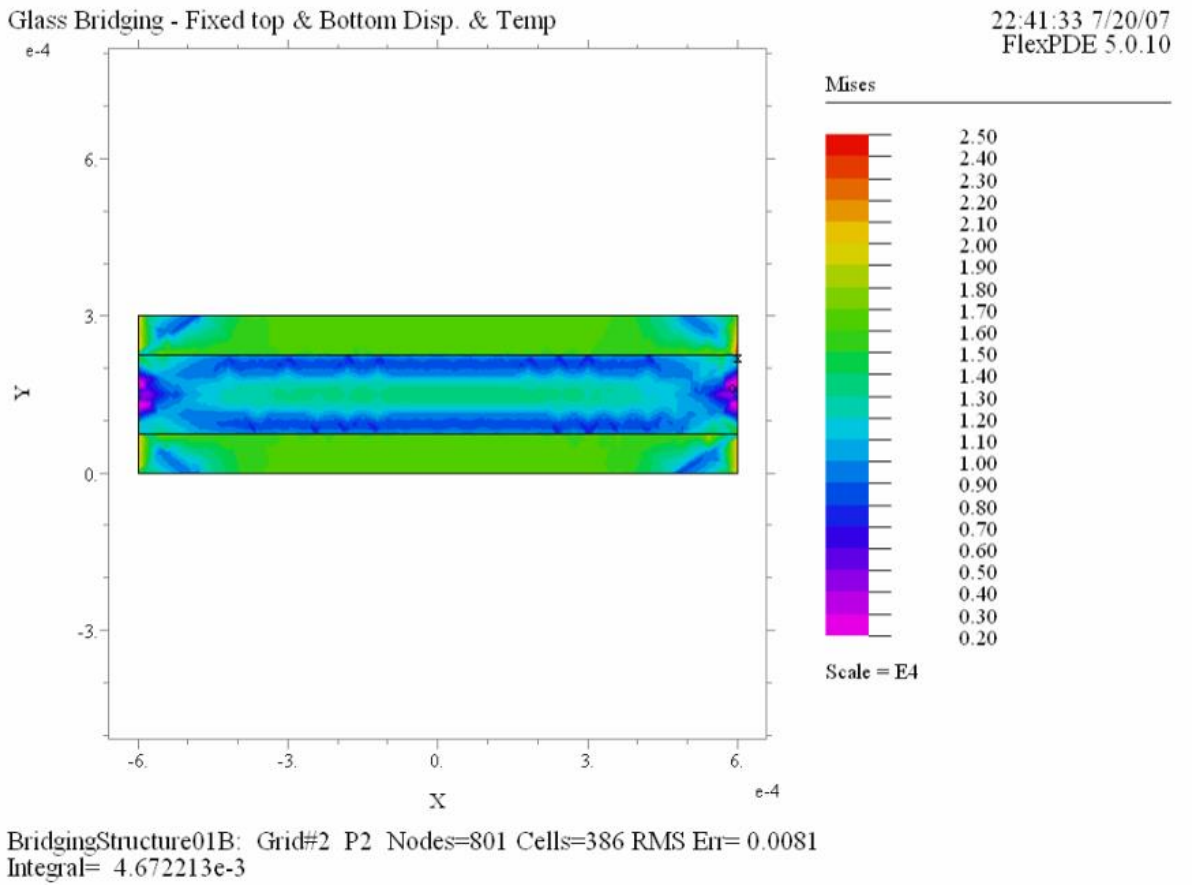

Von Mises Stress Distribution Field

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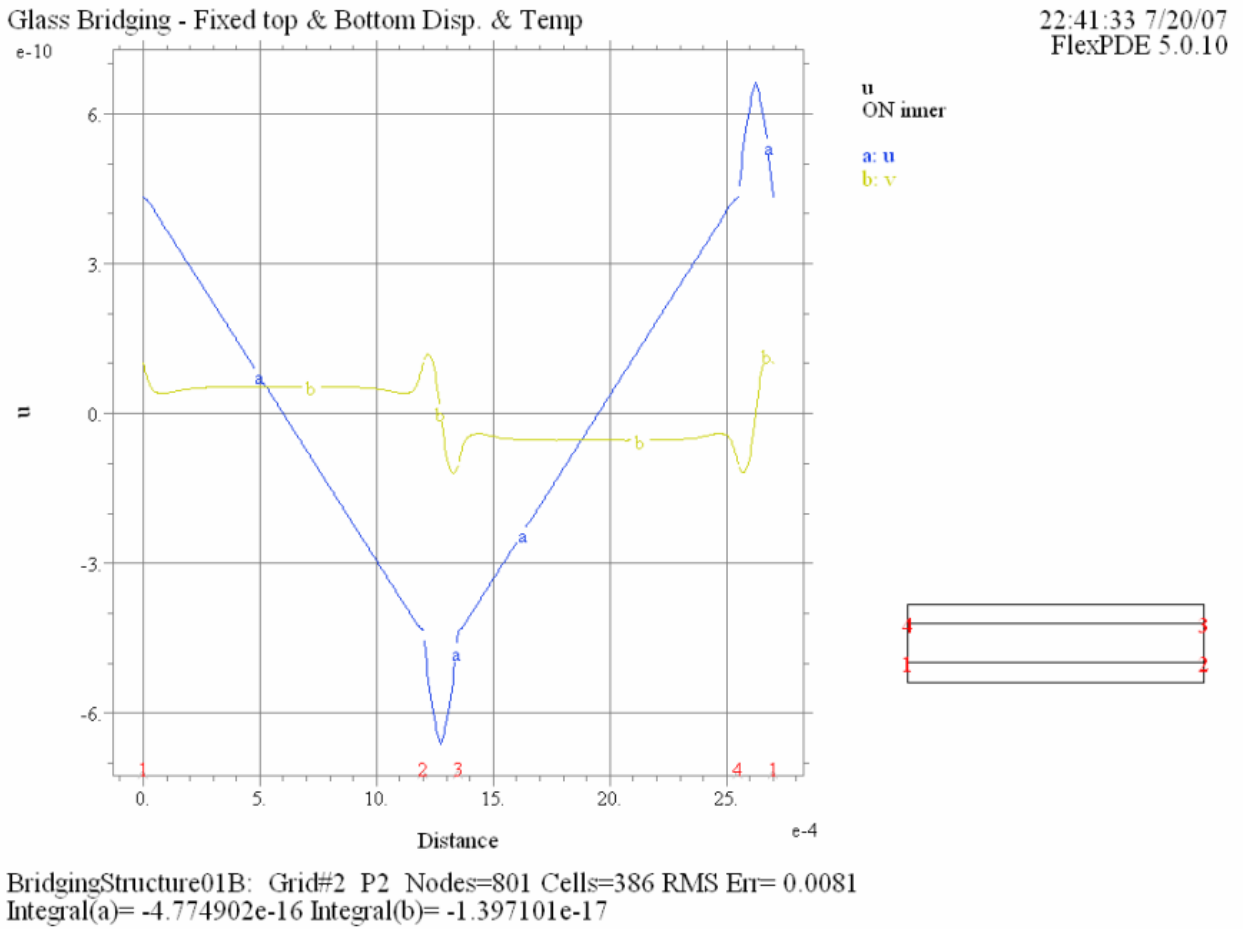

Strain Distribution Field – Horizontal Component

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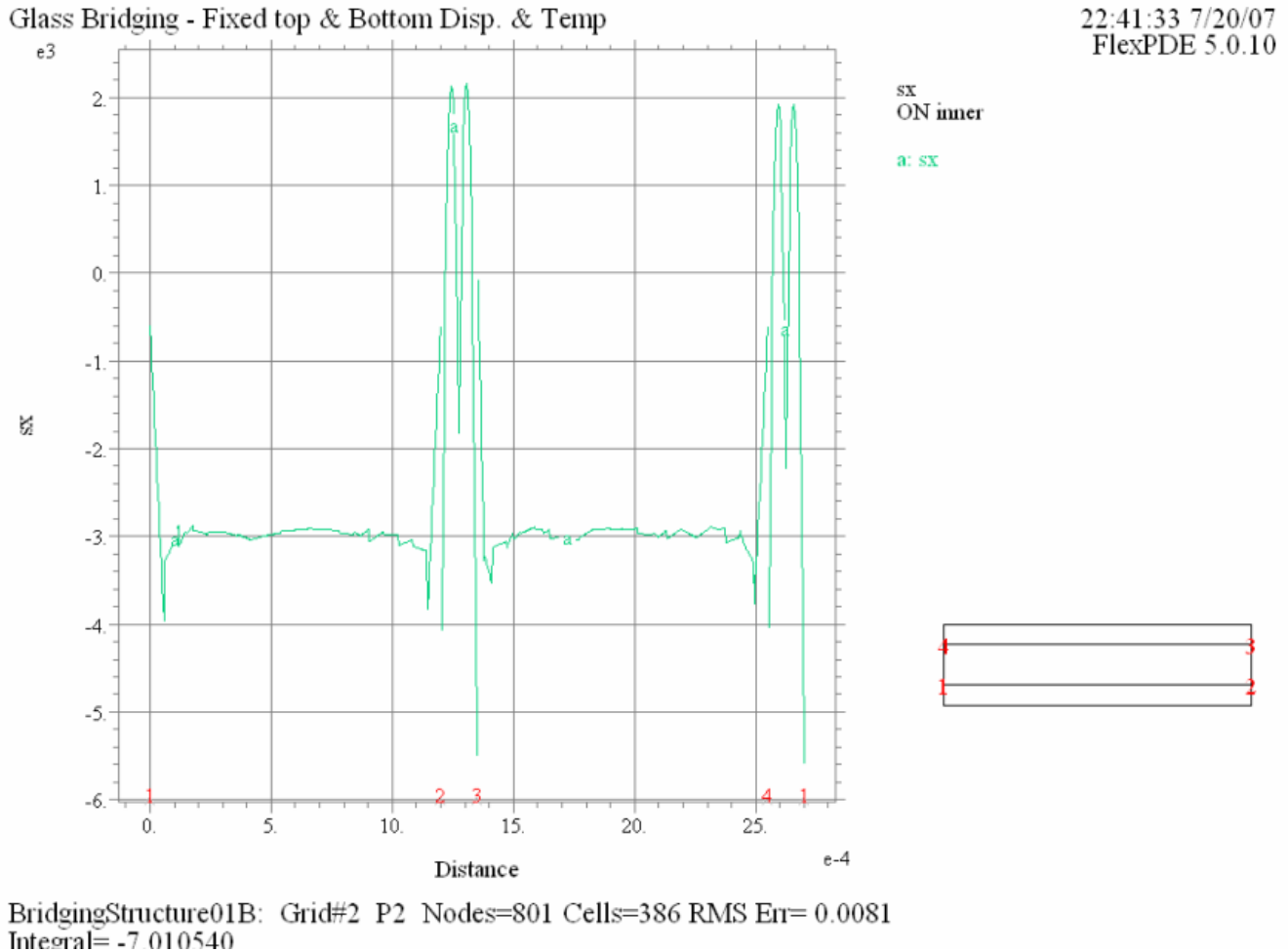

Stress Distribution Field – Horizontal Component

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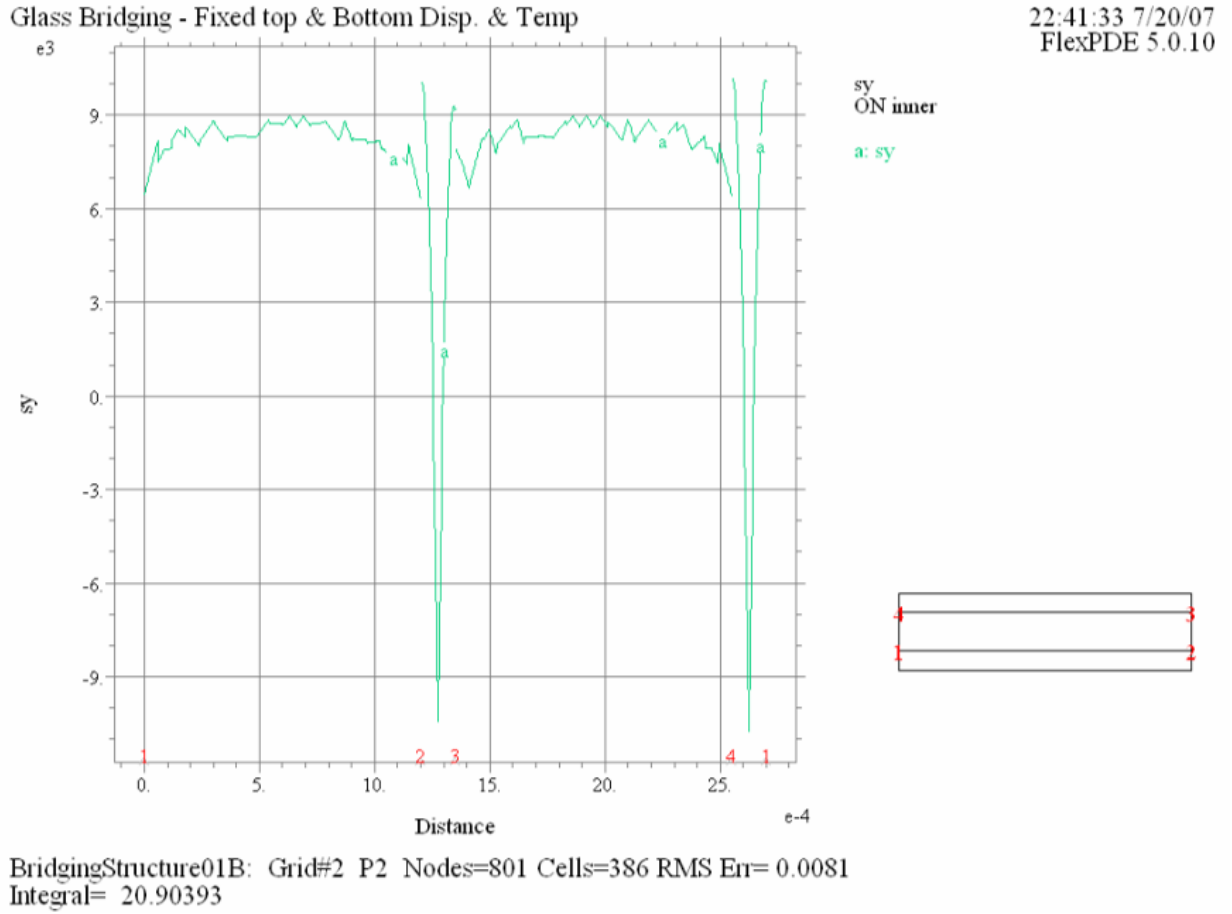

Stress Distribution Field – Vertical Component

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Summary and Conclusions

A finite element model has been developed that allows insight into the field distribution of stress and strain in an anodic bonded glass-silicon MEMS microstructure.

This knowledge helps the engineer to better understand the stress and strain on the glass-silicon bond line and other parts of the solution domain.

The model could be further developed in many further ways.

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