# Enhancing Flip Chip Reliability with Gallium Liquid Metal Solder Joints

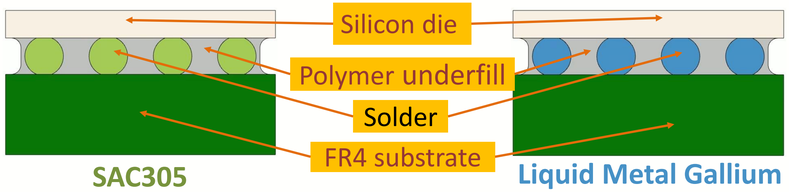
Jonathan Reggie Ebenezer, Mechanical Engineering
Mentor: Dr. Robert Wang, Associate Professor SEMTE
Ira A. Fulton School of Engineering

## How does Liquid Metal Gallium compare to SAC305 in enhancing the reliability of flip-chip packages?

## Motivation

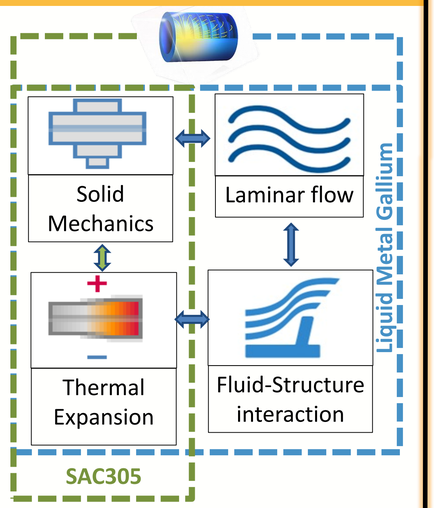
Conventional solder joint materials such as SAC305 suffers from reliability issues such as cracking under thermal strain. Gallium has better thermal and mechanical properties which may reduce stress and improve reliability.

This research explores the potential of gallium liquid metal as a solder joint material in flip-chip packages by investigating its impact on accommodating warpage and stress through parametric design optimization.

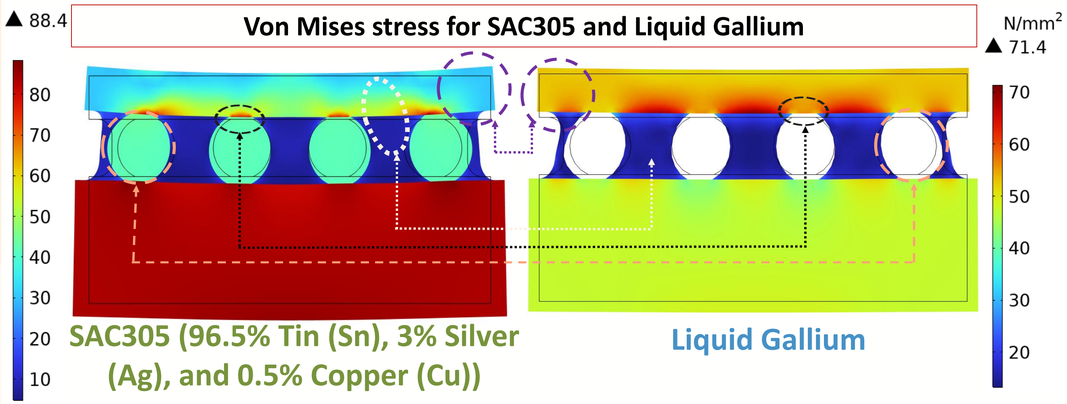



## Methodology

- **Investigating Gallium metal properties**
- **Modeling & Multiphase simulation:** Thermal warpage analysis (30°C to 150°C) on flip chip package
- **Parametric Design**: Optimized package parameters for better thermal performance.
- **Solder material**: SAC305 alloy Vs Gallium



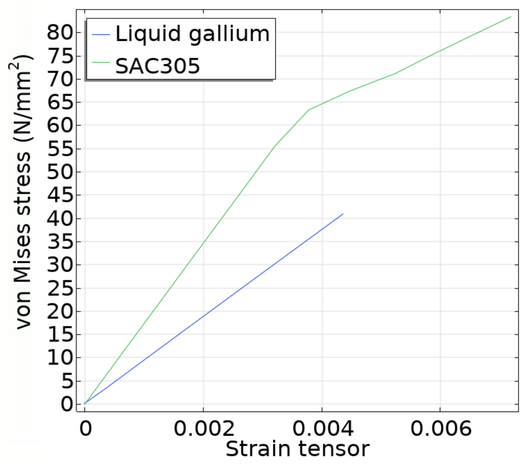

## Results and Discussion




Experiences localized high stress at the interfaces, leading to plastic deformation or failure.

Liquid Gallium exhibits low, evenly distributed Von Mises stress due to its liquid nature.

| | SAC305 | Liquid Gallium |
|---|---|---|
| Warpage | High | Low |
| Equivalent Plastic Strain | Plastic strain localized near solder joints | Very low plastic strain across the solder material |
| Underfill material | Less stress and more strain | Uniform stress and low overall strain |




SAC305 undergoes plastic deformation.

Liquid Gallium behaves like a fluid and does not experience yield or plasticity in the same way.

Therefore, Liquid Gallium's stress-strain curve remains linear rather than showing the typical plastic region seen in solid materials.

## Conclusions and Future Work

- Liquid gallium has the ability to accommodate thermal expansion and distribute stress evenly could provide significant benefits in long-term reliability.
- It can complement traditional solders in packaging designs, offering advantages in thermal cycling and low-stress applications.

**Future Directions:**

- Explore alternative underfill materials.
- Modify gallium by adding its oxide skin and/or adding alloying elements.

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Ira A. Fulton Schools of Engineering
Arizona State University