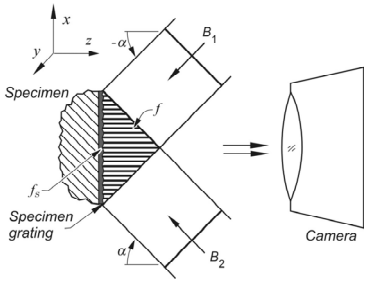
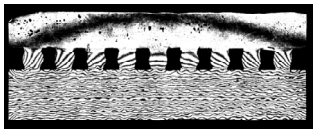
LOMSS

Moiré Interferometry for Real-Time Observation of Thermal Deformations



V field



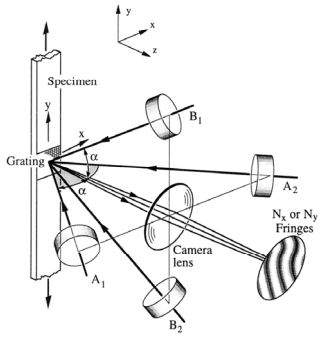
$$U(x,y) = \frac{1}{f} N_x(x,y)$$

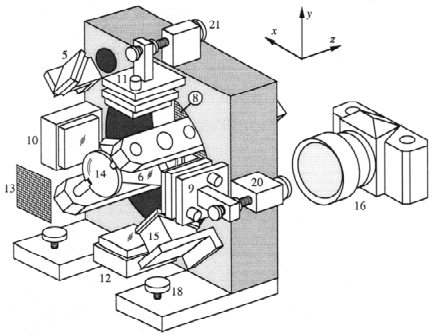
$$V(x,y) = \frac{1}{f} N_y(x,y) \qquad f = 2400\, lines/mm$$

Schematic diagram of moiré interferometry

System Integration and Optimization

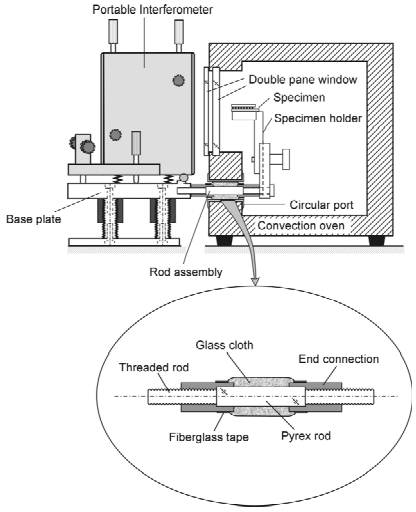
Implementation of 4 beam interferometry (1st generation)





System Integration and Optimization

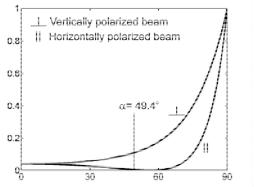
Integration with thermal chamber (2nd generation)

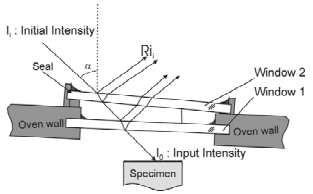


- Compact and portable interferometer design
- Mechanical isolation of the interferometer and the specimen from the oven to prevent undesirable vibration caused by the oven
- Minimization of heat conduction from the environment chamber to the optical system using the Pyrex connecting rods
- The oven chamber can be either convection-based or conduction-based

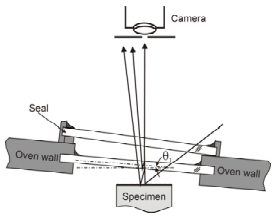
System Integration and Optimization

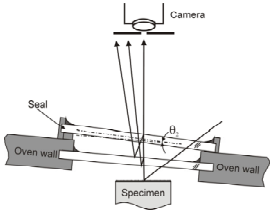
4) Optimization of the system regarding oven installation





Optimization of beam polarization with respect to the plane of incidence.

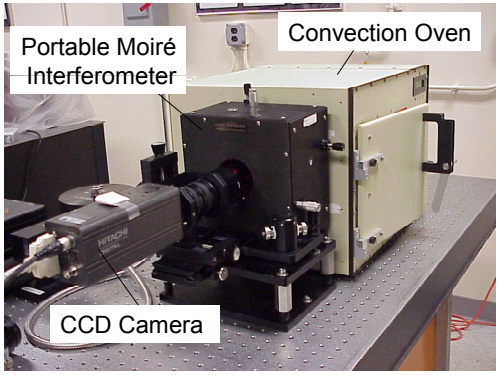




Window angle optimization to eliminate undesired interface patterns

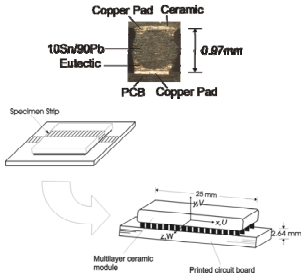
Convection-Based System

Photograph of convection-based real-time moiré interferometry

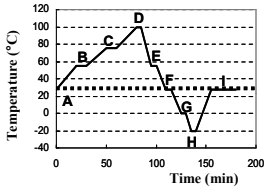


Convection-Based System

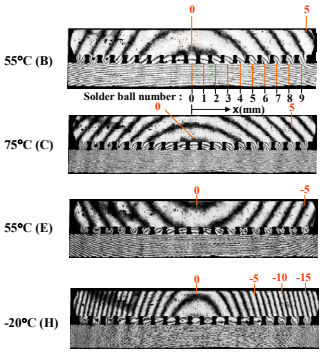
Ceramic BGA package subjected to thermal cycling



Specimen Configuration

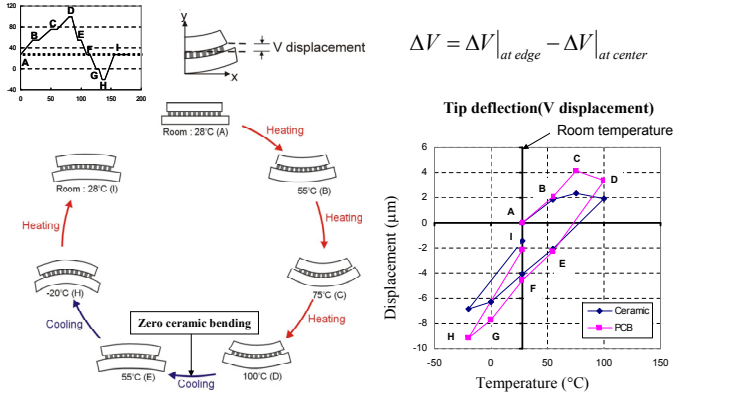


Thermal cycle profile

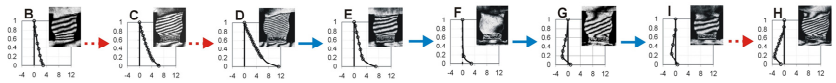


Convection-Based System

Ceramic BGA package subjected to thermal cycling (2)

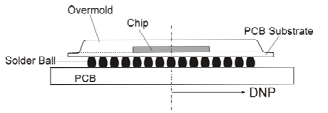


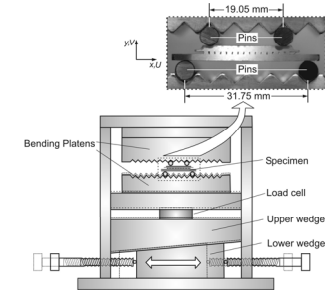
$$\Delta V = \Delta V\big|_{at\ edge} - \Delta V\big|_{at\ center}$$

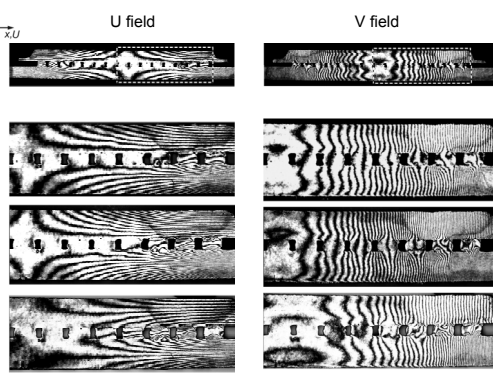


Convection-Based System

Plastic BGA package subjected to flexural loading

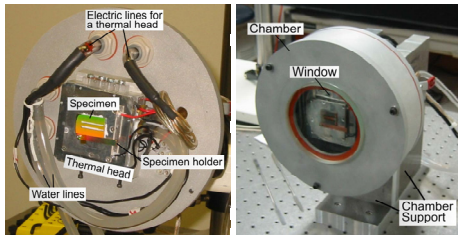


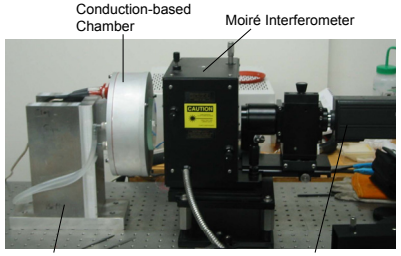




Conduction-Based System

Configuration of conduction based moiré interferometry system

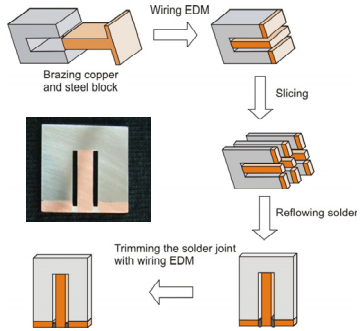




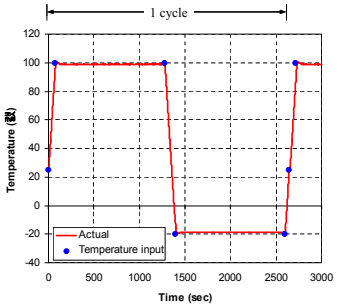
- High power (30W) thermo-electric cooler was used for wider temperature ranges and higher ramp rate.
- In order to achieve uniform temperature and to remove moistures, mechanical pump was used to maintain low chamber pressure (~ 0.08 atm) during the experiment.
- The gap between the specimen and thermal head was filled by thermal compound/grease to improve heat transfer.
- Maximum ramp rate of 90°C/min was achieved. (c.f., 10°C/min in convection-based system)

Conduction-Based System

Characterization of the creep behavior of eutectic solder subjected to thermal cycling



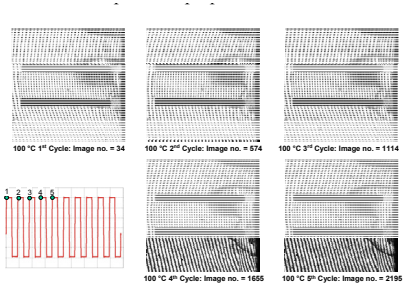
Specimen preparation



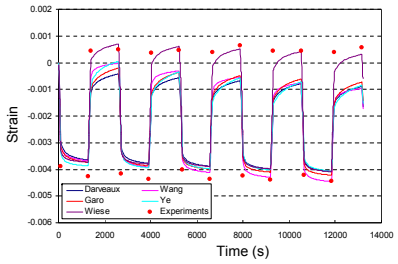
Thermal cycling profile

Conduction-Based System

Characterization of the creep behavior of eutectic solder subjected to thermal cycling (2)



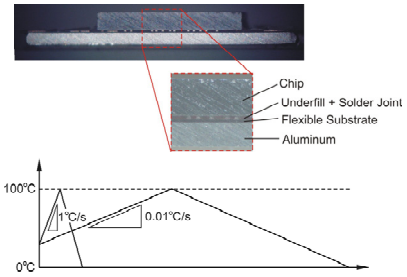
Cycle-by-cycle U field deformation history

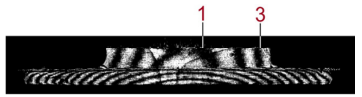


Verification of numerical models

Conduction-Based System

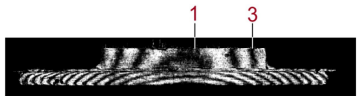
The effect of ramp rate on deformation of flip chip package





Ramp rate = 1°C/s

U



Ramp rate = 0.01°C/s