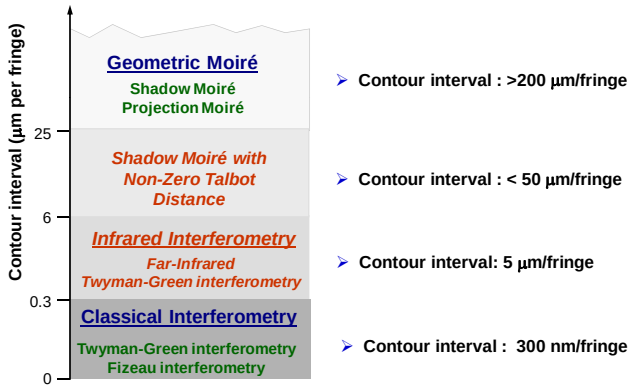
LOMSS

Real-Time Observation of Warpage of Semiconductor Packaging Components

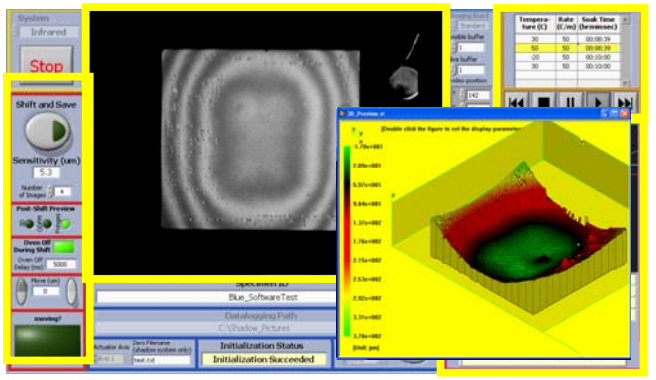


- Contour interval : >200 μm/fringe
- Contour interval : < 50 μm/fringe
- Contour interval: 5 μm/fringe
- Contour interval : 300 nm/fringe

Advanced Control and Fringe Measurement Software

A single LabView-based application controls both systems, offering features such as:

- *Live video display*
- *Phase-shifting controls*
- *Real-time oven monitoring*
- *On-the-fly temperature profile controls*
- ***Real-time 3D preview** of the specimen's surface topography*



Shadow Moire using Non-Zero Talbot Distance (SM-NT)

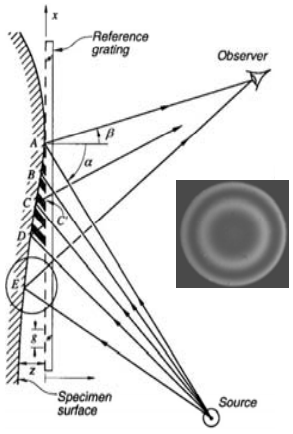
Basics of Shadow Moiré

Shadow moiré provides topographical maps (absolute out-of-plane displacements)

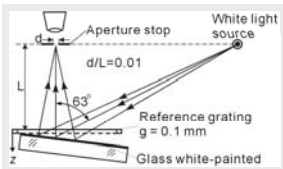
Governing Equation

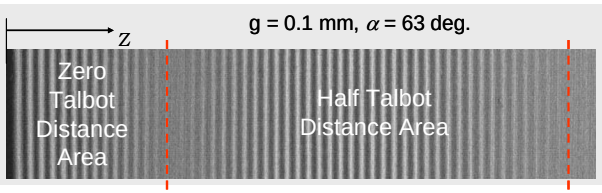
$$z(x,y) = \frac{g}{\tan\alpha + \tan\beta} N(x,y)$$

Contour Interval (Γ) : $\frac{g}{\tan\alpha + \tan\beta}$



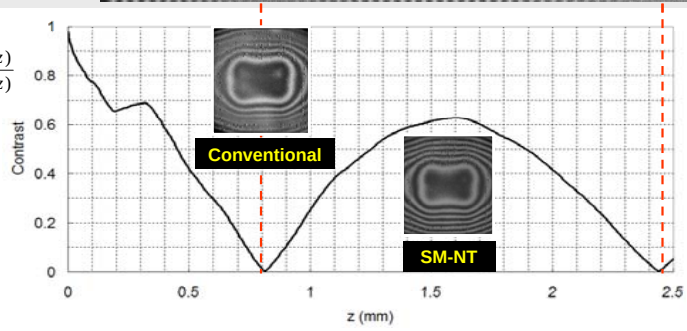
SM-NT Benefits



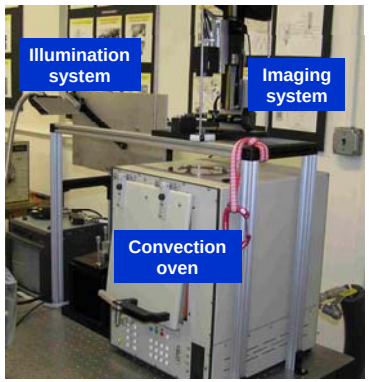


$$C_T(z) = \frac{I_s^{max}(z) - I_s^{min}(z)}{I_s^{max}(z) + I_s^{min}(z)}$$

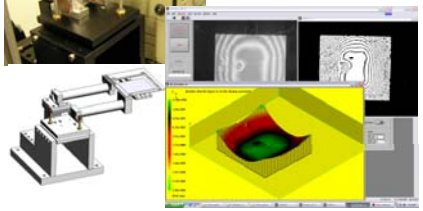
Talbot Distance is a function of grating pitch and incidence angle.



SM-NT Implementation



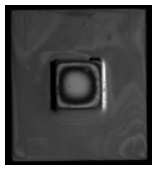
Completely automated temperature control using convection oven

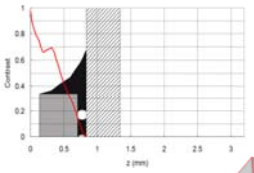


- ***Temperature Range: -40ºC to 250ºC***
- ***Output: 2-D contour map or 3-D deformed shape***

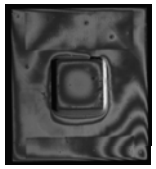
Comparison of SM-NT to Traditional SM

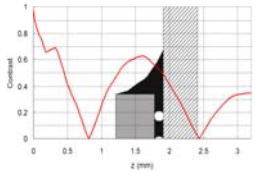
Conventional Shadow Moiré

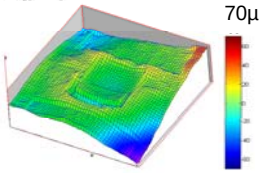




Shadow Moiré with Non-Zero Talbot Distance







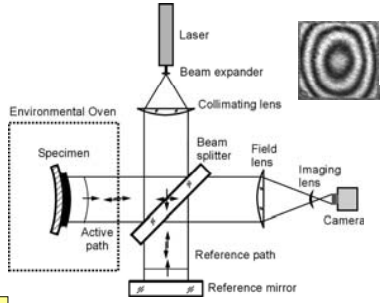
70µ

-70µm

Advanced Twyman-Green Implementations

Basics of Twyman-Green (T/G) Interferometry

- Out-of-plane displacement measurement technique
- Coherent light source is split into active and reference wavefronts
  - Active wavefront distorted by specimen's surface
  - Reference wavefront remains undistorted
  - Bringing the beams together creates an interference pattern contouring the specimen's topography



Governing Equation: $z(x,y) = \frac{\lambda}{2} N(x,y)$

T/G Implementation for Real-time Observation

Setup

514nm argon laser

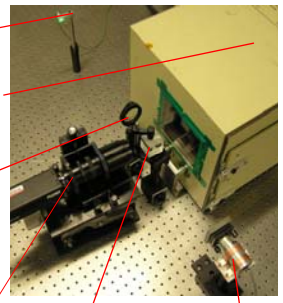
Environmental chamber

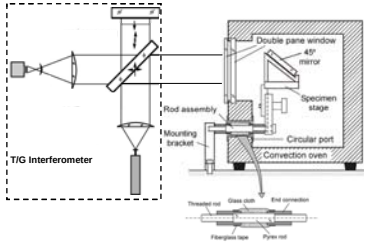
Collimating lens

Imaging system

Beam splitter

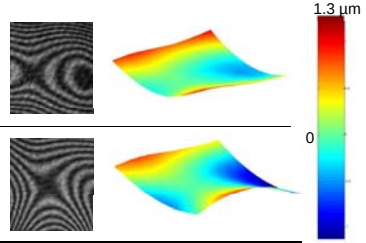
PZT with mounted reference mirror





210°C

24°C



1.3 µm

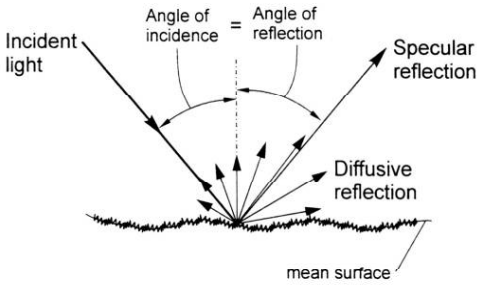
0

-1.45µm

Extension of T/G into Far Infrared Domain

Rayleigh Criterion for Effective Roughness

$$\varepsilon_r = \frac{4\pi h \cos\theta}{\lambda}$$

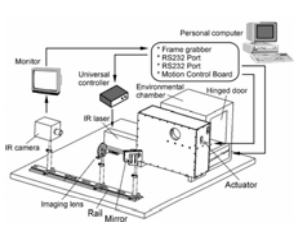


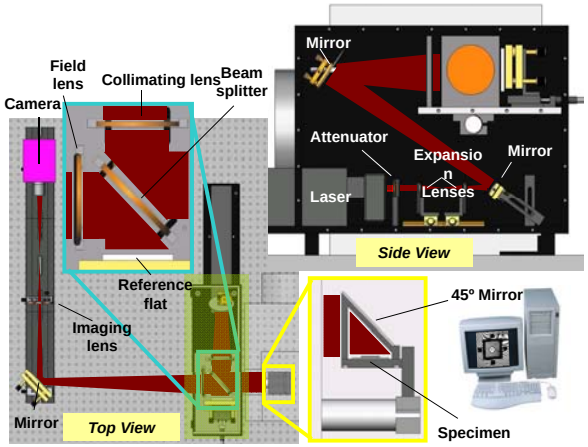
h = height of surface irregularities,
λ = wavelength of light and
θ = angle of incidence

Far-Infrared Interferometry

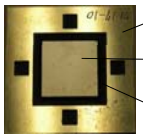
- *Effective roughness reduces as the wavelength increases*
- *CO_2 laser (λ=10.6 μm) is 20 times longer than visible light.*
  - *Surface finish requirement is greatly relaxed.*
  - *Surfaces which are "optically rough" for visible light become specular for infrared light.*

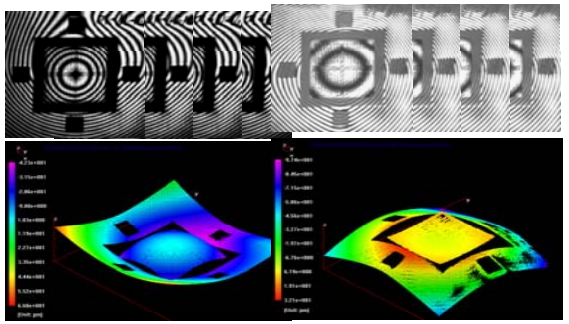
Far Infrared Twyman-Green Interferometry (FITGI)





FITGI Sample Experiment





24°C *210°C*