Improvements in automation for shell surfaces holographic characterizations

C. Hermerel, C. Chicanne, L. Jeannot, A. Choux, E. Busvelle(1), J-B. Vioix(1), P. Mérillot, G. Pascal
CEA Valduc, F-21120 Is-Sur-Tille.
(1) Université de Bourgogne, F-89000 Auxerre.
Summary

- DHM principle

- Data processing software
  - Principle: Reconstruction of the sphere – 3D visualization
  - Bumps, divots characterization
  - Others defects

- Metrology capability

- Conclusion / Perspectives
Introduction – DHM principle

- Laser Source
- Lens
- Mirror
- Camera
- Unorthogonal axis
- Objective
- Microshell

- O Object beam
- R Reference beam
Introduction – DHM principle

Hologram (250 x 250 µm²)

Phase without spherical component

Phase unwrapped

Microshell

intensity

fringes

100 µm
Data processing software: principle

- Recognition of interest points on neighboring strips
- Reconstruction of one strip
- Search of a translation between two images (rotation along a meridian) using image correlation.
- 3D Reconstruction of the sphere
- 3D sphere visualization
- Estimation of the covered surface rate
- Bumps, divots characterization
  - Morphological analysis of the image is used to localize the defects,
  - They are measured using a regression with a spherical cap.
Bumps, divots characterization – software evolution

With the previous software version some ghost bumps were regularly detected due to unavoidable numerical gap between grey levels on two neighboring images:

Example:

![Numerical grayscale gap between two images](attachment:image.png)

**Ghost bumps**
Data processing software : improvements

Bumps, divots characterization – software evolution

- The ghost bumps are automatically suppressed using a correlation coefficient (< 0.1).
- The bumps are directly represented in Haan curves (rev.3) with a color code (function of the correlation coefficient)
  - to ensure that the points are not ghost data
  - to have a warning on critical big bumps
Data processing software: improvements

Bumps, divots characterization – software evolution

➢ To check the bumps repartition and to target easily suspicious bumps or defects, the bumps and divots are pointed by a square on the strips with a color code (function of the position on the Haan Curves (rev.3))

- Divot (red squares)
- Bump present on another strip (yellow squares)
- Bump under green curve (black squares)
- Bump between green and “pink” curves (green squares)
- Bump height <120 nm (no square)

Others square colors
- □ Bump between “pink” and blue curves (“pink” square)
- □ Bump above blue curve (blue square)
For each bump or divot the value of Mixed Mass and PVRMS is now calculated (rev.5).

\[ \sum_{i=1}^{n} m_i \text{ mixed mass } < 10 \text{ ng} \]

\[ \sum_{i=1}^{n} PVRMS_i \text{ } < 5 \mu m \]
Data processing software: improvements in progress

Others defects: scratches and divots

- Others defects can’t be fitted using classical functions
- They will be identified with their 2D morphological parameters

\[
\text{Stretching: } \alpha = \frac{r}{R} \quad \text{and concavity: } \gamma = \frac{\text{per}(\text{conv}(S))}{\text{per}(S)}
\]

Points are plotted with a color code to indicate the maximum depth of each scratch.
For example:
- 0-50 nm: blue
- 50-100 nm: green
- ...

- rectilinear scratch (\(\alpha \) near to 0 et \(\gamma \) near to 1)
- curvilinear scratch (\(\alpha \) near to 1 et \(\gamma \) near to 0)
- divots (\(\alpha \) and \(\gamma \) near to 1)
Metrology capability

Step and roughness: bumps size representative

- Measure on step height standard calibrated
  (174 nm measured for 176.5 ± 1.9 nm)

- Measure on roughness standard calibrated
  (82.2 nm measured for 79.7 ± 2.5 nm)
AFM / DHM measurements comparison on one isolated bump

AFM on spheremapper was used to ensure the capability on DHM on 1 µm high bump.

DHM : h=887 nm ± 20 nm

AFM : h = 902 nm ± 5 nm

The heights measured are similar.
New mechanical configuration

A new mechanical configuration permits to acquire data along two hemispheres in suppressing shell manipulation between strips acquisition.

The software has been adapted to this new hardware configuration to stitch the two hemispheres data.
Conclusions/Perspectives

Conclusions

The DHM permits fast speed 3D surface image acquisition in order to characterize and count defects (bumps, divots,…) on microshells outer surface.

The DHM metrology capability has been demonstrated with standard calibrated samples and with a comparison with AFM.

The new DHM mechanical configuration permits to acquire data along two hemispheres in suppressing shell manipulation between strips acquisition.

Perspectives

The reduction of images number to cover the microshell outer surface is in study (spiral shape travel acquisition)

→ The software will be adapted to this new hardware configuration.