Fast Quality Control with Diffractive Micro- and Nanostructures

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CTI Project “Qualinject”

- Economic impact
- Market example: lab-on-chip diagnostic devices
- Collaborative project
- The idea
- Replication of micro and nanostructures
- Laser measurements of test structures
- Summary and Outlook
Economic Impact

Optimizing plastic molding:
• Facilitates mass production of microtechnology
• Promotes the swiss industry at various levels (material, production, development, sales)

Holographic structures from 3D A.G.

Grilamid TR of EMS-GRIVORY

Molded nanostructures from Injector S.A.
Market Example

- Lab-on-chip systems for medical diagnostics
- Typical dimensions: 5-100 µm
- Complex structures with packed geometry
- Replacement of silicon and glass by polymers

*Microfluidic Chip From Claros Diagnostics S.A.R.L*

Quantitative immunoassay blood tests.

*NucliPrep™ lab-on-chip platform from Ayanda Biosystems S.A.*

RNA extraction and purification from cells.
Collaborative Project

➢ Partners from industry
  – 3D A.G. (Main partner)
  – Claros Diagnostics S.A.R.L.
  – EMS-CHEMIE A.G.
  – Ayanda Biosystems S.A.
  – Injector S.A.

➢ Partners from research
  – EPFL IMT, CSEM Alpnach, PSI INKA
The Idea

• Integration of quality control structures
  – Quality testing on site
  – Improved efficiency

• Show sensitivity of diffraction structures to
  – process variations
  – Structure height
Replication of Micro and Nanostructures

- Silicon masters (photolithography and RIE)
- Replication by injection moulding
- Material: PMMA, COC, PC, PA-TR (Grilamid TR of EMS)
- Master and replica detailed analysis methods:
  - Light microscopy
  - Confocal Laser Scanning Microscopy (CLSM)
  - Atomic Force Microscopy (AFM)
  - Scanning Electron Microscopy (SEM)
Diffractive Micro and Nanostructures

Silicon master

Polymer replica

Depth = 120nm
Period = 10μm

Height = 100nm
Period = 10μm
Laser Measurements of Test Structures

He-Ne Laser \(\lambda=633\text{nm}\)

3D adjustable stage for micro structured samples

Tiltable CMOS-camera with prism

Periodicity: 10 \(\mu\text{m}\)

Reflected Diffraction Patterns

Transmitted Diffraction Patterns

Periodicity: 4 \(\mu\text{m}\)

Scanning layer
Influence of Periodicity on Diffraction Angle

\[ m \lambda = 2 \Lambda \sin \phi \]

Good correlation between calculated and measured diffraction angle

<table>
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<th>Diffraction order m</th>
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<td>Wavelength ( \lambda ) [nm]</td>
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<td>Period ( \Lambda ) [nm]</td>
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<td>Diffraction angle ( \phi ) [°]</td>
<td>14.20</td>
<td>9.11</td>
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Influence of Structure Height on Diffraction Intensity

Good correlation between total diffraction intensity and structure height
Influence of Defects on Diffraction Pattern

Defects → Irregular diffraction peaks
→ Lower separation between diffraction peaks
Influence of UV radiation on Diffraction Pattern
Summary

• Large replication differences dependent on polymer and processing
• Laser diffraction patterns:
  – Suitable for quality control of replication accuracy
  – Differentiation between various periodicities, structure quality and heights
  – Detection of defects and material degradation
• Best replication achieved with PA-TR1 (Grilamid TR of EMS) and PMMA
Outlook

- Holographic structures
- New portable laser diffraction measurement setup
- Study correlation limitations by combining micro and nano structures
- Validation with microfluidic applications
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