Spectral imaging device based on a tuneable MEMS Fabry-Perot interferometer

Jarkko Antila
25 Apr 2012
SPIE Defence, Security & Sensing 2012
Baltimore
Contents

- Introduction
- ALD MEMS Fabry-Perot interferometer principles and its use for imaging purposes
- Instrument idea and design
- Calibration
- Measurements results
- Conclusions and future work
Contents

- Introduction
- ALD MEMS Fabry-Perot interferometer principles and its use for imaging purposes
- Instrument idea and design
- Calibration
- Measurements results
- Conclusions and future work
VTT’s approach to future optical sensors

- Utilization of Fabry-Perot interferometers
- Make them small but keep throughput high
- Make them batch-producible and robust
- Develop integration and packaging solutions
- Add new data dimensions by hyperspectral imaging
**Staring type of hyperspectral imager**

- Takes a series of 2D images each representing one wavelength

- Benefit: if target (or camera) moves between the images, the wavelength layers can later on be combined by software through image analysis.
Contents

- Introduction
- ALD MEMS Fabry-Perot interferometer principles and its use for imaging purposes
- Instrument idea and design
- Calibration
- Measurements results
- Conclusions and future work
ALD MEMS Fabry-Perot interferometer

- MEMS Fabry-Perot interferometer utilizing Atomic Layer Deposition
- Thin, accurately controlled, **pin-hole free layers in the visible range**
- AC-controlled through a built-in series capacitor giving **extended travel range**
Gap flatness enables imaging

- Tensile stress enables **large size** of several millimeters
- Built-in tensile stress in the thin upper mirror and an annular pulling force region gives a **flat aperture region**
- **Flatness typically < 10 nm** over the aperture (peak-to-peak)
Contents

- Introduction
- ALD MEMS Fabry-Perot interferometer principles and its use for imaging purposes
  - Instrument idea and design
- Calibration
- Measurements results
- Conclusions and future work
Instrument idea and design

- **Hand-held hyperspectral imager** using the ALD MEMS-FPI tuneable filter for 460-585 nm
- **White LEDs for illumination**
- **Commercial** optical components
- **Simple** interfacing for demonstration
Realized instrument

From the front

From the side

Completed device with cover
Contents

- Introduction
- ALD MEMS Fabry-Perot interferometer principles and its use for imaging purposes
- Instrument idea and design
- **Calibration**
- Measurements results
- Conclusions and future work
Calibration system

- Using a colour detector and a multipeak measurement scheme requires a special calibration procedure
- A set of calibration constants is created to be used in the measurements
Contents

- Introduction
- ALD MEMS Fabry-Perot interferometer principles and its use for imaging purposes
- Instrument idea and design
- Calibration
- Measurements results
- Conclusions and future work
Measurement results – calibration and characterization

<table>
<thead>
<tr>
<th>Property name</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free membrane diameter</td>
<td>3.0 mm</td>
</tr>
<tr>
<td>Optical aperture diameter</td>
<td>1.5 mm</td>
</tr>
<tr>
<td>Maximum mirror movement</td>
<td>ca. 50 % of initial air gap</td>
</tr>
<tr>
<td>Chip dimensions</td>
<td>0.6 x 4 x 4 mm³</td>
</tr>
<tr>
<td>Maximum used voltage (peak-to-peak, square wave)</td>
<td>17.6 V</td>
</tr>
<tr>
<td>Optical resolution (Full-Width at Half-Maximum, FWHM)</td>
<td>ca. 20 nm</td>
</tr>
</tbody>
</table>

![Graph showing the relationship between voltage and wavelength.](image)
Measurement result – target measurements

- 20 € bank note was used as the target
Contents

- Introduction
- ALD MEMS Fabry-Perot interferometer principles and its use for imaging purposes
- Instrument idea and design
- Calibration
- Measurements results
- Conclusions and future work
Conclusions and future work

- VTT has built a palm-sized MEMS-based hyperspectral imager demonstrator utilizing an ALD MEMS Fabry-Perot interferometer.
- The demonstrator is capable of measuring 50 spectral channels between 460-585 nm with 20 nm resolution, or optionally shows live image through one selected spectral band.
- The low contrast of the used ALD MEMS FPI device caused distortion in the final spectrum due to spectral crosstalk.
  The filter will be upgraded to a new version in the near future.

- The MEMS-based hyperspectral demonstrator showed the potential for realising a small and low cost hyperspectral imager, paving way for high-volume applications for spectral imaging.
Thank you!
VTT - 70 years of technology for business and society