Discussions

The technical discussions undertaken in the period since the last CCL meeting in 2015, concentrated on the planning of a 2D grid plate comparison and the issue of optical size metrology of structures (bidirectional optical measurements). In addition, international comparisons for MRA purposes were prepared and organised.

Comparison activities

In February 2012 the final report about the results of EURAMET.L-K7.2006 (Pilot: B. Acko, MIRS, 100 mm line scales, 31 participants; 2 loops in parallel) was published on the KCDB website and Metrologia. The Executive Report was distributed as well.

Currently the line scale comparison APMP.L-K7.2014 using a 500 mm scale is running. The comparison, piloted by KRISS, was started in April 2015 and the circulation of the transfer standard (owned by KRISS, manufactured by Mitutoyo using a low thermal expansion substrate material (Clearceram)) is expected to be finished at the end of 2016. There are 15 NMIs participating, mostly from APMP with the addition of 1 lab from AFRIMETS, and 2 labs from EURAMET and SIM each.

SIM-L-K7.2016 is a bilateral line scale comparison between INTI and INRIM which is currently running and scheduled to finish until the end of 2018.

The next CCL-K7 comparison on line scales is scheduled to start in 2018/2019. This comparison currently is under preparation. In addition, a separate EURAMET supplementary comparison with stage micrometers is planned, piloted by BEV.

Other planned activities are comparison measurements on line, cross and circular features on 2D optical masks, being important for optical CMM and optical measuring microscopes including x-y-position, size and roundness (according to EN ISO 10360:7) of features on transparent substrates (masks, plates).

(Remark: The topic of bidirectional optical measurements (width (CD), diameter) of 2D-structures and the development of an infrastructure for optical CD measurements (linescales, opt. CMM) has been addressed in
research project proposals within the EURAMET EMRP/EMPIR metrology research programmes (SIBS Call 2012, SRT i11; IND call 2014, SRT i07; IND call 2017 SRTi02), which, however, were not selected for funding.)

Recent published papers
There is no special conference which deals with the DG 7 issues only, but at conferences like e.g. the Macroscale in 2011, 2014 and 2017 some contributions on line scale related research work were presented and published. The following list of papers (2008-2017) in the field of line scale metrology and metrology on 2D optical plates and photomasks has been generated by scanning the publication lists of CCL members and does not claim to be complete. In particular, a larger effort of research is performed in metrology for lithography applications, including dimensional metrology. These lithography related topics are partly dealt with in the WG-N and not fully covered here.


B Bodermann, R König, D Bergmann, W Häßler-Grohne, J Flügge, H Bosse: The road towards accurate optical width measurements at the industrial level; Fringe 2013: 7th International Workshop on Advanced Optical Imaging and Metrology: (2014), 35 – 41


J Unkuri, A Rantanen, J Manninen, V-P Esala and A Lassila: Interferometric 30 m bench for calibrations of 1D scales and optical distance measuring instruments; Meas. Sci. Technol. 23 (2012) 094017 (8pp)


F Meli: Calibration of Photomasks for Optical Coordinate Metrology; Macroscale 2011 proceedings (online)

R König, B Bodermann, D Bergmann, E Buhr, W Häßler-Grohne, J Flügge and H Bosse: Towards traceable bidirectional optical size measurements for optical coordinate measuring machine metrology; Macroscale 2011 proceedings (online)

R Köning, G Wimmer, K Karovic, V Witkovsky: Estimating the standard uncertainty contribution of the straight-line fit algorithm used to determine the position and the width of a graduation line, Metrologia 49 (2012) 169–179


C Weichert, M Stavridis, M Walzel, C Elster, A Wiegmann, M Schulz, R Köning, J Flügge, R Tutsch: A model based approach to reference-free straightness measurement at the Nanometer Comparator; Modeling aspects in optical metrology II; (Proceedings of SPIE: 7390): (2009), 739000-1 - 739000-10

H Bosse, J Flügge, Jens; R Köning, C G Frase, W Häßler-Grohne, A Just, R D Geckeler: Dimensionelle Metrologie an ebenen Substraten mit Mikro- und Nanostrukturen = Dimensional metrology on plane substrates with micro- and nanostructures; Technisches Messen: 76 (2009), 2, 54 – 64

J Flügge, Ch Weichert, EnTe Hwu, R Köning, H Bosse, A Wiegmann, M Schulz, C Elster, R D Geckeler: Interferometry at the PTB nanometer comparator - design, status and development; Fifth International Symposium on Instrumentation Science and Technology; (Proceedings of SPIE: 7133), 2; (2009), 713346-1 - 713346-8


J E Decker, A G Steele, H Bosse, R J Douglas: Analysing redundancy in a line scale comparison using Monte Carlo methods; Measurement Science and Technology: 19 (2008), 6, 064005-1 - 064005-6

I Tiemann, C Spaeth, G Wallner, G Metz, W Israel, Y Yamaryo, T Shimomura, T Kubo, T Wakasa, T Morosawa, R Köning, J Flügge, H Bosse: An international length comparison using vacuum comparators and a photoelectric incremental encoder as transfer standard; Precision Engineering: 32 (2008), 1, 1 – 6


Potential topics for DG discussions

There seem to be several trends, also visible in the recent research papers (order is not indicating priority):


P Köchert, J Flügge, C Weichert, R König, E Manske: Phase measurement of various commercial heterodyne He-Ne-laser interferometers with stability in the picometer regime, Measurement Science and Technology, 23 (2012), 7, 1-6, dx.doi.org/10.1088/0957-0233/23/7/074005 IOP Publ. ISSN 0957-0233 (print); ISSN 1361-6501


J Guan, P Köchert, C Weichert, R Tutsch: A high performance one-dimensional homodyne encoder and the proof of a novel two-dimensional homodyne encoder. Precision Engineering, 37 (2013), 4, 865-870,


R König, C Weichert, P Köchert, J Guan, J Flügge: Redetermination of the Abbe Errors’ Uncertainty Contributions at the Nanometer Comparator, freely available at http://www.measurement.sk/M2013


1. Setting up an infrastructure for improved traceability chain for high precision optical size reference measurements on well defined structures (like e.g. photomasks) to optical CMM measurements on different type of measurement objects;

2. Extending the analysis of line scale comparisons with respect to condensed measurement results to be used for linking, where possible. An example of a condensed measurement result is the deviation from nominal length, determined over all measured line positions of a line scale;

3. Extending the measurement capabilities of high precision line scale comparators, e.g. for determination of straightness or roundness deviations of features; standards with graduations calibrated for position and straightness may be valuable references for industrial 2D comparators as well as the recently developed 1.5D length encoder systems;

4. Calibration of length encoders in addition to classical line scales, maybe also using a length encoder system as a transfer standard for DG 7 comparison measurements;

5. Take into account the application of interferometers as well as graduated standards and scale-based measurement systems for calibration and position feedback purposes in measurement instrumentation as well as manufacturing equipment, like e.g. lithography wafer scanners and machine tools and analyse the requirements from these applications on calibration aspects of graduated scales at the NMI and accredited laboratory level;

6. Customers are asking frequently also line width and from edge to edge distances with line scale calibration. These would be useful for calibration of vision CMMs.

**Other notes**

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Harald Bosse, DG7 moderator

10. April 2018