DFM
Danish National Metrology Institute

ANNUAL REPORT
2013

WHAT METROLOGY IS

Metrology is the science of measurement and is the backbone of our high-tech society. Most aspects of daily life are influenced by metrology, and increasingly accurate measurements are essential to drive innovation and economic growth in our society.

WHAT DFM IS

DFM is the appointed National Metrology Institute of Denmark, contributing to the integrity, efficiency and impartiality of the world metrology system and responsible for coordinating the Danish metrology infrastructure. DFM is owned 100 % by DTU.

WHAT WE DO

DFM's scientific research contributes to the development in new knowledge, or new measurement techniques and new standards, which support the accurate measurements required by Danish industry and Authorities.

The services offered are high-level calibrations and reference materials traceable to national primary or reference standards, courses related to metrology and consultancy services.

DFM has a special role in developing measurement capabilities needed by small and medium sized high-tech companies in order for them to evolve and prosper.

DFM works to ensure global confidence in Danish metrological services, which is critical for competing in the global market place.

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FEBRUARY 17, 2014

Steen Konradsen, Chairman of the Board and Michael Kjær, CEO

DFM experienced strong growth in revenue and maintained a healthy profit level in 2013. The revenue increased 18 % to 25.4 million DKK – the highest level in DFM's history. The profit for the year was 0.5 million DKK. The management considers both revenue and profit as being satisfactory. Investments increased to 2.6 million DKK from 2.0 million DKK in 2012, primarily due to investments in new equipment required to maintain the Danish metrological infrastructure.

Danish industry needs access to strong metrological competences and state-of-the-art services to maintain and improve competitiveness. This is particularly important when upgrading production facilities, which requires higher measurement quality. DFM is dedicated to meet these metrological needs, creating value for industry and society. DFM is pleased that it has been possible to increase activities and investments significantly in 2013.

Maintaining and developing the basic metrology infrastructure is costly and require unique skills not readily available in industry. DFM is pleased that the Danish Council for Technology and Innovation decided in 2013 to provide funding for new mass comparators at DFM, this secures the long-term ability of industry to make measurements traceable to the Danish kilogram. The new mass comparators, at a value of 3.3 million DKK, replace equipment that is more than 20 years old. The investment confirms that critical metrology infrastructure continues to be a priority to the Council.

DFM achieved the highest level of new funding for R&D projects in its history. The funding increased to 11.0 million DKK. DFM's research activities have the greatest impact, when the knowledge and technology generated, is transferred directly to industry and universities. R&D projects are an effective technology transfer mechanism to the partners involved. Industry partners get access to state-of-the-art metrology competences, services and facilities. DFM supports activities in the whole range of the R&D pipeline, from basic science in collaboration with universities facilitating pre-competitive research, to deployment of advanced technologies in collaboration with Danish industry, including a high proportion of SME's which normally do not have the resources to develop critical infrastructure in-house.

Commercial sales increased from 2.8 million DKK to 3.0 million DKK as the demand from Danish industry for DFM's calibration services continued to grow. Development of new services is a high priority at DFM, and commercial sales is expected to continue its growth in 2014, as new services are being introduced.

Steen Konradsen
Chairman of the Board

Michael Kjær
CEO

DFM STAFF MEMBER ELECTED TO EURAMET BOARD OF DIRECTORS

Jan C. Petersen, new member of the EURAMET Board of Directors

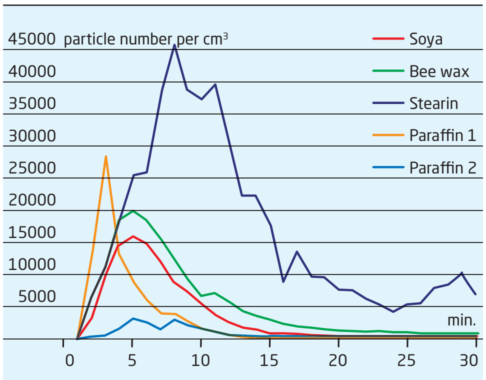
The European Association of National Metrology Institutes (EURAMET) is the Regional Metrology Organisation (RMO) of Europe. It coordinates the cooperation of National Metrology Institutes (NMI) across Europe in fields such as research in metrology, traceability of measurements to the SI units, international recognition of national measurement standards, and maintenance of Calibration and Measurement Capabilities (CMC) of its members. Through knowledge transfer and co-operation among its members, EURAMET facilitates the development of national metrology infrastructures.

At the 2013 EURAMET General Assembly held in Reykjavik, Iceland, three positions in the EURAMET Board of Directors became vacant. DFM staff member Jan C. Petersen was elected to fill in one of the vacant positions. Members of the Board of Directors are elected by ballot at the General Assembly by a simple majority of the valid votes cast. Members will be elected for a term of two years and can be re-elected several times but not for more than three consecutive terms. Jan has been the Danish EURAMET Delegate since 2009.

The EURAMET Board of Directors consists of the Chairperson, two Vice-Chairpersons and six members. The Board of Directors is responsible for the matters with which EURAMET is concerned, unless the responsibility for such matters has been entrusted to another body by the Byelaws. The Board of Directors should consult the General Assembly ahead of a decision if a broader view of opinion is required. The Board of Directors' tasks include the following governance of EURAMET; identification of objectives and development of strategies; execution of the decisions taken by the General Assembly; discussion and endorsement of the budget; appointment of personnel to the Secretariat; development and maintenance of an effective and efficient management system; regular quality management system reviews, and verification of corrective actions.

As a member of the Board of Directors, DFM will have a closer insight to present and future activities in EURAMET as well as the possibility to influence the directions of EURAMET. Jan's interests include issues such as facilitating increased sharing of metrology facilities and competences in Europe, increased interregional cooperation to address expected future metrology needs, and strengthening the research cooperation among NMI's within Horizon 2020 (in addition to EMPIR cooperation).

Accurate measurement of large scale facilities is a challenge at e.g. petroleum storage sites. The tank has a diameter D=52m and height h=16m



Particle number concentration measured for particles with sizes between 100nm and 400nm, linear scale

Partial combustion creates soot particles

Large-scale dimensional metrology

Accurate and traceable measurements of large objects like airplanes, wind turbines or large tanks can be quite challenging. This is not a field with much activity in Denmark, and so far it has not been pursued by Danish metrology institutes or accredited laboratories.

When trading commodities such as petroleum stored in large tanks, seller and buyer must agree on the volume and from that agree on price. The traded volume is determined from tank calibrations, which relates the height of the liquid surface to the liquid volume. The total tank volume is often in the range of 10 to 100 million litres.

Intertek Denmark performs calibrations of large tanks within northern Europe. These tanks are typically used for storage of petroleum products. The tank calibration is based on measurements of coordinates on the interior tank surface using a modern theodolite with an integrated laser based distance measuring device. Intertek Denmark is seeking accreditation of their calibration service and has approached DFM for support in development of software to analyse the large amount of measurement data and evaluate the measurement uncertainties. The final solution is based on DFM's multivariate data analysis tools.

The data analysis includes essential corrections from effects such as tank tilt, thermal expansion, displacement caused by a floating roof, as well as tank deformation due to pressure of the liquid, which again depends on the liquid level, density and tank material.

DFM can measure the combustion particles that are emitted during your next candle light dinner

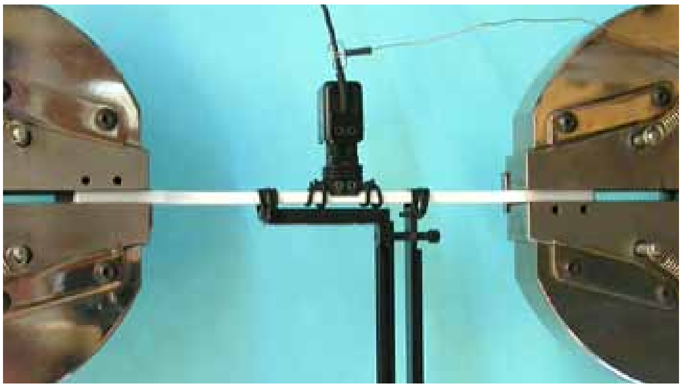
With the booming market for alternative candle fuels such as beeswax and soya fat, the comparison of combustion aerosols are becoming more and more important in order to avoid unnecessary contamination of living spaces with soot particles and the associated health issues. DFM has established a new measurement facility for quantifying the amount of combustion particles produced by candles.

Candles are typically made from fossil paraffin or non-fossil stearin. When candles are burned indoors, oxygen from the air is replaced not only by carbon dioxide and water, as in a perfect combustion, but also by unhealthy sooth particles due to incomplete combustion. The evaluation of the candle quality by characterizing the released aerosol of soot particles is still regulated and standardized with methods that relate to indirect visual macroscopic effects only, such as the deposition of candle soot on a glass plate.

DFM was approached by an SME (small and medium-sized enterprises) to investigate their alternative combustible materials for candle use. Co-financed by an Innovation Voucher (Videnkupon), DFM built a combustion chamber, which allows the direct measurement of the particle number concentration in the soot aerosol. During the project, DFM has compared the particle size distribution of more than 20 different candles. It is envisioned that this work will gives rise to reconsideration of normative work related to the quantification of the combustion efficiency of candle lights.

DFM is committed to support industry and institutions in performing challenging measurements. From dimension measurement of large scale petroleum tanks to micrometer sized particle counting, the following examples illustrate where DFM has contributed to everyday challenges of Danish industry.

Production faults in plastic food packaging can lead to increased manufacturing expenses

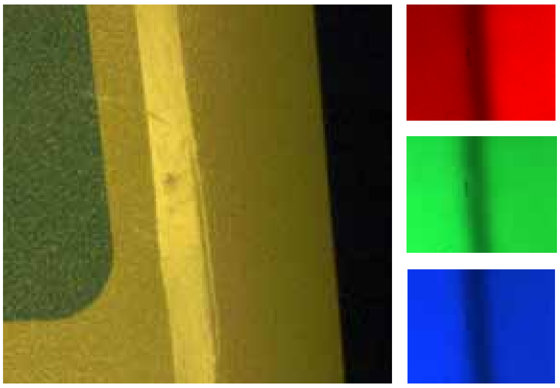


DFM's setup for calibration of extensometer-calibrators, traceable to the laser wavelength of DFM's primary length standard

Measuring errors in food packaging

Faults in food packaging can lead to the discarding of whole production batches incurring significant losses. In typical production lines, various optical techniques are used to look for packaging errors, including fast image analysis. In a small project funded by the Innovation Voucher Scheme, DFM has worked with a company that develops detection solutions for a major Danish packaging supplier. The goal of the project was to increase the detection probability for error types that occur in injection molded packaging.

DFM performed a combination of spectral investigations and measurements of the reflective properties of different kinds of injection molded plastic. DFM was able to identify critical areas, where a modification of existing error detection setups could lead to enhanced error contrast as well as enable the detection of an error type, that was previously almost impossible to distinguish.



Difference in contrast between diffusive and specular reflecting surfaces of food packaging

New length calibration service ensures high quality mechanical components

Accurate knowledge of material properties is essential when manufacturing mechanical components in order to ensure reliability and durability. As an example, stress-strain relationships of products are measured with material testing machines by recording the change in length of a test item as a function of the applied load. The change in length is measured by so-called extensometers, which obtain traceability to the SI-system via extensometer-calibrators.

FORCE Technology provides accredited calibration of extensometers and has asked DFM for a national calibration service for their reference instruments. Consequently, DFM developed a calibration method for the extensometer-calibrator based on laser interferometry. The wavelength of the laser is calibrated with direct reference to one of DFM's primary length standards. Relative uncertainties at the 10^{-6} level are obtained for displacements up to 100 mm. The main source of uncertainty lies in the intrinsic properties of the extensometer-calibrator itself.

In 2013 DFM calibrated two extensometer-calibrators. These instruments are in turn used at FORCE Technology for the calibration of about 50 extensometers per year, each of which provides traceability for a large number of material tests. This is a typical example of the so-called 'multiplication effect', where a few essential calibrations at the highest national level provide traceability for a large number of daily routine measurements in industry.

NEW MASS COMPARATORS DONATED TO DFM

Tweezers with a 2g mass standard

Mass comperator covering the range 1kg - 20kg

Stack of two 10kg mass standards

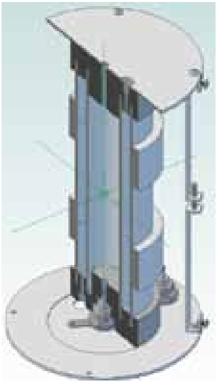
Robotic mass comperator covering the range 1g - 100g

A special grant from the Danish Council for Technology and Innovation (RTI) made it possible to replace outdated mass comparators and secure the dissemination of mass at the highest level of quality to Danish and foreign customers.

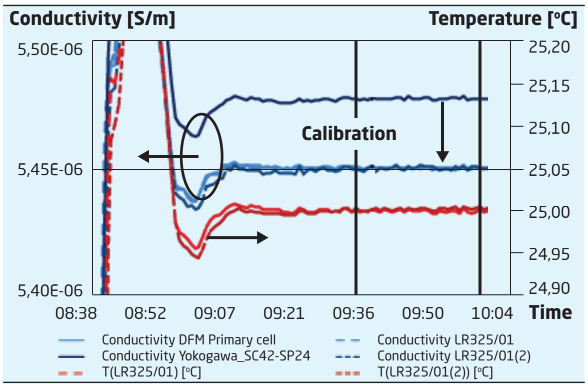
The mass laboratory at DFM was established in 1989, when state-of-the-art mass comparators covering the range from 1 mg to 10 kg were acquired. A very high level of reliability in calibration of mass standards has been a trademark of DFM. This is achieved through redundancy in computer controlled measurements combined with application of sophisticated data analysis tools. Sets of mass standards are all calibrated by subdivision and multiplication, usually starting at the 1 kg level. This process is monitored by DFM check standards, which are added to the set of mass standards and calibrated as if their masses were not known.

After more than 20 years of operation, the original mass comparators were worn out and needed to be replaced. The special grant from RTI made it possible to acquire four new mass comparators covering the range from 1 mg to 20 kg. Of these four comparators, one is fully robotic (1 g - 100 g) and two (100 g - 1 kg, and 1 kg - 20 kg) have turntables for automatic handling of four weights. As a result, the efficiency of calibration has been increased, and the cost of calibration has been reduced significantly, all this to the benefit for DFM's customers.

ELECTROLYTIC CONDUCTIVITY CELL CALIBRATION FOR ULTRA-PURE WATER APPLICATIONS



Cross-section View of DFM's coaxial primary cell



Calibration data from the primary cell compared to data from the probe-under-test. Blue curves are conductivity, red curves are temperature

Carsten Thirstrup about to mount a typical commercial probe in the calibration system

DFM offers a new accredited calibration service for ultra-pure water (UPW) applications. The calibrations are based on a primary measurement cell enabling traceable measurements of the electrolytic conductivity of ultra-pure water (UPW). The service offers measurements of cell constants of electrolytic conductivity cells from the purity level of UPW (5.5 µS/m) up to purity levels of 1.5 mS/m with an uncertainty of 0.5%.

Ultra-pure water is a necessity for a number of industries and technology development. It is widely used in manufacturing processes in the pharmaceutical and food industries, in chemical and biochemical analytical laboratories, in cleaning and rinsing in the semiconductor, flat-panel display and solar power industries, and as feed water in power plants.

In order to ensure a purity level of ultra-pure water, it is essential to have a robust, reliable and accurate measurement method for determination of the purity level. Measurements of electrolytic conductivity allow the purity to be determined easily the purity, because only small amounts of contamination cause a significant change of the electrolytic conductivity of water. As an example, if 1 µg of NaCl is added to 1 liter of UPW, the conductivity of the water is 4 % higher than that of UPW, and even a short exposure of UPW to atmospheric air causes a significant change in the electrolytic conductivity. Until now, it has not been possible for industry to obtain a traceable calibration of electrolytic conductivity measurements close to the UPW level.

A new measurement system of electrolytic conductivity has been established at DFM. The system comprises flow-loops of UPW and solutions of KCl covering conductivity levels from 5.5 µS/m to 1500 µS/m at a temperature of 25 °C. The DFM primary cell and the conductivity-cell-to-be-calibrated are mounted in the same flow loop and simultaneous measurements at the same conductivity level and temperature enable determination of the cell constant of the conductivity-cell-to-be-calibrated. In the Figure above, a schematic cross sectional view of the DFM measurement cell is illustrated. The solution flows between the two concentric electrodes. The plot in the middle illustrates an example of measurement data plotted as function of time. The data were acquired for the DFM primary cell, the conductivity cell-to-be-calibrated (a commercial Yokogawa SC42-SP24 cell) and two control conductivity cells. The conductivity data from the cell-to-be-calibrated are adjusted by a scale factor, which brings the data to the same conductivity level as the primary cell. The scale factor determines the cell constant of the conductivity cell-to-be-calibrated.

Comparison measurements have been performed with the German Physikalisch-Technische Bundesanstalt (PTB) for electrolytic conductivity between 5.5 and 1500 µS/m, and the results were in agreement within the measurement uncertainty.

A VERSATILE INTEGRATING SPHERE BASED PHOTO-ACOUSTIC SENSOR FOR TRACE GAS ANALYSIS

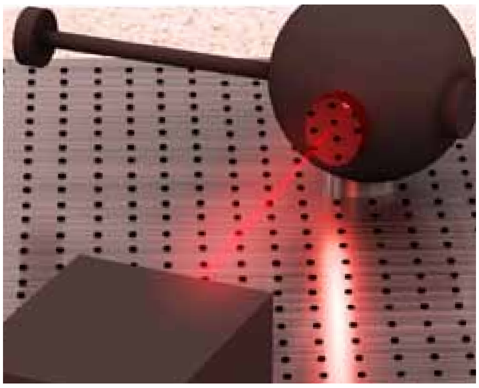
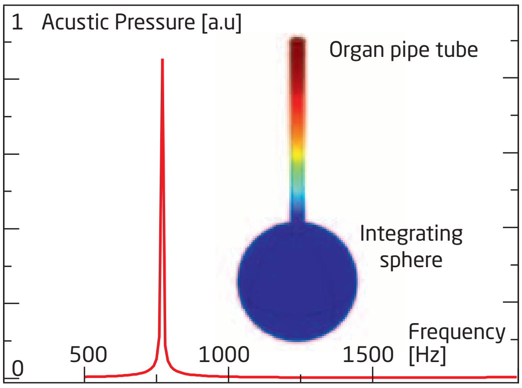
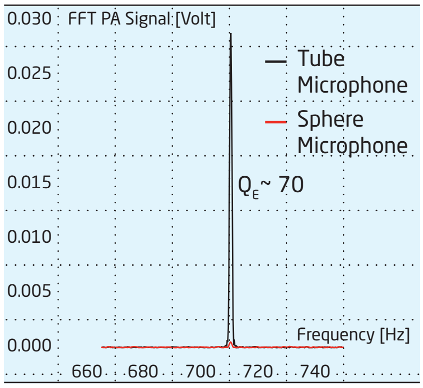


Illustration of the integrating sphere with attached organ pipe tube for PA measurements



Simulation of the frequency response and distibution of the acoustic pressure field



Power spectrum of the photo acoustic signal inside the integrating sphere (Mic1) and at the closed end of the organ pipe tube (Mic2). The peak is at the resonant frequency of the organ pipe tube

Compact, low cost, highly sensitive and automated trace gas detection systems are important for a number of applications, including environmental and industrial monitoring. Photoacoustic spectroscopy (PAS) has turned out to be a very promising technique, empowered by the simplicity of the technique and low cost detection components, however still allowing measurements of molar mixing ratios at levels below 10^{-9}.

The concentration of trace gases is measured by quantifying the optical absorption at specific wavelengths depending on which molecular species is of interest. In transmission spectroscopy the Beer-Lamberts law determines the dependence between optical attenuation and interaction length, thus quantifying the molecular concentration. In PAS a pressure wave is created by heating and subsequently cooling of the absorbing molecules by intensity modulation of light. The photoacoustic (PA) signal strength is proportional to the concentration, thus the concentrations can be quantified.

Using an optical integrating sphere as the measuring cell the light intensity experienced by the gas is enhanced, due to multiple reflections inside the sphere, and the optical alignment is simplified. In our experiment the optical power is enhanced by a factor of 20 for a 2 µm laser used to probe specific ro-vibration lines of CO_2. Driving the light modulation at a frequency, which is acoustically resonant to the absorption cell, enhances the PA signal. However, due to the uniform distribution of the light field inside the integrating sphere, acoustic resonances cannot be exploited directly. By attaching an organ pipe onto the integrating sphere, a new acoustic resonance condition is established and resonances can be exploited.

The figure shows a simulation of the acoustic field pressure and frequency response, with low acoustic amplitude (blue) in the sphere and a strong (red) standing wave at the end of the organ pipe. The plot on the right, shows measurements of the acoustic spectrum experienced by a microphone mounted at the end of the organ pipe and inside the sphere. It is observed that the background absorption signals are highly attenuated due to the thermal conduction and diffusion effects in the cell walls. These features makes the sensor suitable for various practical sensor applications in the ultraviolet to the mid infrared wavelength region. The total enhancement factor of the integrating sphere based sensor is approximately 1400 compared to a single-pass non-resonant PA sensor making it useful for many practical applications, where sensitivity, low cost and compactness is needed.

RESPONDING TO THE METROLOGY RESEARCH & INNOVATION CHALLENGE IN EUROPE – EMRP AND EMPIR

Having participated in a European Metrology Research Project regarding measurements of nanometre sized airborne particles, DFM has developed an accredited calibration service for particle counters which are typically used for clean classification and monitoring

Metrology, the science of measurement, is an essential prerequisite for our high-tech world. Public intervention at the EU level helps to achieve a critical mass of actors and investments required for addressing important metrology challenges. Consequently, cost-effectiveness as well as impact of European metrology activities and investments is increased by coordination of metrology research strategies within Europe.

The current European Metrology Research Programme (EMRP) was established in 2009 with participation from 23 countries. The total value of the EMRP is 400 million EUR distributed over a period of approximately seven years. The EU contributes 50 % of the programme value, while the remaining part is funded nationally. The Danish commitment is just over 1 % divided between DFM and the six Designated Institutes that constitute the Danish metrology infrastructure. The Danish EMRP participation is co-financed with 15,4 million DKK from the Danish Council for Technology and Innovation.

The final call under the EMRP was issued in 2013. Danish metrology institutes won 28 EMRP projects at a total project value of just over 4 million EUR, and DFM's participation amounts to 11 projects with a value of 1.4 million EUR.

The value to the Danish metrology organizations and to Danish industry in general has been much higher, than it appears from the participation level. The organizations have gained access to important metrology competences developed in Europe, which can now be transferred to Danish industry, and it allows specific Danish metrology needs to be addressed at a European level. Also, it has significantly increased collaboration between the Danish metrology organisations and their European counterparts.

A good example of the value to Danish industry is DFM's participation in a project on measurements of automotive exhaust emissions. In this project DFM's expertise in traceable measurements of nano particles supports development of calibration facilities for emission particles, which are needed in order to put the new EU directives into practice. Via the EMRP project DFM has gained further knowledge about measurements of nano- and micrometre sized particles, which has been used in accredited calibration of particle counters used in pharmaceutical production, as well as measurements of combustion particles from various types of candles for a Danish SME.

The Danish metrology organisations are looking forward to continue European collaboration within the European Metrology Programme for Innovation and Research (EMPIR) – the successor programme to EMRP. The new programme is expected to have a budget of 600 million EUR and 28 participant countries with calls in the period 2014 – 2020. EMPIR will be different from EMRP in a number of ways. Participation from non-metrology organisations will be increased in order to improve access to excellent science outside the NMIs. New instruments will also be added to support innovation and standardisation, and thereby further improve industrial exploitation.

NEW INSTRUMENTS FOR MICRO- AND NANOCHARACTERIZATION

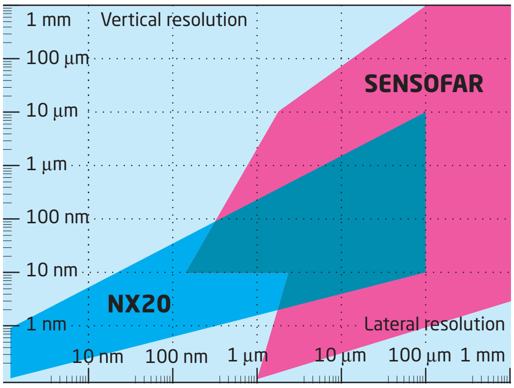


Figure 1. Measurement ranges of the new instruments at DFM

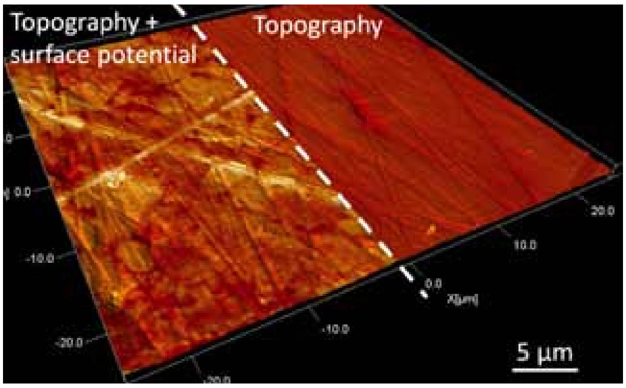


Figure 2. Atomic force microscopy of an aluminum-silicon alloy. When superimposing the surface potential (left half) onto the 3D topography (right half), areas of aluminum (bright yellow), silicon (dark red) and mixed compounds (medium orange) can be identified

Figure 3. A nano-textured surface, developed in the NanoPlast project, gives the plastic brick an iridescent effect also known from the wings of a butterfly. The nano-textures helps to minimize the use of chemical dyes

Metrology AFM - NX20

As the first of its kind in Denmark, the NX20 Atomic Force Microscope (AFM) from Park Instruments is pushing the limits for characterization of structures with micro and nano feature sizes. With its unique design, the new instrument can handle up to six inch wafers and perform failure analysis of large areas. DFM has, for instance, measured the surface roughness on large parts of highly polished satellite x-ray mirrors.

In addition to common topography measurements, the new AFM is also able to measure complementary quantities, such as the surface potential as a function of position at the atomic scale. This assists the understanding of many surface phenomena such as corrosion, catalytic activity, and doping of semiconductors. Especially measurements of the catalytic activity will form a central area of research for DFM in the next years, as the features of NX20 have already contributed to winning two new projects. In both projects, one of which is national and the other is European, DFM will investigate the photocatalytic properties of nanoparticles. In the national project, it is also envisioned to use the NX20 for electrochemical surface analysis in collaboration with DTU.

For the pharmaceutical industry, the material properties of their active pharmaceutical ingredients is of major importance for the processability of ingredients in the production phase. However, early on in the development phase, only very small amounts of the active pharmaceutical ingredients are available, and common techniques for mechanical testing cannot be applied. DFM focuses on developing measuring methods using nanoindentation and AFM characterisation in collaboration with Lundbeck and KU. With the NX20 microscope, DFM can now analyze material properties, e.g. hardness and elasticity, of surfaces and particles. By pressing a very hard diamond tip into a surface, an imprint is made as shown in Figure 4. From an analysis of the measured force applied to the tip and the size of imprint created,the material properties are extracted.

Advanced light microscope - Sensofar

The Sensofar Plu Neox is an advanced optical microscope, which combines confocal and interference imaging. By stacking many images, the vertical resolution is dramatically increased, and a relative uncertainty down to 10^{-5} on dimensional measurements can be achieved. With a vertical scan range of several hundred microns in which nanometer resolution is maintained, confocal and interference measurements have found application in a broad range of fields, such as life science, material research, and semiconductor industry.

Investments in a newly designed atomic force microscope (AFM) and an advanced optical microscope ensure that DFM can provide faster service for customers with a need for accurate and traceable dimensional measurements from atomic scale and up to several millimeters, e.g. on functional surfaces with embedded nanostructures. The dimensional ranges covered by the two instruments are indicated in figure 1.

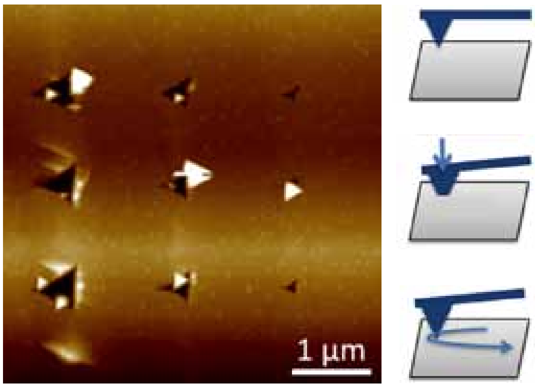


Figure 4. Nanoindentations in a crystal. First the hard tip is pressed into the surface. Secondly the surface is scanned. The image to the left shows the measured imprints. The applied force of the indenter is increased from the right column to the left column; the applied forces are the same in each column.

Figure 5. Poul Erik Hansen is studying the surface of a manufactured item in the new Sensofar microscope

Figure 6. Sidewall measurement of a thread with DFMs new advanced microscope

In the European project 'The Neutral Helium Microscope', the goal is to analyze surface coatings using a newly developed microscope, based on neutral helium atoms, with a resolution from several micrometers down to 100 nm. For this project, the Sensofar Plu Neox plays a crucial role in providing traceable measurements, calibration of reference standards and analysis of thin film and structural coatings on metals and semiconductor samples.

Machine polished metal surfaces are not flat on the microscale. A closer look at the surface reveals oscillatory structures with a variety of periods ranging from less than one micrometer to several micrometers. With a combined confocal and interference microscope, one can image several millimeters with a high resolution and thus investigate the surface in great detail. In a single measurement, one obtains a 3D image of the surface, in which curvatures, grooves and similar features on the surfaces are easily observable. With the Sensofar, DFM can now measure the thickness of materials. This includes glass cover slides, thin films, and other transparent materials. It is also possible to measure the inner dimensions of glass containers, such as cuvettes.

More Imaging Instruments

With a recall to Figure 1, there are some dimensional ranges (the light blue areas), which are not covered by the new instruments. Structures falling within these ranges can be characterized by other methods. For instance scanning electron microscopy (SEM) is a suitable technique to cover the upper left area in Figure 1. The lower right area is trickier. In order to cover this area, DFM is developing techniques based on measurements of scattered light. With in-house instruments based on these techniques, DFM is able to characterize most micro- and nanostructured surfaces.

IMAGING POSSIBILITIES

- Certifying reference particles
- Certifying calibration standards (e.g. gratings and step heights)
- Surface roughness
- Sidewall analysis of deep trenches
- Photocatalytic properties and electrochemical analysis on nanoscale
- Thickness of materials (e.g. cover glass, thin films, and dimensions of cuvettes)

ACCOUNTS OF PARTICULAR ACTIVITIES

Participation in committees and working groups under the Metre Convention and EURAMET

- Comité International des Poids et Mesures (CIPM)
- EMRP Committee
- Consultative Committee for Amount of Substance (CCQM)
- Consultative Committee for Acoustics, Ultrasound and Vibration (CCAUV)
- EURAMET Genneral Assembly (Eur GA)
- EURAMET Board of Directors (BoD)
- EURAMET Technical Committee for Mass (TC-M)
- EURAMET Technical Committee for Electricity and Magnetism (TC-EM)
- EURAMET Technical Committee for Length (TC-L)
- EURAMET Technical Committee for Photometry and Radiometry (TC-PR)
- EURAMET Technical Committee for Acoustics, Ultrasound and Vibration (TC-AUV)
- EURAMET Technical Committee for Time and Frequency (TC-TF)
- EURAMET Technical Committee for Interdisciplinary Metrology (TC-IM)
- EURAMET Technical Committee for Quality (TC-Q)
- EURAMET Technical Committee for Metrology in Chemistry (TC-MC)
- EURAMET TC-MC Sub Committee for Electrochemical Analysis
- EURAMET TC-EM Sub Committee DC and Quantum Metrology
- BIPM Director's ad hoc Advisory Group on Uncertainty
- Joint Committee on Guides in Metrology - Working Group 1, Guide to the expression of uncertainty in measurement (JCGM-WG1)
- Consultative Committee for Length - Working Group on Dimensional nanometrology (CCL-WGn)
- Consultative Committee for Amount of Substance - Working Group on Electrochemical Analysis (CCQM-EAWG)
- Consultative Committee for Mass and Related Quantities - Working Group on Changes to the SI kilogram (CCM-WGSI-kg)
- Consultative Committee for Mass and Related Quantities - Working Group on Mass Standards - Task Group 2; Uncertainty components due to traceability to the international prototype of the kilogram (CCM-WGM-TG2)
- Consultative Committee for Acoustics, Ultrasound and Vibration - Working Group for key comparisons (CCAUV-KC)
- Consultative Committee for Ultrasound and Vibration - Working Group for RMO Coordination (CCAUV-RMOWG)
- Consultative Committee for Ultrasound and Vibration - Working Group for Strategie Planning (CCAUV-SPWG)

Participation in national and international projects

- Metrology for biofuels (Biofuels), EMRP/RTI
- Nanoplast, HTF
- Polynano, DSF
- Metrology of small structures for the manufacturing of electronic and optical devices (Scatterometry), EMRP/RTI
- New generation of frequency standards for industry (Frequency), EMRP/RTI
- Diagnostic equipment for coronary artery diseases (DECAD), BIF
- Universal ear and non-audible sound (EARS), EMRP/RTI
- Dissemination of the new kilogram (NewKILO), EMRP/RTI
- Detection of oil in compressed air (DOCA), EU FP7/SME
- Spectral reference data for atmospheric monitoring (EUMETRISPEC), EMRP/RTI
- Quantum sensor technologies and applications (QTEA), EU FP7
- Sapere Aude, FTP
- Trivision, RTI
- Proof of Concept for photoacoustic spectroscopy for detection of gas, RTI
- Soyalys, RTI
- Emerging requirement for measuring pollutants from automotive exhaust emissions (EMISSION), EMRP/RTI
- Scanning Neutral Helium Microscopy mechanical par (NEMI), EU FP7
- Detecting of E. COLI bacteria in drinking water, MST
- Crystalline surfaces, self assembled structures and nano-origami as length standards in metrology (Crystal), EMRP/RTI

Calibration certificates and measurement reports

DC Electricity	10
Electrochemistry	263
Mass	19
Length	14
Optical Radiometry	38
Nano Structures	6
Acoustics	10
Particle Metrology	47
Total	407

Publications in refereed journals

- F. Bastkowski, P. T. Jakobsen, F. Stefan, H. B. Kristensen, H. D. Jensen, R. Kawiecki, C. E. Wied, A. Kauert, B. Seidl, P. spitzer, R. Eberhardt, B. Adel. *Automated high precision secondary pH measurements et al, Rev. Sci. Instrum.* 84, 045105, 2013. DFM-2013-P01
- J. A. Nwaboh, J. Hald, J. K. Lyngsø, J. C. Petersen, O. Werhahn. *Measurement of CO2 in a multipass cell and in a hollow-core photonic bandgab fiber at 2µm.* Appl Phys B 110, pp.187-194, 2013. DFM-2013-P02
- Poul-Erik Hansen, Sven Burger. *Investigation of microstructured fiber geometries by scatterometry.* SPIE 8789, 87890R, CCC code: 0277-786X/13/$18, DOI: 10.1117/12.2020526, pp. 1-8, 2013. DFM-2013-P03
- Svava Daviðsdóttir, Stela Canulescu, Kai Dirscherl, Jørgen Schou, Rajan Ambat. *Investigation of photocatalytic activity of titanium dioxide deposited on metallic substrates by DC magnetron sputtering.* Surface & Coatings Technology 216, pp. 35-45, 2013. DFM-2013-P04
- Mirza Karamehmedović, Poul-Erik Hansen, Thomas Wriedt. *An efficient rough-interface scattering model for embedded nano-structures.* Thin Solid Films 541, pp. 51–56, 2013. DFM-2013-P05
- C. Motzkus, T. Macé, F. Gaie-Levrel, S. Ducourtieux, A. Delvallee, K. Dirscherl, V. D. Hodoroaba, I. Popov, O. Popov, I. Kuselman, K. Takahata, K. Ehara, P. Ausset, M. Maillé, N. Michielsen, S. Bondiguel, F. Gensdarmes, L. Morawska, G. Johnson, E.M. Faghihi, C.S. Kim, Y.H. Kim, M.C. Chu, J. A. Guardado, A. Salas, G. Capannelli, C. Costa, T. Bostrom, Å. K. Jämting, M. A. Lawn, L. Adlem and S. Vaslin-Reimann. *Size characterization of airborne SiO_2 nanoparticles with on-line and off-line measurement techniques: an interlaboratory comparison study.* Journal of Nanoparticle Research 15, pp.1919, 2013. DFM-2013-P06
- Rikke Svava, Katarzyna Gurzawska, Yu Yihau, Kenneth Brian Haugshøj, Kai Dirscherl, Steven B. Levery, Niklas Rye Jørgensen, Klaus Gotfredsen, Iben Damager, Peter Ulvskov, Bodil Jørgensen.. *The structurally effect of surface coated rhamnogalacturonan I on response of the osteoblast-like cell line saOS-2.* J Biomed Mater Res A, DOI: 10.1002/jbm.a.34868, 2013. DFM-2013-P07
- J. Fischer, B. Fellmuth, C. Gaiser, T. Zandt, L. Pitre, S. Briaudeau, F. Sparasci, D. Truong, Y. Hermier, R. M. Gavioso, C. Guianvarc'h, P. A. Giuliano Albo, A. Merlone, F. Moro, M. de Podesta, G. Sutton, R. Underwood, G. Machin, D. del Campo, J. Segovia Puras, D. Vega-Maza, J. Petersen, J. Hald, L. Nielsen, S. Valkiers, B. Darquié, C. Bordé, C. Chardonnet, C. Daussy, L. Gianfrani, A. Castrillo, P. Laporta, G. Galzerano. *"The IMERAPlus joint research project for determinations of the Boltzmann constant".* TEMPERATURE: ITS MEASUREMENT AND CONTROL IN SCIENCE AND INDUSTRY. AIP Conf. Proc. 1552, pp. 1-10, 2013. DFM-2013-P08
- Svava Davidsdóttír, Kai Dirscherl, Stela Canulescu, Rajashekhara Shabadi, Rajan Ambat. *Nanoscale Surface potential imaging of the photocatalytic TiO_2 films on aluminium.* The Royal Society of Chemistry 3, pp. 23296-23302, 2013. DFM-2013-P09
- Katarzyna Gurzawska, Kai Dirscherl, Yu Yihua, Inge Byg, Bodil Jørgensen, Rikke Svava, Martin W. Nielsen, Niklas R. Jørgensen, Klaus Gotfredsen. *Characterization of Pectin Nanocoatings at Polystyrene and Titanium Surfaces.* Journal of Surface Engineered Materials and Advanced Technology 3, pp. 20-28, 2013. DFM-2013-P10
- Simone Tanzi, Marco Matteucci, Thomas Lehrmann Christiansen, Søren Friis, Mette Thylstrup Christensen, Joergen Garnaes, Sandra Wilson, Jonatan Kutchinsky, Rafael Taboryski. *Ion channel recordings on an injection-molded polymer chip.* The Royal Society of Chemistry 13, 4784-4793, 2013. DFM-2013-P11
- Matteo Calaon, Hans N. Hansen, Guido Tosello, Jørgen Garnaes, Jesper Nørregaard, Wei Li. *Microfluidic chip designs process optimization and dimensional quality control.* Microsyst Technol, DOI 10.1007/s00542-013-2025, 2013. DFM-2013-P12

Other reports

- Lars Nielsen, *DFM Årsrapport 2012*, DFM-2013-R01
- Pia Tønnes Jacobsen, Hans D. Jensen, Jørgen Avnskjold *DFM measurement report for CCQM-P142*, DFM-2013-R02
- Hans D. Jensen, Pia Tønnes Jakobsen, *Comparability and scaling of conductivity measurements in KCl(aq) and mixed-solvent*, DFM-2013-R04
- David Balslev-Clausen, Jan Hald, *Validation of Method for Multipass cell length measurements Using Bosch LASER distance tools*, DFM-2013-R05
- Kai Dirscherl, *Comparison of primary particle counting standards*, DFM-2013-R06
- Michael Kjær, Jan C. Petersen, Hans D. Jensen og Isabella Stendal, *Faglig rapportering til Rådet for Teknologi og Innovation for 2012*, DFM-2013-R07
- Kai Dirscherl, Lars Lundgreen, *Preliminary metrologic evaluation of the TSI Bio Trak*, DFM-2013-R08
- Salvador Barrera-Figueroa, *Final report EURAMET.AUV.A-S1*, DFM-2013-R09
- Mark Polland, Morten H. Madsen, Kai Dirscherl, Jette Kjeldgaard, *Ekoli progress report period 1*, DFM-2013-R13
- Hans D. Jensen, Carsten Thirstrup, *DFM Measurement report - UPW and low conductivity comparison, DFM - PTB*, DFM-2013-R14
- Hans D. Jensen and Carsten Thirstrup, *UPW and low conductivity measurement comparison. DFM Measurement report, EURAMET 1271*, DFM-2013-R15

Confidential reports 2013

- Michael Kjær, *Noter til DFM-2013-F05 rapporten.* DFM-2013-F01
- Kai Dirscherl, Jan Hald, *Kalibrering af en extensometer kalibrator,* DFM-2013-F02
- Kai Dirscherl, Jan Hald, K*alibrering af en forskydningsmåler,* DFM-2013-F03
- Pia Tønnes Jakobsen, *DFM measurement report for measurements on solutions for Oy FF-chemicals Ab,* DFM-2013-F04
- Michael Kjær, Jan C. Petersen, *Strategi- og handlingsplan for: Nyt indsatsområde ved DFM,* DFM-2013-F05
- Poul Erik Hansen, *Ruhedsundersøgelse af kæbe BD025 for Polerteknik,* DFM-2013-F06
- Michael Kjær, R*isikovudering for DFM A/S,* DFM-2013-F07
- Poul Erik Hansen, Kai Dirscherl, *Measurements on steel coated surfaces,* DFM-2013-F08
- Poul Erik Hansen, *Measurement of modified Si surfaces,* DFM-2013-F09
- Jan Hald, *TankCalibration Software – funktion og validering,* DFM-2013-F10
- Philip Grabow Westergaard, Jan Hald, Jan W. Thomsen, Jens K. Lyngsø, *Versatile FRLS based on molecular absorption spectroscopy: State-of-the-art Technology review and parametric analysis,* DFM-2013-F11
- Philip Grabow Westergaard, *Technical Note 2 – Preliminary FRLS designs, performance predictions and definition of experimentalvalidation approach,*DFM-2013-F12
- David B. Clausen, Jens Brunzendorf, D 2.2.5 *Length measurement of PTB White cells and Herriot cells using Bosch laser distance measurement modules,* DFM-2013-F13

Contributions at conferences

- Antoni Torras-Rosell, Salvador Barrera-Figueroa, Finn Jacobsen *The Versatility of the Acousto-optic measuring principle in characterizing sound fields.* Institute of Acoustics, Nottingham, United Kingdom, May 2013. DFM-2013-K01
- B. Piber, T. Koukulas, A. Torras-Rosell, P. Theobald. *Advances in the free-field measurement of acoustic velocity using gated photon correlation spectroscopy.* Internoice, Innsbruck, Austria, May 2013. DFM-2013-K02
- Salvador Barrera-Figueroa, Antoni Torras-Rosell, Finn Jacobsen. *Extending the frequency range of free-field reciprocity calibration of measurement microphones to frequencies up to 150 kHz.* Internoise, Innsbruck, Austria, September 2013. DFM-2013-K03
- Antoni Torras-Rosell, Elisabet Tiana-Roig, Efren Fernandez-Grande, Cheol-Ho Jeong, Finn T. Agerkvist. *Towards an enhanced performance of uniform circular arrays at low frequencies.* Internoise, Innsbruck, Austria, September 2013. DFM-2013-K04
- Antoni Torras-Rosell, Efren Fernandez-Grande, Finn Jacobsen. *Holographic reconstruction of sound fields based on the acousto-optic effect.* Internoise, Innsbruck, Austria, September 2013. DFM-2013-K05
- Antoni Torras-Rosell, Oliver Lylloff, Salvador Barrera-Figueroa, Finn Jacobsen. *Reconstruction methods for sound visualization based on acousto-optic tomography.* Internoice, Innsbruck, Austria, September 2013. DFM-2013-K06
- Antoni Torres-Rosell, Salvador Barrera-Figueroa. *Sensing the sound with Light.* 5th COOMET Competition Young Metrologist, Braunsweig, Germany, June 2013. DFM-2013-K07
- Søren V. Søgaard, Troels Pedersen, Morten Allesø,Jørgen Garnæs, Jukka Rantanen. *Application of Ring Shear Testing to Optimize Pharmaceutical Formulation and Process Development of Solid Dosage Forms.* Nordic Rheology Conference, Copenhagen, Denmark, June 2013. DFM-2013-K08
- Jørgen Garnæs. *Size and Mechanical Properties of Nano Particles Measured by Atomic Force Microscopy.* NS2013, 10th Seminar on quantitative Microscopy (QM) & 6th Seminar on Nanoscale Calibration, Standards & Methods. Athènes Services, Paris, France, April 2013. DFM-2013-K09
- Jørgen Garnæs. *Mechanical properties and accurate size measurement of polystyrene nano particles.* Scandinavian SPM User Meeting, iNano, Aarhus, Denmark, February 2013. DFM-2013-K10
- Jørgen Garnæs, Simone Tanzi, Matteo Calaon, Jiri Cech, Rafael Taboryski, Hans N. Hansen, Jesper Nørregaard, Morten H. Madsen, Poul-Erik Hansen m.fl. *Application of nanometrology to polymer production.* International Congress of Metrology, Paris, France, October 2013. DFM-2013-K11
- Poul-Erik Hansen, Sven Burger. *Investigation of microstructured fiber geometries by scatterometry.* Spie Optical Metrology Conference, Munich, Germany, May 2013. DFM-2013-K12
- Kai Dirscherl. *A novel approach to estimate deformations of adsorbed nanoparticles.* Nanoscale 2013, Paris, France, April 2013. DFM-2013-K13
- Kai Dirscherl. *Pre-normative study of size distributions of combustion particles from fossil and non-fossil fuels.* ETH Conference on Combustion Nanoparticles, Zürich, Switzerland, June 2013. DFM-2013-K14
- Kai Dirscherl. *Calibration service for mobility measurements based on reference material for monodisperse spherical particles in aerosols.* ETH Conference on Combustion Nanoparticles, Zürich, Switzerland, June 2013. DFM-2013-K15

- Mikael Lassen, Adriano Berni, Lars Skovgaard Madsen, Radim Filip, Ulrik Lund Andersen. *Experimental Gaussian Error Correction of Quantum States in a Correlated Noisy Channel.* ICOLS 2013, Berkeley, USA, June 2013. DFM-2013-K16
- Mikael Lassen, Anders Brusch, David Balslev-Clausen, Jan Hald, Jan C. Petersen. *Versatile Photoacoustic Spectrometer for Sensitive Gas Analysis using an Integrating Sphere as Absorption Cell.* ICOLS 2013, Berkeley, USA, June 2013. DFM-2013-K17

Other talks

- J. Garnaes, Investigation on surface analysis and functionality with AFM – half day with lectures and exercise in seminar 42215 – Geometrical metrology and machine testing, The Technical University of Denmark, 10 April 2013
- J. Garnaes, The history of metrology, Lecture under order a researcher, HTX Frederiksberg, Frederiksberg, 3 May 2013
- J. Garnaes, Invited to participate in the roundtable discussion: Metrology challenges for nanotechnologies, 16th International congress of metrology, Paris, 10 October 2013
- J. Garnaes, Danish metrology and Danish Fundamental Metrology, Visit by Chinese metrology delegation, National Metrology Institute, NIM, DTU Mek, Lyngby, 4 September 2013
- J. Garnaes, The history of metrology, QTea technology workshop, NKT Photonics, Birkerød, 7 October 2013
- M. H. Madsen, Nanotechnology, Temaklubben Birkerød, Birkerød, 26 October 2013
- M. H. Madsen, Science dating, Nano-Science Center, University of Copenhagen, Copenhagen, 22 November 2013
- K. Dirscherl, Investigation on Surface analysis and functionality with AFM, DTU seminar 41731, DTU Byg, Lyngby, 13 April 2013
- K. Dirscherl, Nanopartikler, Forskningens Døgn, Vinding Skole, Vejle, 2 May 2013
- K. Dirscherl, Vinklernes alsidighed, Forskningens Døgn, Spejdergruppe Horsens, Horsens, 2 May 2013
- K. Dirscherl, Vinklernes alsidighed, Forskningens Døgn Solrød Gymnasium, Solrød, 3 May 2013
- K. Dirscherl, Vinklernes alsidighed, Forskningens Døgn, Danmarks Lodsmuseum, Dragør, 3 May 2013
- K. Dirscherl, Introduction to Metrology, DTU seminar 11123, DTU Byg, Lyngby, 12 June 2013
- J. Hald, Length metrology at the primary level DTU seminar 41731, DTU Mek, Lyngby, 17 April 2013
- J. Hald, Lasers applied for time- and length standards, Dept. of Physics and astronomy, University of Aarhus, Aarhus, 17 October 2013
- D. B. Clausen, Optical isotope measurements with Cavity Ring Down Spectroscopy, GEO seminar, Geological Museum, Copenhagen, 11 October 2013
- A. Torras-Rosell, The opto-acoustic method, Akustikkens dag, Dansk Akustisk Selskab, IHA, Aarhus, 7 March 2013
- A. Torras-Rosell, The acousto-optic effect and possible applications, Advanced Acoustics, DTU seminar, DTU Elektro, Lyngby, 2 May 2013
- L. Nielsen, Hvor lang er en meter, hvad vejer et kilogram, Forskningens Døgn, DTU, Lyngby, 2 May 2013
- L. Nielsen, Avanceret usikkerhedsberegning, DFM seminar, DFM, Lyngby, 21-22 May 2013
- L. Nielsen, Hvor lang er en meter, hvad vejer et kilogram, Dansk Teknologihistorisk Selskab, DFM A/S, Lyngby, 14 September 2013
- Marco Triches, FIBER LASER OPTICAL FREQUENCY STANDARD FOR INDUSTRIES, Quantum Matter – Foundations and Applications Summer School, Granada, Spain, September 2013
- Marco Triches, INTEGRATED, FIBER BASED FREQUENCY STANDARD, QTea Technology Workshop, DFM, October 2013
- J. Garnæs, The SI system – definitions and realisations before, now, and in the future. QTea Technology Workshop, NKT, October 2013
- J. C. Petersen, Laser Safety, QTea Technology Workshop, DFM, October 2013
- J. Hald, Traceability in measurements – the metrology infrastructure, QTea Technology Workshop, DFM, October 2013
- L. Nielsen, Calculation of measurement uncertainty according to GUM, QTea Technology Workshop, DFM, October 2013
- L. Nielsen, Multivariate data analysis, QTea Technology Workshop, DFM, October 2013
- P.E. Hansen & K. Dirscherl, Nano technology and metrology, QTea Technology Workshop, DFM, October 2013

INCOME STATEMENT AND BALANCE SHEET

INCOME STATEMENT (1000 DKK)	2013	2012
Commercial revenue	2 996	2 812
Project revenue	7 732	4 788
Government funding	14 681	14 035
Total revenue	**25 409**	**21 635**
Travel expenses	428	348
Other out-of-pocket expenses	3 339	2 038
Total out-of-pocket expenses	**3 767**	**2 386**
Gross profit	**21 642**	**19 249**
Staff costs	15 445	13 082
Other external expenses	4 209	3 840
Total costs	**19 654**	**16 922**
Operating profit before depreciation and impairment losses	**1 988**	**2 327**
Depreciation and impairment losses on property, plant and equipment	1 540	1 533
Operating profit before financial income and expenses	**448**	**794**
Financial income	50	107
Financial expenses	-2	-6
Profit before tax	**496**	**895**
Tax on profit for the year	0	0
Profit for the year	**496**	**895**
Profit for the year to be carried forward.		

BALANCE SHEET AT 31 DECEMBER (1000 DKK)

ASSETS	2013	2012
Deposits	372	372
Total deposits	**372**	**372**
Equipment	9 580	4 927
Leasehold improvements	1 181	1 371
Total property, plant and equipment	**10 761**	**6 298**
Total non-current assets	**11 133**	**6 670**
Contract work in progress	**2 886**	**1 130**
Trade receivables	1 205	546
Amounts owed by parent company	0	0
Prepayments	102	0
Other receivables	1 008	209
Total receivables	**2 315**	**755**
Securities	**0**	**0**
Cash at bank and in hand	**8 755**	**14 648**
Total current assets	**13 956**	**16 532**
Total assets	**25 090**	**23 202**

EQUITY AND LIABILITIES	2013	2012
Share capital	1 000	1 000
Retained earnings	14 801	14 305
Total equity	**15 801**	**15 305**
Prepayments from customers and of funding	3 258	5 203
Prepayments of government funding	3 191	114
Trade payables	364	506
Debt to associated companies	45	28
Other payables	2 431	2 046
Total current liabilities	**9 289**	**7 897**
Total equity and liabilities	**25 090**	**23 202**

KEY FIGURES

KEY FIGURES IN MILLION DKK	2009	2010	2011	2012	2013
Net sales	18.1	19.2	20.1	21.6	25.4
Gross balance	16.8	17.3	17.9	19.2	21.6
Profit or loss for the financial year [1]	-0.3	0.6	1.0	0.9	0.5
Net capital	12.9	13.5	14.4	15.3	15.8
Commercial sale	2.5	2.2	2.7	2.8	3.0
- to small enterprises (less than 50 employees)	0.3	0.4	0.6	0.5	0,4
- to medium size enterprises (50-250 employees)	0.8	0.5	0.5	0.7	0,7
- to large enterprises (more than 250 employees)	0.4	0.5	0.5	0.5	0,8
- to Danish public institutions	0.3	0.2	0.6	0.6	0,0
- to foreign enterprises and institutions	0.7	0.7	0.5	0.5	1,1
Foreign net sales	1.4	1.6	0.9	2.2	6.5
Research and development					
Number of collaborative projects	11	10	18	18	21
- thereof innovation consortia	2	2	1	1	0
- thereof international projects	4	5	7	9	12
R&D activities (million DKK)	15.4	18.6	18.5	21.2	25.4
- thereof self-funded	0.6	1.6	1.2	2.4	3.1
R&D work (man-year)	10.6	11.5	12.3	13.9	16.2
Number of customers					
Danish private enterprises	44	37	27	32	31
- thereof small enterprises (less than 50 employees)	10	19	10	14	14
- thereof medium size enterprises (50-250 employees)	10	6	6	8	6
- thereof large enterprises (more than 250 employees)	15	12	11	10	11
Danish public institutions	9	9	5	11	5
Foreign enterprises and institutions	22	21	18	24	26
Total customer base	66	67	50	67	62
Number of staff categorized by education (man-year)					
Dr & PhD	10	11	11	13	17
MSc	4	4	4	3	2
Other technical staff	3	3	3	3	3
Administrative staff	2	2	2	2	2
Total staff	19	20	20	21	24
Number of publications					
Refereed publications	5	8	9	7	12
PhD - og Master theses	0	1	0	0	1
Other reports	24	24	23	25	15
Conference papers	5	11	14	22	18
Calibration certificates and measurement reports	263	271	442	396	417
Press cuttings	16	14	4	9	9
Education					
DFM courses (number of days)	9	9	5	5	2
DFM courses (number of participants)	26	22	39	56	4
Supervision/teaching at universities (number of students/courses)	2	2	3	9	0
Co-supervision of master thesis students (number of theses)	2	5	5	3	4
Contribution to teaching at universities (number of days)	5	4	8	5	5
Committee work (number of committees)	30	23	26	25	24
- thereof international committee work	20	20	22	22	21
Efficiency					
Turnover per employee (1000 DKK)	925	976	999	1031	1058
Profit per employee (1000 DKK)	-18	36	49	43	20
Commercial turnover per DKK of governmental funding	0.2	0.2	0.2	0.2	0.2
R&D turnover per DKK of governmental funding	1.2	1.4	1.3	1.5	1.7

1) Excluding extraordinary items

DANISH METROLOGY INSTITUTES

According to the CIPM Mutual Recognition Arrangement, a country can have one national metrology institute (NMI) and a number of designated institutes (DI). In Denmark, these metrology institutes are appointed by the Danish Safety Technology Authority (www.sik.dk). In the list below, each appointed metrology institute is identified by the acronym used in the BIPM database over Calibration and Measurement Capabilities. The fields covered by the appointments are indicated in the table on the next page.

BKSV-DPLA
Brüel & Kjær Sound & Vibration
Measurement A/S
Skodsborgvej 307, DK-2850 Nærum
Contact: Erling Sandermann Olsen
Phone: +45 7741 2000
ErlingSandermann.Olsen@bksv.com

DELTA
DELTA Danish Electronics, Light & Acoustics
Venlighedsvej 4, DK-2970 Hørsholm
Contact: Anders Bonde Kentved
Phone: +45 7219 4275
abk@delta.dk

DFM
DFM A/S, Danish National Metrology Institute
Matematiktorvet 307, DK-2800 Kgs. Lyngby
Contact: Jan Hald
Phone: +45 4525 5876
jha@dfm.dk

DTI
Danish Technological Institute
Kongsvang Allé 29, DK-8000 Århus C
Contact: Jan Nielsen
Phone: +45 7220 1236
jan.nielsen@teknologisk.dk

DTU
Technical University of Denmark
Anker Engelundsvej 1, Building 101A,
DK-2800 Kgs. Lyngby
Contact: Niels Axel Nielsen
Phone: +45 4525 7120
nan@adm.dtu.dk

FORCE
FORCE Technology
Navervej 1, DK-6600 Vejen
Contact: Mogens Simonsen
Phone: +45 7696 1630
mss@force.dk

TRESCAL
Trescal A/S
Mads Clausens Vej 12, DK-8600 Silkeborg
Contact: Torsten Lippert
Phone: +45 8720 6969
torsten.lippert@trescal.com

THE 12 SUBJECT FIELDS OF METROLOGY

Fundamental metrology in Denmark follows the EURAMET division into 12 subject fields, while the subfields reflect metrological activities in Denmark. Plans of action drawn up for each subject field serve as guidelines for the appointment of metrology institutes and give suggestions for other initiatives. The years in which plans of action have been published are shown in parenthesis.

SUBJECT FIELD	CONTACT PERSON	SUBFIELDS	METROLOGY INSTITUTE
MASS	Lars Nielsen, DFM	Mass measurement	DFM
(1989, 1997, 2008)	ln@dfm.dk	Force and Pressure	FORCE
		Volume and Density	FORCE
ELECTRICITY AND MAGNETISM	Hans Dalsgaard Jensen, DFM	DC electricity	DFM
(1989, 1994, 2002)	hdj@dfm.dk	AC electricity	TRESCAL
		HF electricity	TRESCAL
LENGTH	Jan Hald, DFM	Basic length measurements	DFM
(1989, 1998, 2007)	jha@dfm.dk	Dimensional metrology	DTU & DTI
		Micro/Nano	DFM
TIME AND FREQUENCY	Jan Hald, DFM	Time measurement	
(1992, 2000)	jha@dfm.dk	Frequency	
THERMOMETRY	Jan Nielsen, DTI	Temperature measurement by contact	DTI
(1992, 1999, 2007)	jan.nielsen@teknologisk.dk	Non-contact temperature measurement	DTU
		Humidity	DELTA
IONISING RADIATION AND RADIOACTIVITY	Arne Miller, DTU	Absorbed radiation dose – Industrial products	DTU
(1992, 2000)	armi@risoe.dtu.dk	Absorbed radiation dose – Medical products	
		Radiation protection	
		Radioactivity	
PHOTOMETRY AND RADIOMETRY	Anders Brusch, DFM	Optical radiometry	DFM
(1990, 1996, 2004)	ab@dfm.dk	Photometry	
		Colorimetry	
		Optical fibres	
FLOW	Jesper Busk, FORCE	Gaseous flow (volume)	FORCE
(1990, 1999, 2007)	jrb@force.dk	Water flow (volume, mass and energy)	DTI
		Flow of liquids other than water	FORCE
		Anemometry	DTI
ACOUSTICS, ULTRASOUND AND VIBRATION	Salvador Barrera-Figueroa, DFM	Acoustical measurements in gases	DFM & BKSV-DPLA
(1992, 2000, 2009)	sbf@dfm.dk	Acoustical measurements in solids	BKSV-DPLA
		Acoustical measurements in liquids	
AMOUNT OF SUBSTANCE	Pia Tønnes Jacobsen, DFM	Environmental chemistry	
(1992, 1995, 2004)	ptj@dfm.dk	Laboratory medicine	
		Products and materials	
		Food chemistry	
		Pharmaceutical chemistry	
		Microbiology	
		Electrochemistry	DFM
INTERDISCIPLINARY METROLOGY	Hans Dalsgaard Jensen, DFM	No subdivisions	
	hdj@dfm.dk		
QUALITY	Kai Dirscherl, DFM	No subdivisions	
	kdi@dfm.dk		

DETAILS OF PERSONNEL

Board of directors

Lars Barkler
CEO, Lithium Balance A/S

Niels Axel Nielsen
Senior Vice President,
Technical University of Denmark (Vice Chairman)

René Logie Damkjer
Member of the Board

Steen Konradsen
CEO, Baunehøj Invest ApS (Chairman)

Søren Stjernqvist
President, Danish Technological Institute

Kai Dirscherl
Senior Scientist, DFM A/S

Jan C. Petersen
Team Leader, DFM A/S

Management

Michael Kjær
CEO

Accountants

KPMG
Statsautoriserede Revisionspartnerselskab

Visitors and students

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Svava Davíðsdottír, PhD student
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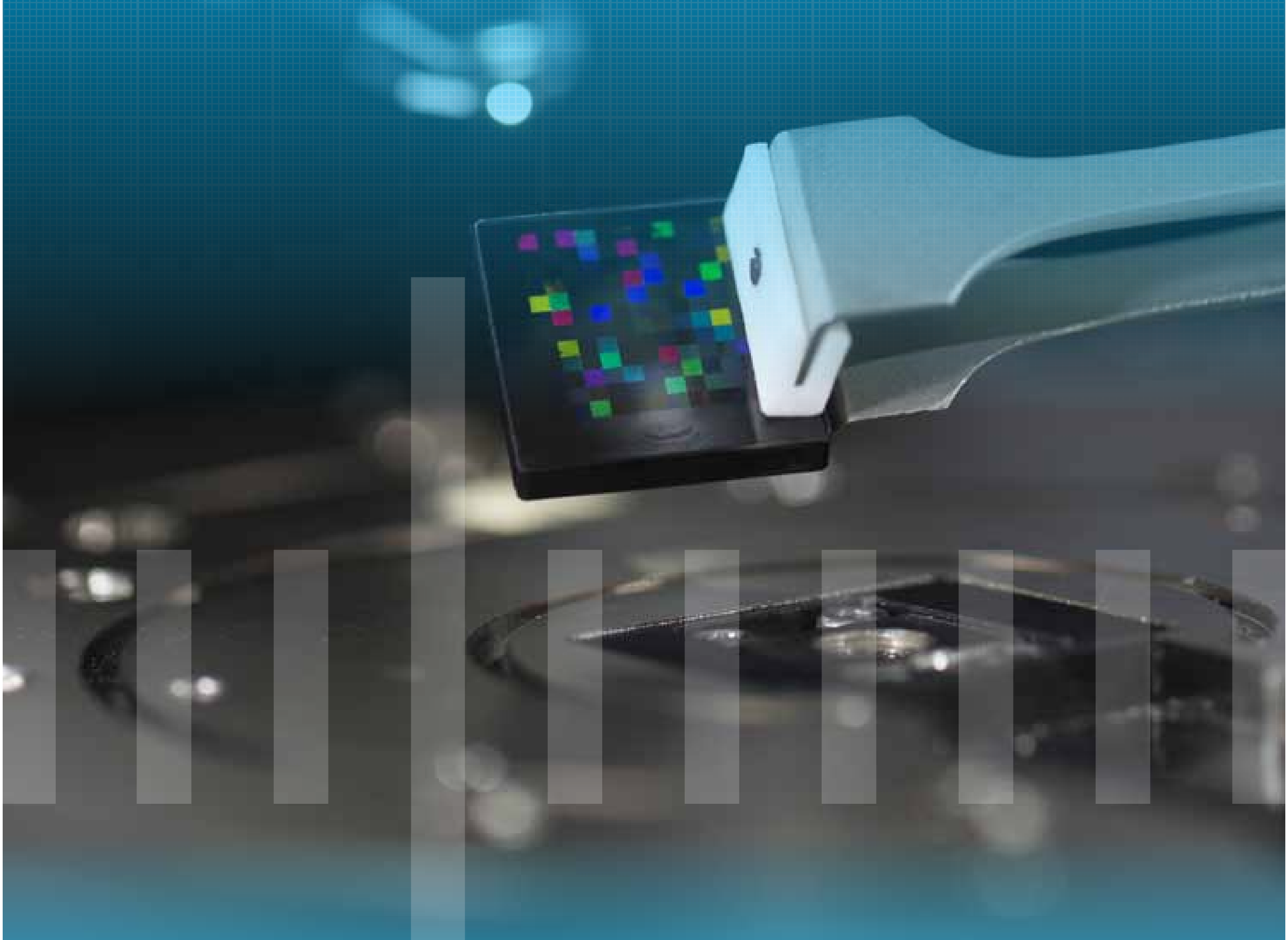
MISSION

TO DEVELOP AND DISSEMINATE MEASUREMENT KNOWLEDGE AT AN INTERNATIONAL SCIENTIFIC LEVEL WITH FOCUS ON DANISH INTERESTS



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