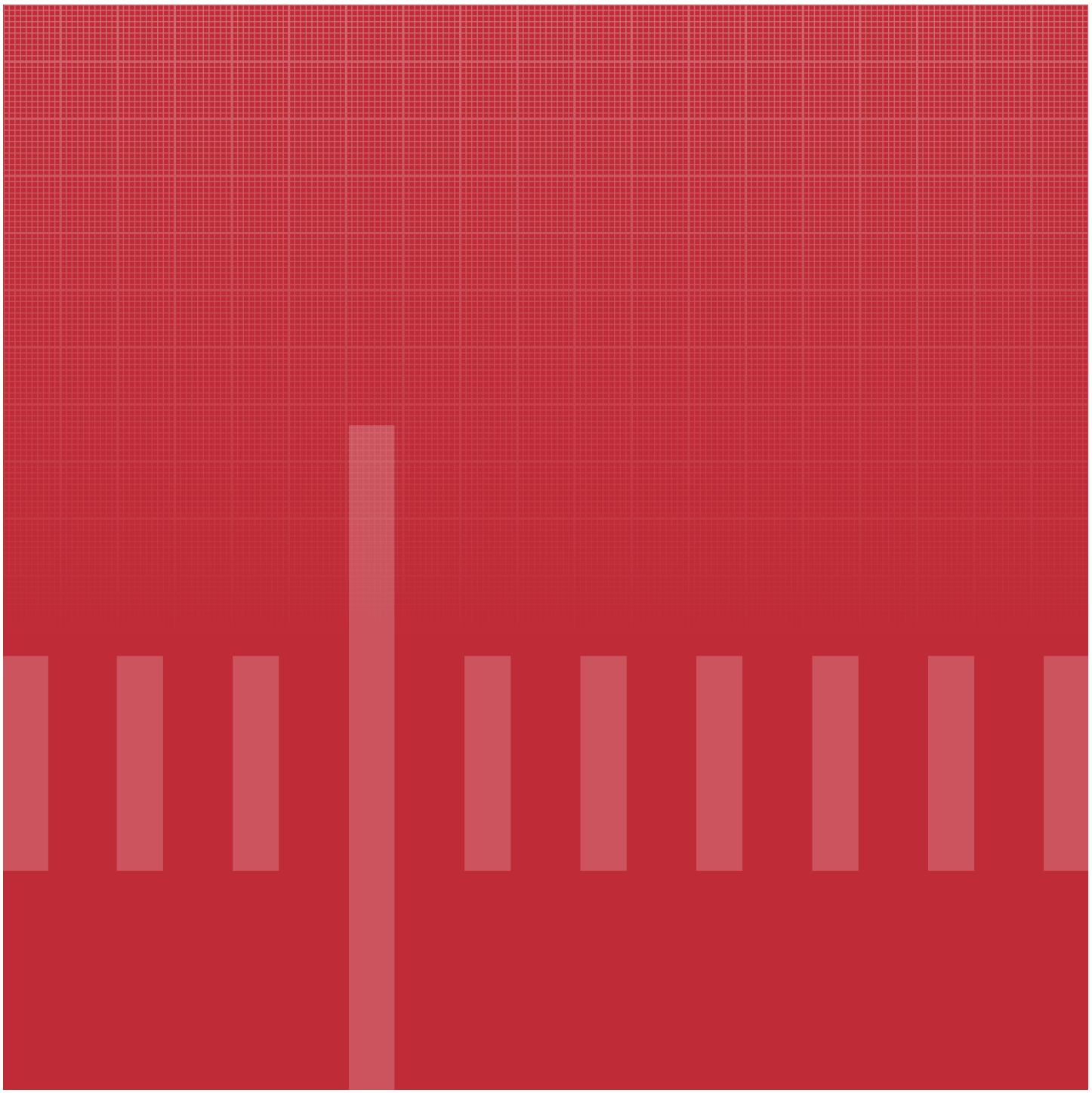
DFM
Danish National Metrology Institute

ANNUAL REPORT
2012



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DFM's scientific research results in new knowledge, measurement techniques and standards, which support the need for 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.

ANNUAL REPORT 2012 EDITED BY

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MANAGEMENT REPORT 2012
FEBRUARY 11, 2013

DFM continued its positive development in 2012. Total revenue increased to 21.6 million DKK from 20.1 million DKK in 2011, and profit was 0.9 million DKK, approximately the same as last year. The management considers both revenue and profit as being satisfactory.

There was a strong growth in new funding for R&D projects, increasing to 10.0 million DKK – the highest level in DFM's history. More than 80 % of it was EU-FP7 funding from the EU-SME, EU-ITN and EMRP programs. This is in accordance with DFM's strategy of increasing its participation in EU projects. Commercial sales increased from 2.7 million DKK to 2.8 million DKK.

The financial results and the new funding ensure that DFM has a strong foundation to develop new metrology capabilities in the coming years, in areas of high importance to Danish society.

A new strategy plan for the period 2013-2015 was approved by the Board. The strategy plan includes the launch of a number of new research activities at a higher level of ambition, than was possible in previous plans, enabling DFM to provide more significant contributions to the Danish metrology in the health, energy, and food sectors. DFM will continue its focus on supporting Danish high tech SME's and further intensify collaboration – nationally with industry and universities, and internationally with other National Metrology Institutes. There will be a significant increase in investments in the period driven by:

- A need for the replacement of a significant part of DFM's basic metrology equipment.
- DFM's plan to expand and improve its laboratory facilities.
- New research activities that will require new equipment.

DFM will further increase its development of new commercial services to Danish industry; it is planned to introduce several new services supporting the medical industry.

In 2012, DFM was re-approved as a member of the Advanced Technology Group (GTS) for the period 2013-2015 by The Ministry of Science, Innovation and Higher Education. Following this, The Danish Council for Technology and Innovation decided to increase funding to DFM's metrology infrastructure and research activities for the contract period 2013-2015. DFM is pleased with the result, which ensures continued development of the Danish metrology infrastructure, which is of critical importance to society.

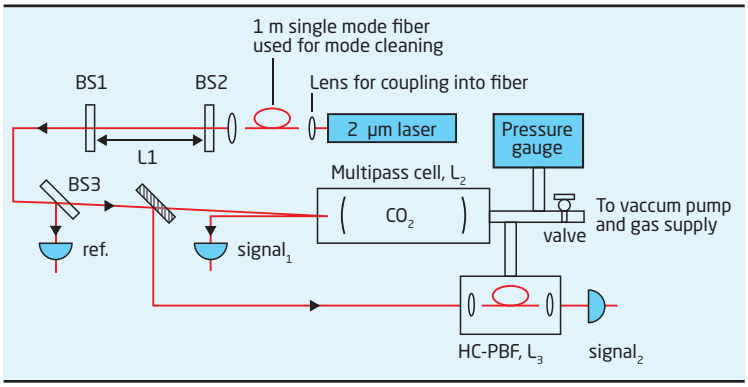
As the National Metrology Institute of Denmark and the leading site in Denmark for metrology research, DFM is targeting development of new metrological capabilities in areas of high importance to society. It is DFM's goal to be recognized globally among the leaders within the specific fields covered by DFM. The management expects that the positive developments will continue in 2013 and lead to further expansion of DFM's activities supporting Danish industry and society in general.

Steen Konradsen
Chairman of the Board

Michael Kjær
CEO

RECORD NUMBER OF RESEARCH AND DEVELOPMENT PROJECTS

The year 2012 has been the most successful year for DFM in terms of number of active, externally funded projects and in terms of value of new awarded projects.



Schematic diagram of the setup used for CO_2 quantification.

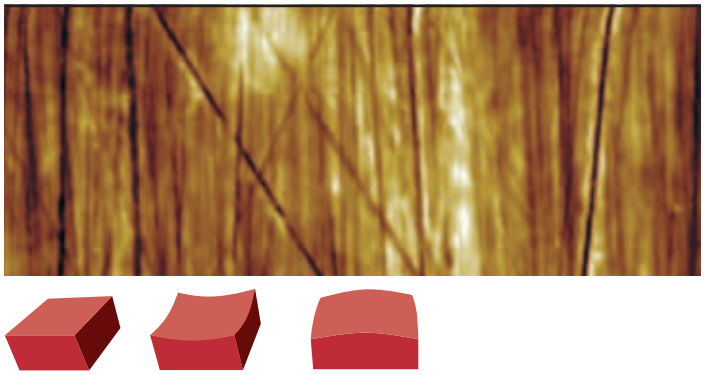


Image and drawing of roughness working standard developed by NIL Technology and measured as part of NanoPlast.

The projects range from a much application oriented project focusing on the development of prototype instrumentation to a very fundamental project aiming at improving the determination of molecular absorption line strength. The size of the projects varies from approximately 100 hours of man power for a project dealing with demonstrating a proof of concept to approximately 3500 hours for developing a prototype instrument. The projects have been awarded from various national agencies as well as EU's Framework Programme.

All of DFM's focus areas, acoustics, electrochemistry, mathematics, photonics and nanometrology, have been successful in attracting external funding for R&D activities.

Acoustics

In acoustics the R&D focus has in recent years – apart from conventional acoustic metrology – also included the application of acoustic devices in healthcare. The project activities are concerned with the use of acoustic equipment for diagnostics of coronary artery disease and with constructing a universal ear including the detection of non-audible sound.

Electrochemistry and mathematics

The electrochemistry team is getting involved with characterizing biofuels while in mathematics there is focus on providing the basis for dissemination of traceability on mass measurement with suitable uncertainty, when a new definition of the kilogram is in place.

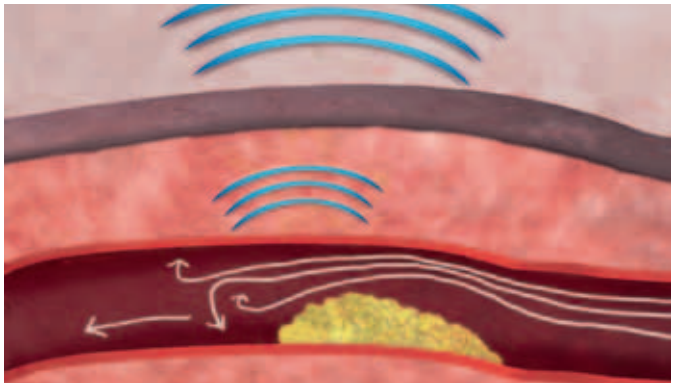
Photonics

The photonics team are now engaged in quite a diverse number of projects dealing with establishing a new generation of frequency standards based on hollow-core photonic bandgap fibres, investigation of quantum sensor technologies and their applications, development and characterization of a facility for measuring light therapeutic equipment, and investigation of photomultiplier tubes used for investigation of chemiluminescence in optofluidic devices. The spectroscopic facilities are concerned with projects on spectral reference data for atmospheric monitoring and the development of a prototype instrument for measuring oil in compressed air.

Nanometrology

In nanometrology there are two main areas of R&D; surface and particle characterization. The surface characterization efforts are particularly targeted on polymer surfaces of various structures and make use of both AFM and optical technologies. Some of the characteristics aimed at are self-cleaning and non-chemical colour changing functionalities. Scatterometry is used to characterize small structures related to manufacturing of electronic and optical devices. Particle characterization focuses on combustion particles from car emission, particle contamination of polished steel surfaces and particle size from the production of hydraulic tools measured as residue in cleaning agents.

DFM SUPPORTS DANISH INDUSTRY



Turbulence in streaming blood caused by partial obstruction (stenosis) in the coronary arteries creates very weak sounds known as "coronary murmurs". Photo: Acarix.

For some people lack of daylight may result in fatigue. Photo: Colourbox.

Listen to your heart with microphones – a life saver

During the development of the CADScor® System, a patented algorithm that helps to detect coronary artery disease at the general practitioner, DFM was asked to help qualify its acoustical quality. The product has been developed by the Danish SME Acarix A/S. It consists of a sensor unit (a microphone and an electronic data processing system) that can be attached to the chest with an adhesive patch, and a docking station for data management and the daily qualification of the sensor unit,

In order to ensure that the blood flow turbulences caused by constrictions in the arteries are correctly measured, DFM has developed a method to test the microphone, ensuring that the sound is measured and recorded properly in a frequency range that includes frequencies down to a few hertz. The acoustic qualification of the system helps Acarix A/S to apply for a CE marking that improves their ability to commercialise their product. The development of the qualification system has been carried out with support from the Business Innovation Fund.

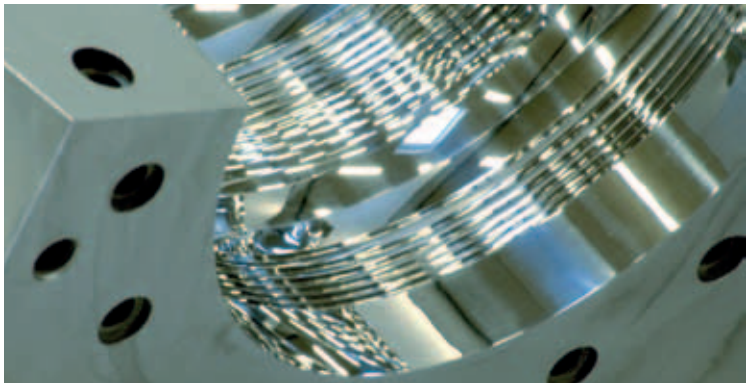
Better light – better life

Daylight therapeutic lamps are widely used for treatment of people suffering from depression and fatigue, especially during the dark winter months. Research into this method of treatment is carried out at Rigshospitalet. In 2012 DFM collaborated with researchers to characterize the light sources used for the treatment. This project helped researchers get a better grasp on the therapeutically relevant features of their light. During this project DFM was able to apply the knowledge accumulated during earlier projects, particularly a recent project aimed at characterizing and optimizing glasses with a built-in light panel for alleviating winter fatigue.

Exact knowledge about the spectral composition and brightness of the lamps helps determine the therapeutic effect of artificial daylight sources. This knowledge will help Rigshospitalet to achieve their goal of successful treatment of patients.

"DFM helped us choose the right equipment for measuring the biolamps used for light treatment. They calibrated the equipment and measured the intensity and spectrum. The collaboration with DFM has ensured exact measurements enabling us to save resources and, most importantly, making us able to collect vital, reliable data of highest possible quality from our experiments", Brenda McMahon, MD, Neurobiology Research Unit, Rigshospitalet

Supporting Danish Industry through scientific work and pioneer projects is one of the most distinguished tasks of DFM A/S. Here we present a couple of recent projects that will give you a good understanding of the diversity of projects DFM A/S is being involved in every year.



Contamination of the initial material is often a decisive factor when polishing a surface. Photo: Polerteknik Aps.

The right amount of UV-light can have a positive effect on pigs' health. Photo: Colourbox.

The quality of a surface polish already begins with the raw material

Polishing steel can be a difficult task if the steel production environment is of variable quality, so that contamination can settle already in the raw material.

Irregularities on the polished surface are not necessarily a sign of insufficient polishing process. Handling of the raw material in the production line is the first critical step where the production site must eliminate possible sources of error. Polerteknik ApS engaged DFM to identify the unknown source of error in their polished surfaces. After measuring different steel surfaces with high resolution at the nanometre scale, DFM could demonstrate that the quality of the final polished product was indeed greatly impacted by the raw material used. This discovery allows Polerteknik Aps to inform their end customer accordingly, and that even high-end polishing procedures cannot correct for initial material contaminations. In this way, customer expectations regarding the final polished surface can be aligned.

Vitamin D research

DTU Food is investigating the level of vitamin D developed by a pig after being irradiated with UV-light and after having eaten forage mixed with vitamin D. Measuring how the vitamin D level depends on UV-light requires knowledge of the light that the pig is exposed to. In a small project, DFM made UV-measurements and found the spectral irradiance for the lamp in order to extrapolate the lamps ability to simulate sun-exposure in the UV-range.

"People from DFM quickly understood our problem and added an important dimension to our research", Jette Jakobsen, Senior Scientist, Division of Food Chemistry, DTU Food

EURAMET GENERAL ASSEMBLY 2012 IN KONGENS LYNGBY

Participants at the EURAMET General Assembly 2012 at DTU in Kongens Lyngby.

The 6th EURAMET General Assembly took place at the campus of the Danish Technical University in Kongens Lyngby on 22nd and 23rd May.

The General Assembly contains two sessions, a plenary session and a delegates only session. In the plenary session the attendees are EURAMET Delegates, representatives of EURAMET Associates and Liaison Organisations, TC-Chairs, Invited Guests and staff of EURAMET Secretariat. Approximately 62 people from 34 countries attended the plenary session.

The CEO of DFM Michael Kjær opened the meeting and welcomed the participants to Denmark. He gave an overview of the Danish metrology infrastructure. The President of DTU Anders Bjarklev gave a welcome address on behalf of the hosting organisation of the General Assembly.

New EURAMET strategy initiated

An important item that was discussed during the meeting was EURAMET Objectives and Strategic Matters, which is related to the development and implementation of the EURAMET 2020 Strategy. The strategy includes measures to engage key stakeholders, to increase influence with European policy makers and national governments, to further develop co-operation in R&D, to deliver high value to members and associates, and to support quality infrastructure in Europe and internationally.

European metrology research

Another important item on the agenda was the European Metrology Research Programme – EMRP and the preparation of the follow-up programme EMPIR. A midterm evaluation of the EMRP was carried out during the last year. The report was published by the European Commission in April 2012, and the overall conclusions on the management of the programme were very positive; however, gaps between expectations and reality were identified in relation to capacity building, interaction with wider scientific community and mobility.

As usual, highlights and scientific challenges of the EURAMET Technical Committees was an important item on the agenda as well.

ACCURATE MEASUREMENTS OF X-RAY MIRRORS FOR SPACE BASED TELESCOPE

Silicon substrate for X-ray mirrors. The background image (from ESA, sci.esa.int) is an artist's impression of the ATHENA spacecraft, which is a candidate for a coming ESA mission.

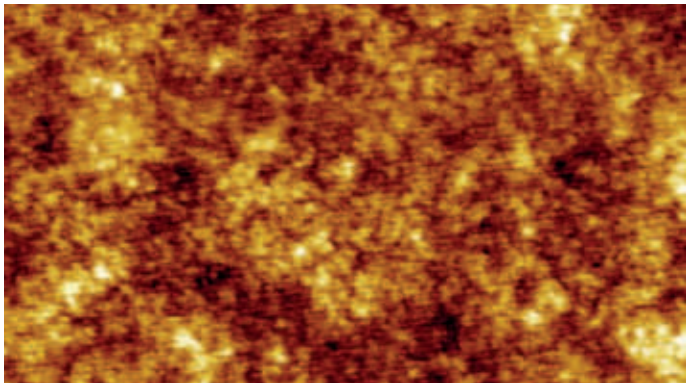


Image of the silicon substrate used in the trial production of X-ray mirrors. The area shown is 0.001 mm x 0.0005 mm and the height variation is in the order of 1 nm, that is, a millionth of a millimeter. White is high and dark is low.

DFM has measured the surface structure of a trial production of X-ray mirrors in collaboration with DTU Space and ESA, the European Space Agency. This investigation is one of the first steps in constructing an X-ray telescope to be launched into space in 2020.

DFM has accurately quantified the vertical deviations of the real mirror surface from its ideal flat form. The average deviation was found to be in the order of 1 nm, that is, a millionth of a millimeter, which is equivalent to roughly the size of just four silicon atoms.

These measurements are important to DTU Space as their task is to develop an advanced recipe for the production of the X-ray mirrors, and one of the most difficult specifications to define, fulfill and document is the proper smoothness of the mirrors' surface. All the results in DFM's measurement reports are traceable to the SI units and include uncertainties determined according to internal procedures. These features of the reported results secure that they can be used to specify and document the final production of the mirrors for the space mission.

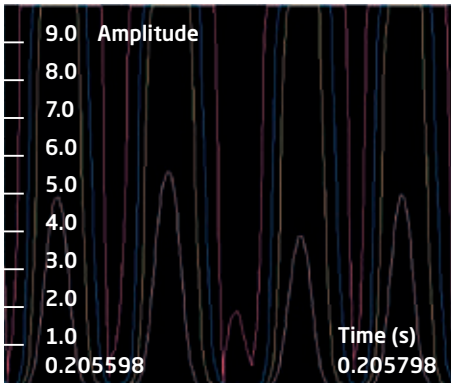
Applied measurement technique

DFM have used a so called metrology atomic force microscope (AFM) to quantify the vertical deviations of the real mirror surface. This high resolution microscope works by accurately tracing the contours of the surface to be measured by a sharp tip. Using the AFM microscope DFM offers calibration of step height standards and similar objects. The internal calibration procedure for this service has formed an excellent basis for the specialized measurements carried out for DTU Space.

Outlook

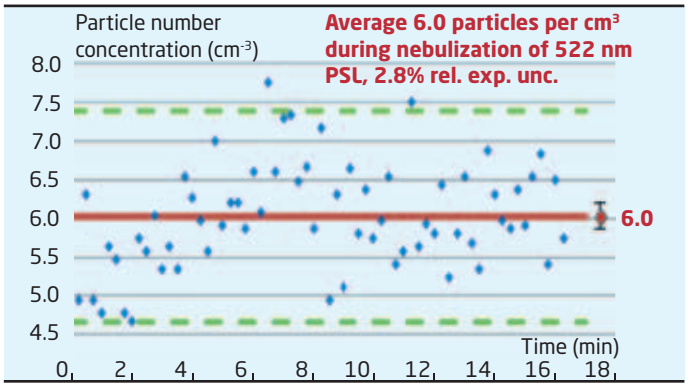
The trial production of X-ray mirrors shall in their final form consist of multiple, thin layers (of for example metal) deposited on top of a silicon substrate. These multi-layers can reflect X-rays hitting the mirror at low grazing incidence. The mirrors will be collected in modules which shall focus X-rays from the space on an image detector. The ATHENA (Advanced Telescope for High Energy Astrophysics) mission is an X-ray observatory under extended study by ESA with a possible launch date after 2020.

NEW FACILITY FOR CALIBRATION OF PARTICLE COUNTERS



Several amplifier stages ensure that no particle passes undetected.

Accurate particle counting requires good control of clean air.



The average particle number concentration of the calibration aerosol is stable within 3%.

In response to the need of the Danish pharmaceutical industry, DFM has established a facility for calibration of particle counters used in clean room production lines. The facility includes a new Danish primary standard based on laser diffraction.

In pharmaceutical production lines it is very important to constantly monitor the quality of the air with respect to unwanted airborne particles such as dust, dirt or bacteria. These particles can contaminate the final product and easily render a whole batch worthless. To avoid this, instruments are installed that count the particle number concentration in air and give alarm if necessary. The instruments also must categorize the counted particles with respect to particle size. The new facility at DFM enables calibration of particle counters in terms of both particle size and particle number concentration.

Typical particle sizes

Nanoparticles have a diameter of approximately 1 billionth of a metre. Microparticles are 1000 times larger, but still as small as 1 millionth of a metre, and 50 times smaller than the thickness of a human hair. Typical particle sizes for calibration are 500 nanometre and 5 micrometre, as these particle size boundaries play an important role in the pharmaceutical industry. However, DFM's primary standard can count particles between 100 nanometre and 8 micrometre.

Counting method

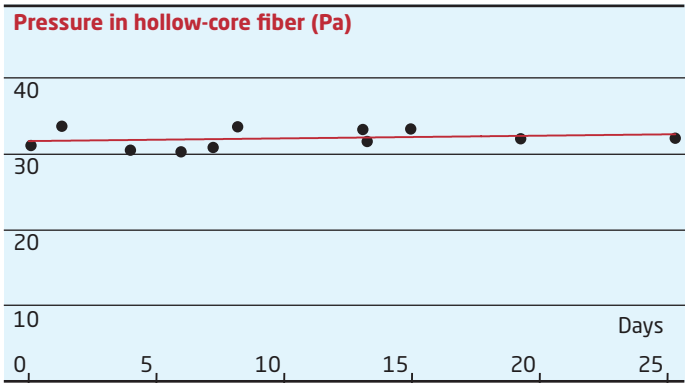
The method for counting airborne particles applied by DFM is based on optical laser diffraction. As a particle passes through a laser beam, the laser light is diffracted. The intensity of the diffracted light can be measured and related to the particle's size according to principles of optical theory. As every single particle can be counted individually, this method is a primary method. This primary method stands in contrast to e.g. filter methods, where the mass gain of a filter membrane before and after its exposition to particles allows an indirect measure of the number of particles via a calibrated weighing instrument, the filter pore size and the particles' material density.

Validation

The primary standard has participated in national and international comparisons, e.g. with the Swiss metrology institute METAS. In cooperation with Novo Nordisk, it has also been used to evaluate the counting efficiency of innovative particle counters that can distinguish between biologically inactive particles such as dust, and active particles such as bacteria.

SEALING GAS-FILLED HOLLOW-CORE OPTICAL FIBRES

One end of a hollow-core fibre is sealed in a small, compact glass cell. The fibre enters three concentric tubes. The smallest tube is used to support the fragile uncoated fibre and is not part of the seal.



The graph shows the spectroscopic measurements of gas pressure inside the sealed hollow-core fibre. The solid line represents a linear fit corresponding to a pressure increase of (14 ± 21) Pa/year.

In recent years, DFM has studied properties of hollow-core optical fibres and developed new techniques for laser spectroscopy in gas-filled hollow-core fibres. The fibres are normally placed inside bulky vacuum setups where pumps and gas supplies allow for evacuation and gas filling of the fibres through the open fibre ends. Applications in space and industry are now targeted, and this requires sealing of the gas-filled fibres in order to dispense with the vacuum equipment.

In the EMRP project *New generation of frequency standards for industry,* DFM develops a compact frequency-stable fibre laser system. The frequency stability is achieved by using an acetylene absorption line at a well-defined laser frequency as reference. The acetylene molecules are held inside a hollow-core fibre, and the success of this project depends on a suitable technique for sealing the fibre. Changes in pressure inside the fibre broaden and shift the molecular absorption line leading to reduced frequency stability.

The main source for pressure changes is leakage of atmospheric air into the fibre. A life time of about 3 years for the frequency stabilised laser requires that the gas pressure in the hollow-core fibre changes less than 10 Pa/year.

Sealing technique

In a new design the end of the hollow-core fibre is inserted into a small glass tube. This tube is inserted into a larger glass tube with a lens glued onto the other tube end and a small glass tube for gas filling fused into its side. Low viscosity epoxy resin is used to seal the narrow air gaps between the fibre and the glass tubes as well as between the lens and the tube. After having filled the fibre with the desired amount of gas, the filling tube is sealed by fusing.

Measurements show that atmospheric air leaks through the epoxy and results in a pressure increase of (460 ± 20) Pa/year, which is consistent with typical gas permeabilities of epoxy resins. Additional application of a dedicated silicone based vacuum sealant reduces the gas permeability, and spectroscopic measurements over a period of 25 days show a pressure increase of (14 ± 21) Pa/year inside a fibre sealed at both ends. Conformity to the 10 Pa/year limit will be demonstrated with a slightly improved design and an extended measurement time.

OPTICAL MEASUREMENTS OF MICRO AND NANO STRUCTURES

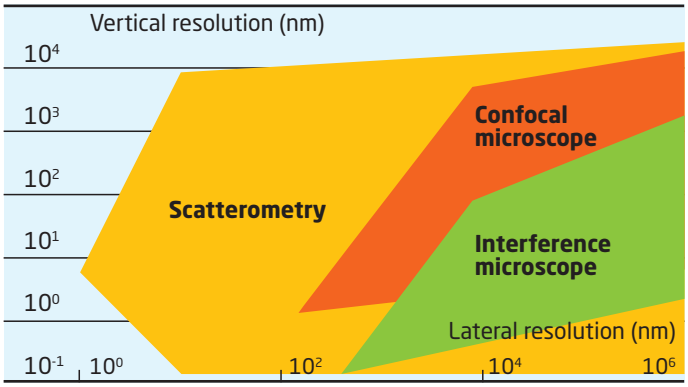


Fig. 1: Optical measurement techniques and their ranges of resolution in the lateral and vertical directions.

Fig. 2: Platinum wire on substrate.

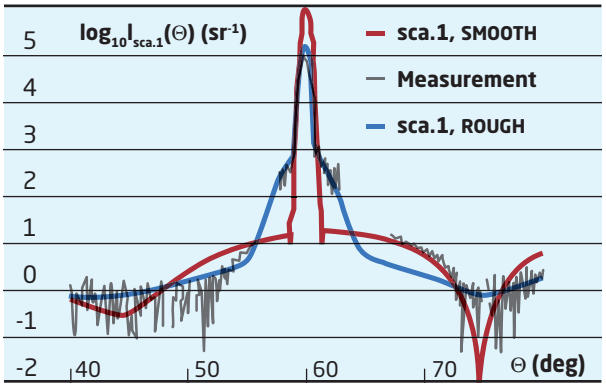


Fig. 3: Measured and fitted power of light scattered in different angles by platinum wire on substrate.

One of the great challenges in optical metrology is dimensional measurements of small structures with features less than 1 micrometer. In order to meet this challenge, DFM is developing an optical measurement technique based on scattering of light.

The measurement resolutions of several optical methods are illustrated in Fig. 1. Note that high resolution of a method corresponds to small values of resolution on the axes of the plot.

The very high vertical resolution of interference and confocal microscopes make these instruments the obvious choice for measuring dimensions of small structures if high lateral resolution is not needed.

Scatterometry is a light scattering technique for measuring dimensional properties of small structures with lateral and vertical resolutions of a few nanometer. The fraction of the scattered power to the incident power is sensitive to the shape and dimensions of the structure and may therefore be used to characterize the structure itself. The dimensional quantities are obtained by fitting the fraction of scattered power, which can be calculated from the interaction of the incident light with a structure of given shape and dimensions, to the measured fraction of scattered power.

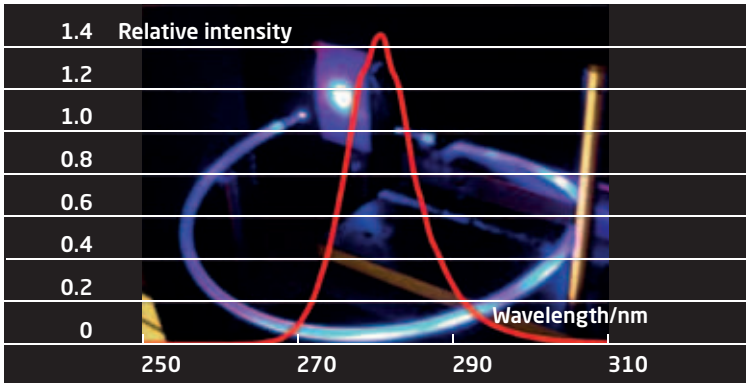
New trends in scatterometry

Scatterometry of periodic structures is well-established. New trends include the study of complex structures like line structures with rough sidewalls (Line Edge Roughness), curved structures, and isolated structures.

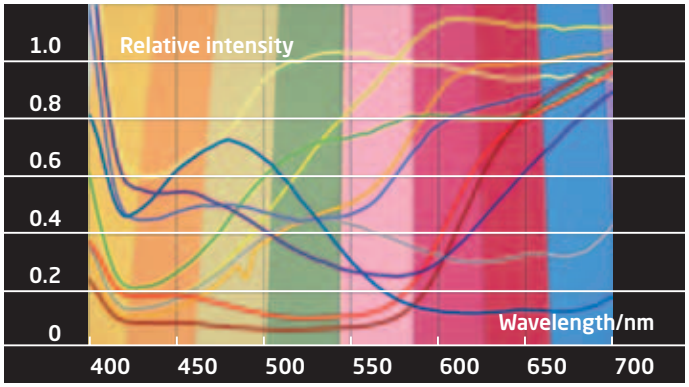
An example of the latter is the isolated platinum submicron wire on a silicon substrate shown in Fig. 2. Using a translation stage and a microscope, the platinum wire was placed in the center of the beam from a helium-cadmium laser. The measured fraction of scattered power as a function of the angle of the incident light is shown in Fig 3.

The platinum wire was modeled by an ellipsoidal cylinder, with semi-axes a and b, lying flat on the silicon substrate. Assuming that the substrate is perfectly smooth, the values $a = 350$ nm and $b = 290$ nm for the semi-axes gave the best (but still rather poor) fit of the calculated fraction of scattered light (red curve in Fig. 3) to the measured data. A much better fit (blue curve in Fig. 3) was obtained by assuming a rough surface of the silicon substrate leading to the values $a = 290$ nm and $b = 320$ nm for the semi-axes of the platinum wire.

NEW SPECTRORADIOMETRIC COMPETENCES AT DFM



Fluorescence in a fibre that shows the UV light guiding properties of a catheter. The overlay shows the spectral distribution of the light source in the UV.



Different coloured test targets used for measuring the spectral properties of reflected light. The overlay shows the spectral distributions of light reflected from each target.

The spectroradiometric capabilities at DFM have been expanded in the recent year, and new types of measurements are being pursued in health applications. To ensure the quality of future measurements, the traceability to international standards has been established.

Two years ago DFM introduced a spectroradiometric facility to support the very specific service of checking the safety of sunbeds according to the European standard EN 60335-2-27. In addition services were provided for an SME in their effort to optimize sources used for light therapy.

Characterisation of light sources

The facility has since been used in a variety of other applications that has allowed DFM to explore the additional measurement needs in the Danish commercial market. DFM has characterized the spectral distributions and power of artificial daylight lamps and UV lamps that are used for studies of vitamin D production in pigs.

A number of UV LEDs that are used in the medical world for in-situ long term sterilization of catheters have been characterized. These LEDs have a centre wavelength in the UVB region at 280 nm and are powerful with an emitted power of 4 mW. It is of considerable importance to have a good understanding of both the emitted power and the wavelength of such LEDs, since their physiological impact is potentially hazardous. It is of uttermost importance that such light sources are handled correctly. Based on the experience gained recently, DFM was able to precisely characterize the LED's and furthermore provide best-practice guidelines for the use of two power meters to be used in routine work by the customer.

Calibration of reference lamps

DFM has also provided the first calibration of the luminance of reference lamps for a Danish public organization. The luminance signifies how bright a source appears and is used in many applications.

Spectral irradiance measurements, which form the basis of DFM's measurements on light sources, are now well established at DFM. Traceability to the international irradiance scale through the calibration of a standard lamp has been secured through another NMI. DFM is now preparing for accreditation by DANAK in order to respond to requests from a few potential Danish customers. It is expected that the services will cover radiance and irradiance as well as the derived quantities, illuminance and luminance.

ACCOUNTS OF PARTICULAR ACTIVITIES

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

- EMRP Committee
- Consultative Committee for Electricity and Magnetism (CCEM)
- Consultative Committee for Amount of Substance (CCQM)
- Consultative Committee for Acoustics, Ultrasound and Vibration (CCAUV)
- 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)
- 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 Metrology – Discussion Group on Nanometrology (CCL-WGDM-DG7)
- 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)

Participation in national and international projects

- Nano- og mikropartikler – karakterisering, innovative anvendelser og miljørigtig teknologi (NaKIM), RTI
- Metrology for biofuels (Biofuels), EMRP/RTI
- Nanoplast, HTF
- Polynano, DSF
- Metrology for chemical pollutants in air (MACPoll), EMRP/RTI
- 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 (DCAD), BIF
- Universal ear and 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
- Udvikling af lysterapeutisk apparat, RTI
- PMT kalibreringsmetoder, RTI
- Karakterisering af polerede overflader, RTI
- Validering af software, RTI
- Overfladefriktion, RTI
- Partikler I rensevæske, RTI

Calibration certificates and measurement reports

DC electricity	5
Electrochemistry	235
Mass	26
Length	10
Optical radiometry	109
Nano structures	3
Acoustics	8
Total	442

Publications in refereed journals

- Jeppe Clausen, Alexander B. Christiansen, Joergen Garnaes, N. Asger Mortensen, and Anders Kristensen, Color effects from scattering on random surface structures in dielectrics, Optics Express, Vol. 20, Issue 4, pp. 4376-4381 (2012), DFM-2012-P01
- Antoni Torras-Rosell, Salvador Barrera-Figueroa, Finn Jacobsen, Sound field reconstruction using acousto-optic tomography, J. Acoust. Soc. Am., Vol. 131, No. 5, 3786-93, May 2012, DFM-2012-P02
- Bernd Bodermann, Egbert Buhr, Hans-Ulrich Danzebrink, Markus Bär, Frank Scholze, Michael Krumrey, Matthias Wurm, Petr Klapetek, Poul-Erik Hansen, Virpi Korpelainen, Marijn van Veghel, Andrew Yacoot, Samuli Siitonen, Omar El Gawhary, Sven Burger, Toni Saastamoinen, Joint Research on Scatterometry and AFM Wafer Metrology, Frontiers of Characterization and Metrology for Nanoelectronics:2011, AIP Conf. Prof. Proc. 1395,319-323 (2011), DFM-2012-P03
- Antoni Torres-Rosell,1, Salvador Barrera-Figueroa, Finn Jacobsen, An acousto-optic beamformer, J. Acoust. Soc. Am., Vol. 132, No. 1, July 2012, DFM-2012-P04
- Mirza Karamehmedović, Poul-Erik Hansen, Kai Dirscherl, Emir Karamehmedovi, Thomas Wriedt, Profile estimation for Pt submicron wire on rough Si substrate from experimental data, Optics Express, Vol. 20, Issue 19, pp. 21678-21686 (2012), DFM-2012-P05
- Walter Bich, Maurice G Cox, René Dybkaer, Clemens Elster, W Tyler Estler, Brynn Hibbert, Hidetaka Imai, Willem Kool, Carine Michotte, Lars Nielsen, Leslie Pendrill, Steve Sidney, Adriaan M H van der Veen and Wolfgang Wöger, Revision of the 'Guide to the Expression of Uncertainty in Measurement', Metrologia, Vol. 49, No 6, 702-705 (2012), DFM-2012-P06
- Desiree Della Monica Ferreira, Anders C. Jakobsen, Finn E. Christensen, Brian Shortt, Michael Krumrey, Jørgen Garnæs, Ronni B. Simonsen, Development and characterization of coatings on Silicon Pore Optics substrates for the ATHENA mission, Proc. SPIE 8443, Space Telescopes and Instrumentation 2012: Ultraviolet to Gamma Ray, 84435E (September 17, 2012), DFM-2012-P07

Other reports

- Lars Nielsen, Pia Tønnes Jakobsen, Anders Brusch, Annual report and statement of income for 2011, DFM-2012-R01
- Kai Dirscherl, Overfladekarakterisering af plastprismer, DFM-2012-R02
- Michael Kjær, Faglig rapportering til rådet for teknologi og innovation for 2011, DFM-2012-R03
- Michael Kjær, DFM projektpartner strategi samt strategi for at øge projektansøgninger 2012, DFM-2012-R04
- Kai Dirscherl, Comparison of particle counters with nebulized cylindrical particles, DFM-2012-R05
- Kai Dirscherl, Torsionsresonans måling på behandlet stål med AFM, DFM-2012-R06
- Kai Dirscherl, Måling på gummiemne med Atomic Force Mikroskopi, DFM-2012-R07
- Kai Dirscherl, Optical and geometric measurements of a nanoparticle based surface coating, DFM-2012-R08
- Pia Tønnes Jakobsen, DFM Measurement report for bilateral comparison of electrolytic conductivity between LNE and DFM in august 2012, DFM-2012-R09
- Kai Dirscherl, Ruhedsmåling af aluminium emne, DFM-2012-R10
- Poul Erik Hansen, Optical Chirality, DFM-2012-R11
- Salvador Barrera-Figueroa, Free-field reciprocity calibration of microphones at high frequencies, DFM-2012-R12
- Pia Tønnes Jakobsen, Hans D. Jensen, Jørgen Avnskjold, DFM Measurement report for CCQM-K105, DFM-2012-R13
- Johannes Weirich, Surface Plasmon Resonance Sensor, DFM-2012-R14
- Michael Kjær, Kommentar til DFM evaluering – baggrundsrapport, DFM-2012-F01
- Johannes Weirich, Mie theory and size determination of non-spherical sub-micron particles, DFM-2012-F02
- Jan Hald, Sammenligning – Dibal GSE klasse III vægt (2011), DFM-2012-F03
- Michael Kjær, DFM´s strategi for perioden 2013-2015: Metrologi, Vækst og Værdiskabelse, DFM-2012-F05
- Salvador Barrera-Figueroa, Draft A Report EURAMET. AUV.A-S1, DFM-2012-F06
- Michael Kjær, Markedsføringsplan: Kalibrering af sensorer til måling af ledningsevne i ultra-rent vand, DFM-2012-F07
- Johannes Weirich, Size and shape determination of aspherical sub-micron particles using laser diffraction and T-matrix simulations, DFM-2012-F08

- Lars Nielsen, Danvægt sammenligning 2012 - Tællevægt Cely PC-50, DFM-2012-F09
- Lars Nielsen, Danvægt sammenligning 2012 - Klasse III vægt, GSE 350 (30 kg), DFM-2012-F10
- Lars Nielsen, Danvægt sammenligning 2012 - Klasse III vægt, GSE 350 (500 kg), DFM-2012-F11
- Poul-Erik Hansen, Bestemmelse af tykkelse og brydningsindeks ved brug af ellipsometri, DFM-2012-F12

Reports in the series F01-F12 are confidential

Contributions at conferences

- K. Gurzawska, K. Dirscherl, A study of pectin coated tooth implants at the nanometer scale, Nanoparticle day DTU, Lyngby, 17 January 2012
- S. Daviðsdóttir, K. Dirscherl, Surface topography and potential of photocatalytic TiO2 nanoparticles under UV, Nanoparticle day DTU, Lyngby, 17 January 2012
- J. Garnaes, Size and mechanical properties of polystyrene nano particles, Nordic SPM Conference and User Meeting Institute for Surface Chemistry (YKI), Stockholm, 14-15 February 2012
- J. Fischer, B. Fellmuth, C. Gaiser, T. Zandt, L. Pitre, S. Briaudeau, F. Sparasci, D. Truong, Y. Hermier, D. France, 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. C. Petersen, J. Hald, L. Nielsen, S. Valkiers, B. Darquie, C. Borde, C. Chardonnet, C. Daussy, L. Gianfrani, A. Castrillo, P. Laporta, and G. Calzerano, The Imeraplus joint research project for determinations of the Boltzmann constant, Ninth International Temperature Symposium, Los Angeles, 19 - 23 March 2012
- J. Garnaes, Accurate dimensions and material properties at a nanometre scale, Update 2012-Nano Connect Scandinavia, Helsingborg/Elsinore, 27-28 March 2012
- K.Dirscherl, Recent advances in nanometrology, Update 2012-Nano Connect Scandinavia, Helsingborg/Elsinore, 27-28 March 2012
- Svava Daviðsdóttir, Kai Dirscherl, Characterization of PVD deposited TiO_2 film by model reactions, AFM, Kelvin probe and surfaced potential measurements, Seminar on Antimicrobial and self-cleaning surfaces, Copenhagen, 24-25 April 2012
- Anders Brusch, Calibration of single photon detectors. SRT07 preliminary meeting, Grenoble, 26 April 2012
- Jan Hald, Boltzmann og temperaturskalaen, Måletekniske dage, TI Tåstrup, 31 May 2012
- Kai Dirscherl, Medicotekniske målinger: Sensorer, partikler, mikroflow, Måletekniske dage, TI Tåstrup, 31 May 2012
- Johannes Weirich, Kai Dirscherl, Jørgen Garnæs, Poul Erik Hansen, Søren Lund Kristensen, Lars Lundgreen Larsen, Refractive-index determination of micro and nanoparticles, Nanoday at DTU, Lyngby, 1 June 2012
- Antoni Torras Rosell, Salvador Barrera Figueroa and Finn Jacobsen, A beam forming system based on the acousto-optic effect, Ninth European Conference on Noise Control, Prague, 10-13 June 2012
- K.Dirscherl, Recent advances in industrial nanometrology, Industrial Technologies 2012, Aarhus, 19-21 June 2012
- K. Gurzawska, N.R. Jørgensen, K. Dirscherl, R. Svava, S. Nielsen, P. Ulvskov, K.B. Haugshøj, Y. Yu, B. Jørgensen, and K. Gotfredsen, Nanocoating of titanium implants with pectins, International Association for Dental Research General Session, Brazil, 20-23 June 2012
- A. Simonsen, J. Hald, J. K. Lyngsø, and J.C. Petersen, Hollow Core Photonic Bandgap Fibers for Quantitative Measurements of Fractional Amounts of Gases, 2012 OSA Optics and Photonics Congress: Imaging and Applied Optics, Optical Sensors, Monterey, 24-27 June 2012
- Antoni Torras Rosell, Salvador Barrera Figueroa and Finn Jacobsen, Investigating the use of the acousto-optic effect for acoustic holography, Inter-Noise 2012, New York, 19-22 August 2012
- Salvador Barrera Figueroa, Antoni Torras Rosell, Knud Rasmussen, Finn Jacobsen, Vicente Cutanda Henríquez and Peter Møller Juhl, A practical implementation of microphone free-field comparison calibration according to standard IEC 61094-8, Inter-Noise 2012, New York, 19-22 August 2012
- Svava Davíðsdóttir, Kai Dirscherl, Rajan Ambat, Investigation of Photocatalytic Activity of Titanium Dioxide Deposited on Metallic Substrates by Plasma Technique, Conference on Electrochemical Science and Technology, Århus, 11-12 October 2012
- Katarzyna Gurzawska, Niklas Jørgensen, Kai Dirscherl, Rikke Svava, Susanne Nielsen, Peter Ulvskov, Kenneth Haugshøj, Yihua Yu, Bodil Jørgensen, Klaus Gotfredsen, Nanocoating with pectins - a novel surface for osseointegrated titanium implants, European Association of Osseointegration, Copenhagen, 13 October 2012
- J. Weirich, K. Dirscherl, J. Garnaes, L. Lundgreen Larsen, S. Lund Kristensen, Refractive index measurement of insulin micro- and nanoparticles, AAPS annual meeting 2012, Chicago, 14-18 October 2012
- J. Garnaes, Diameter measurements of polystyrene particles with atomic force microscopy, EURAMET TC Length workshop, Warsaw, 23-24 October 2012

- Lars Nielsen, Considerations on mise en pratique for the kilogram based on work of CCM WGM TG2, CCM Workshop on the *mise en pratique* of the new definition of the kilogram, BIPM, Paris, 21-22 November 2012

Other talks

- Lars Nielsen, How can we improve measurement quality?, Modern Metrology Seminars III, DTU-MEK, 23 Februar 2013
- Kai Dirscherl, Geometrical metrology and mechanical testing – Atomic Force Microscopy, DTU course 41731, DFM & DTU MEK, 21 March 2012
- J. Garnaes, Functional surfaces: Optical grating, Modern Metrology Seminars III, DTU-MEK, 19 April 2012
- J. Garnaes, Using surfaces for particle measurements, Modern Metrology Seminars III, DTU-MEK, 19 April 2012
- Jan Hald, Meteren og kilogrammet – før, nu og i fremtiden, Forskningens døgn, Gildbroskolen, 19 April 2012
- Kai Dirscherl, Vinklernes alsidighed- med passer, ur og GPS, Forskningens Døgn, Vallensbæk Skole, 19 April 2012
- Kai Dirscherl, Den røde aftenhimmel – når sollyset spiller bold med nanopartikler, Forskningens Døgn, Idrætsefterskole Haslev, 19 April 2012
- Jan Hald, Meteren og kilogrammet – før, nu og i fremtiden, Forskningens døgn, IDA Vestjyllands Seniorudvalg, 20 April 2012
- Kai Dirscherl, Vinklernes alsidighed- med passer, ur og GPS, Forskningens Døgn, Brorfelde Astronomiske Center, 21 April 2012
- Kai Dirscherl, Nanometrology for bio applications, KU Sund, 24 April 2012
- Lars Nielsen, Kursus i God Vejepraksis, DFM, 8 juni 2012
- Kai Dirscherl, Eksperimentelle metoder i bygningsenergi og indeklima-Metrologiens historik, DTU kursus 11123, DTU-BYG, Lyngby, 8 June 2012
- Salvador Barrera Figueroa, Sound field reconstruction and beamforming based on measurements of the acousto-optic effect, 8th CCAUV Meeting, Paris, 13-14 June 2012.
- Salvador Barrera Figueroa, Determining the pressure sensitivity of a microphone from measurements of the velocity of the membrane, 8th CCAUV Meeting, Paris, 13-14 June 2012.
- Jan Hald, Sporbarhed til SI enhederne, DANAK's akkrediteringsdag for laboratorier, Nyborg, 14 June 2012
- J. Garnaes, Præsentation af DFM, Miljøstyrelsens Nano-netværksmøde, Miljøstyrelsen, 22 August 2012
- Jan C. Petersen, Kursus i Lasersikkerhed I, Martin Professional A/S, Frederikshavn, 20 September 2012
- Jan C. Petersen, Kursus i Lasersikkerhed II, Martin Professional A/S, Frederikshavn, 21 September 2012
- Kai Dirscherl, Vinklernes alsidighed – med passer, ur og GPS, Videnskab på besøg, Issøskolen, 25 September 2012
- Kai Dirscherl, Den røde aftenhimmel – når sollyset spiller bold med nanopartikler, Videnskab på besøg, Vesterbro Ny Skole, 26 September 2012
- Kai Dirscherl, Vinklernes alsidighed – med passer, ur og GPS, Videnskab på besøg, Vesterbro Ny Skole, 26 September 2012
- Kai Dirscherl, Fra målestok til mikroskop – En historisk rejse gennem flere årtusinde, Videnskab på besøg, Gilbjergskolen, 28 September 2012
- Hans Dalsgaard Jensen, Metrologi – giv din måling mening!, Professionshøjskolen Metropol, 4 October 2012

DANISH METROLOGY INSTITUTES

According to the BIPM Mutual Recognition Agreement, 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
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DFM
DFM A/S, Danish National Metrology Institute
Matematiktorvet 307, DK-2800 Kgs. Lyngby
Contact: Jan Hald
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DTI
Danish Technological Institute
Kongsvang Allé 29, DK-8000 Århus C
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Phone: +45 7220 1236
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DTU
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DK-2800 Kgs. Lyngby
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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	Jørgen Garnæs, DFM	Basic length measurements	DFM
(1989, 1998, 2007)	jg@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	Mogens Simonsen, FORCE	Gaseous flow (volume)	FORCE
(1990, 1999, 2007)	mss@force.dk	Water flow (volume, mass and energy)	DTI
		Flow of liquids other than water	FORCE
		Anemometry	
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	Jan Hald, DFM	No subdivisions	
	jha@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, Managing Director, AgroTech – Institute for Agro Technology and Food Innovation

Steen Konradsen, CEO, Baunehøj Invest ApS (Chairman)

Søren Stjernqvist, President, Danish Technological Institute

Kai Dirscherl, MSc (EE), PhD, Senior Scientist, DFM A/S

Jan C. Petersen, PhD, Team Leader, DFM A/S

Management

Michael Kjær, CEO, MSc (EE)

Accountants

KPMG, Statsautoriserede Revisionspartnerselskab

Staff

Lars Nielsen, MSc (EE), PhD

Hans Dalsgaard Jensen, MSc (EE), PhD

Jan C. Petersen, PhD

Jørgen Garnæs, MSc, PhD

Peter Høgh, Technician

Jan Hald, MSc, PhD

Isabella Stendal, Administration

Bo Bengtsen, Technician

Salvador Barrera Figueroa, MSc (EE), PhD

Pia Tønnes Jakobsen, MSc, PhD

Poul Erik Hansen, MSc, PhD

Kai Dirscherl, MSc (EE), PhD

Pia Krog-Pedersen, Administration

Charlotte I. Falk, MSc, PhD Student

Antoni Torras Rosell, PhD Student

Jørgen Avnskjold, Technician

Anders Brusch, MSc, PhD

Mette Bitz Mikkelsen, Receptionist

Johannes Weirich, MSc, PhD (until 1 October 2012)

David Balslev-Clausen, MSc, PhD

Carsten Thirstrup, MSc, PhD (from 5 January 2012)

Marianne Heidam, Product & Marketing Manager (from 1 February 2012)

Mikael Østergaard Lassen, MSc, PhD (from 1 November 2012)

Visitors and students

Francisco J. Garcia Leoro, CESMEC S.A. (23 January - 3 February 2012)

Olav Werhahn, PTB (13 - 17 August 2012)

Maria Kiseleva, Radboud University Nijmegen (15 - 17 October 2012)

Katazyna Gurzawska, PhD Student

Svava Davíðsdóttir, PhD Student

Søren Vinter Søgaard, PhD Student

Matteo Calaon, PhD Student (from 21 February 2012)

Elena Orrú, PhD Student INRIM (7 May - 18 May 2012)

Minhao Pu, PhD Student (from 6 June 2012)

Sébastien Ramone Dupre, PhD Student (2 July - 15 September 2012)

INCOME STATEMENT AND BALANCE SHEET

INCOME STATEMENT (1000 DKK)

	2012	2011
Commercial revenue	2 812	2 731
Project revenue	4 788	3 326
Government funding	14 035	14 066
Total revenue	**21 635**	**20 123**
Travel expenses	348	378
Other out-of-pocket expenses	2 038	1 804
Total out-of-pocket expenses	**2 386**	**2 182**
Gross profit	**19 249**	**17 941**
Staff costs	13 082	12 271
Other external expenses	3 840	3 579
Total costs	16 922	15 850
Operating profit before depreciation and impairment losses	**2 327**	**2 091**
Depreciation and impairment losses on property, plant and equipment	1 533	1 545
Operating profit before financial income and expenses	**794**	**546**
Financial income	107	417
Financial expenses	- 6	2
Profit before tax	**895**	**961**
Tax on profit for the year	0	0
Profit for the year	**895**	**961**

BALANCE SHEET AT 31 DECEMBER (1000 DKK)

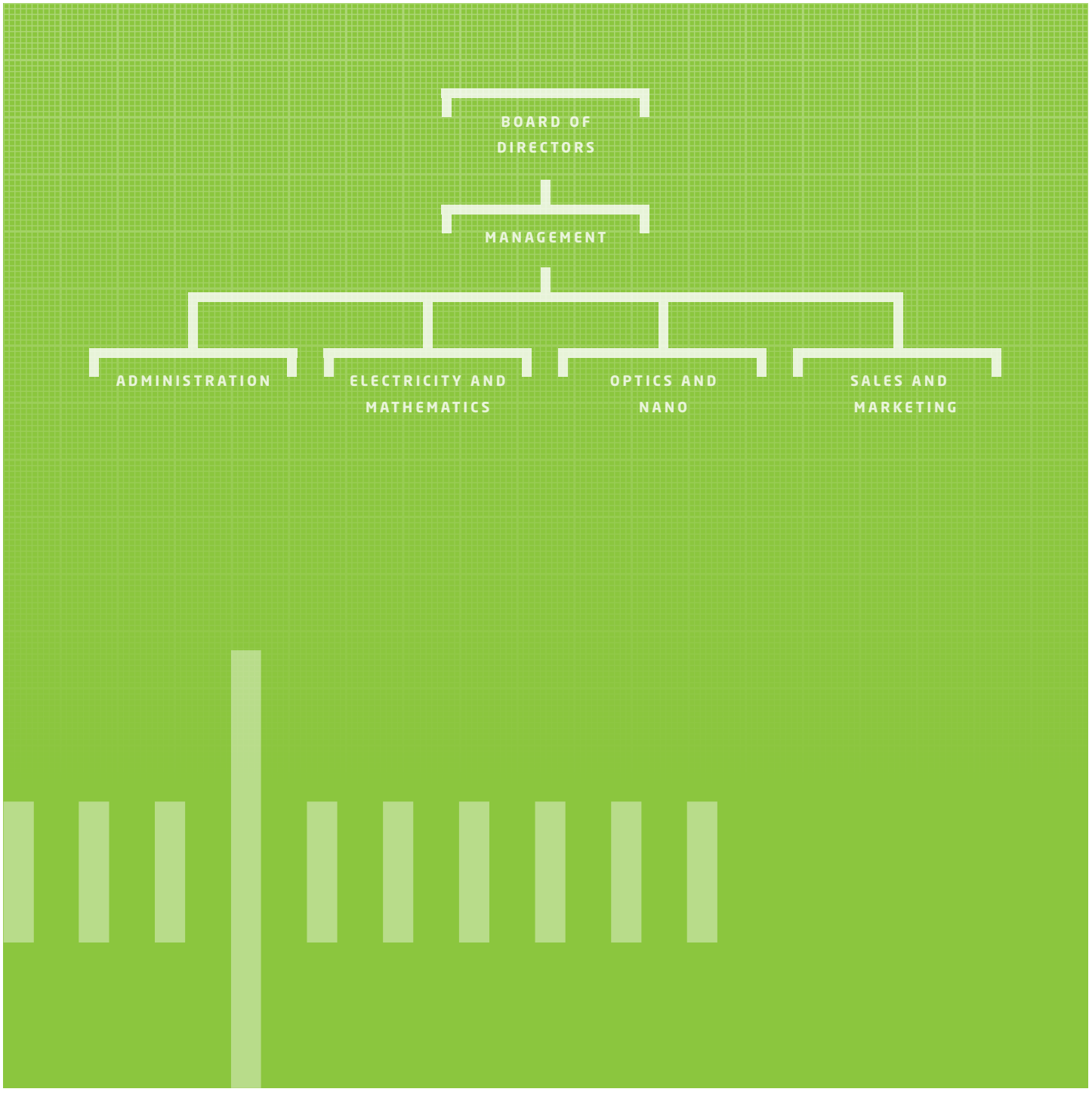
ASSETS	2012	2011
Deposits	372	372
Total investments	**372**	**372**
Equipment	4 927	4 169
Leasehold improvements	1 371	1 865
Total property, plant and equipment	**6 298**	**6 034**
Total non-current assets	**6 670**	**6 406**
Contract work in progress	**1 130**	**1 554**
Trade receivables	546	496
Amounts owed by parent company	0	0
Prepayments	0	99
Other receivables	209	186
Total receivables	**755**	**781**
Securities	**0**	**5 010**
Cash at bank and in hand	**14 648**	**3 576**
Total current assets	**16 532**	**10 921**
Total assets	**23 202**	**17 327**

EQUITY AND LIABILITIES	2012	2011
Share capital	1 000	1 000
Retained earnings	14 305	13 410
Total equity	**15 305**	**14 410**
Prepayments from customers and of funding	5 203	304
Prepayments of government funding	114	61
Trade payables	506	690
Debt to associated companies	28	-
Other payables	2 046	1 862
Total current liabilities	**7 897**	**2 917**
Total equity and liabilities	**23 202**	**17 327**

KEY FIGURES

KEY FIGURES IN MILLION DKK	2008	2009	2010	2011	2012
Total revenue	16.8	18.1	19.2	20.1	21,6
Gross profit	15.0	16.8	17.3	17.9	19.2
Profit for the year [1]	0.5	-0.3	0.6	1.0	0.9
Total equity	13.2	12.9	13.5	14.4	15.3
Commercial sale	3.0	2.5	2.2	2.7	2.8
- to small enterprises (less than 50 employees)	0.3	0.3	0.4	0.6	0.5
- to medium size enterprises (50-250 employees)	0.6	0.8	0.5	0.5	0.7
- to large enterprises (more than 250 employees)	0.5	0.4	0.5	0.5	0.5
- to Danish public institutions	0.2	0.3	0.2	0.6	0.6
- to foreign enterprises and institutions	1.5	0.7	0.7	0.5	0.5
Foreign net sales	2.2	1.4	1.6	0.9	2.2
Research and development					
Number of collaborative projects	10	11	10	18	18
- thereof innovation consortia	2	2	2	1	1
- thereof international projects	7	4	5	7	9
R&D turnover (million DKK)	14.3	15.4	18.6	18.5	21.2
- thereof self-funded	0.6	0.6	1.6	1.2	2.4
R&D work (man-year)	9.4	10.6	11.5	12.3	13.9
Number of customers					
Danish private enterprises	43	44	37	27	32
- thereof small enterprises (less than 50 employees)	9	10	19	10	14
- thereof medium size enterprises (50-250 employees)	7	10	6	6	8
- thereof large enterprises (more than 250 employees)	17	15	12	11	10
Danish public institutions	8	9	9	5	11
Foreign enterprises and institutions	29	22	21	18	24
Total customer base	80	66	67	50	67
Number of staff categorized by education (man-year)					
Dr & PhD	10	10	11	11	13
MSc	3	4	4	4	3
Other technical staff	3	3	3	3	3
Administrative staff	2	2	2	2	2
Total staff	18	19	20	20	21
Number of publications					
Refereed publications	9	5	8	9	7
PhD - og Master theses	1	0	1	0	0
Other reports	41	24	24	23	25
Conference papers	10	5	11	14	22
Calibration certificates and measurement reports	285	263	271	442	442
Press cuttings	9	16	14	4	9
Education					
DFM courses (number of days)	25	9	9	5	5
DFM courses (number of participants)	135	26	22	39	56
Supervision/teaching at universities (number of students/courses)	3	2	2	3	9
Co-supervision of master thesis students (number of theses)	3	2	5	5	3
Contribution to teaching at universities (number of days)	5	5	4	8	5
Committee work (number of committees)	27	30	23	26	25
- thereof international committee work	21	20	20	22	22
Efficiency					
Turnover per employee (1000 DKK)	928	925	976	999	1031
Profit per employee (1000 DKK)	29	-18	36	49	43
Commercial turnover per DKK of governmental funding	0.3	0.2	0.2	0.2	0.2
R&D turnover per DKK of governmental funding	1.2	1.2	1.4	1.3	1.5

1) Excluding extraordinary items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ELECTRICITY AND MATHEMATICS
OPTICS AND NANO
SALES AND MARKETING

DFM
Danish National Metrology Institute

MISSION

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