DFM

Danish National Metrology Institute

# ANNUAL REPORT 2020

## METROLOGY: THE SCIENCE OF MEASUREMENT

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

## DFM PROFILE

DFM is appointed as the Danish National Metrology Institute and contributes to the integrity, efficiency and impartiality of the world metrology system. DFM is also responsible for coordinating the Danish metrology infrastructure. DFM is a fully owned subsidiary of DTU, the Technical University of Denmark.

## DFM ACTIVITIES

DFM' s scientific research results in new knowledge, measurement techniques and standards, which support the needs of Danish industry and authorities for accurate measurements.

The services offered are high-level calibrations and reference materials traceable to national primary or reference standards, training 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 metrology services, which are critical for competing in the global marketplace.

## DIVERSITY AND SUSTAINABILITY

Diversity, inclusion and a global outlook are important to DFM in order to expand its strongholds in research. It is DFMs view that diverse teams perform better than homogeneous teams.

DFM aims to ensure that metrology supports sustainability through new standards and regulations that guide the sustainable development of products, services and processes, via reliable and widely accepted measurements.

ANNUAL REPORT 2020
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Photo: Finn Brøndum and DFM

February 2022

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# WHY DO WE NEED METROLOGY?



Optical investigation of nanostructures on a plastic foil produced by Roll-to-Roll printing

Calibration of roughfness standard - an essential link in the traceability chain for roughfness measurements

**Imagine a society in which there are no common measurement standards. Consumers would not be able to trust that they paid the right amount for food, gas, electricity, petrol, water and other consumables. Manufacturers would not be able to trust that parts bought from several suppliers could actually be assembled, and we would not be able to monitor the change in pollution of our environment and evaluate their effects on global warming.**

Metrology has played an important role in all civilisations. In the earliest civilisations, metrology was used to regulate trade by establishing local standards for weights and measures, but as the world trade expanded, the demand for international standards for weights and measures increased. In parallel, the technological revolution created a demand for other standards than just mass and length: The steam engines required standards for temperature and pressure, the electrical machines required measurement standard for voltage, current and resistance, and other technological inventions spurred the demand for further measurement standards.

Today we live in a global and high technology society. This demands a wide range of international measurement standards of high quality and a system to make sure that all measurements performed in society are traceable to those standards. DFM is part of an international network of national metrology institutes, which work closely together to ensure that the necessary measurement standards are available to the local society and that the measurements performed in different parts of the world are equivalent. These include measurements of physical and chemical quantities, measurements that industries rely on to foster innovation and to develop efficient manufacturing methods, measurements that secure fair trade, consumer protection, health and safety, law and order, and environment monitoring. Measurement are of increasing importance in connection with financial transactions, particularly to secure accurate time stamp of such transactions.

The situation is not static. New technologies continues to appear and the demand for addressing new fields, such as quantum technologies and life sciences, only increases. If the national metrology institutes were not able to meet these demands, the technological development would fade out. So not only do we need metrology in order to run a society, we also need to improve continuously our metrological capabilities!

# MANAGEMENT REPORT 2020



Bjarne Fjeldsted, Chairman of the Board and Michael Kjær, CEO.

**DFM realized a total revenue of 43,1 mio. DKK in 2020 precisely the same as 2019. The impact of the COVID situation on both research and commercial activities were significant. Most researchers were required to work from home for part of the year and commercial revenue was reduced significantly in Q2 but recovered in Q3 and Q4. Overall, commercial revenue fell 3 % compared to 2019. The profit for the year was also reduced to 0,7 mio.DKK versus 1,2 mio.DKK in 2019. The management considers both revenue and profit as satisfactory given the COVID situation in 2020.**

DFM purchased a new state of the art Coordinate Measuring Machine (CMM). The CMM is scheduled to be operational at the end of september2021 and will be one of best ever installed in Denmark in terms of measurement uncertainty. The CMM will allow DFM to further increase both the scope and quality of services available to industry.

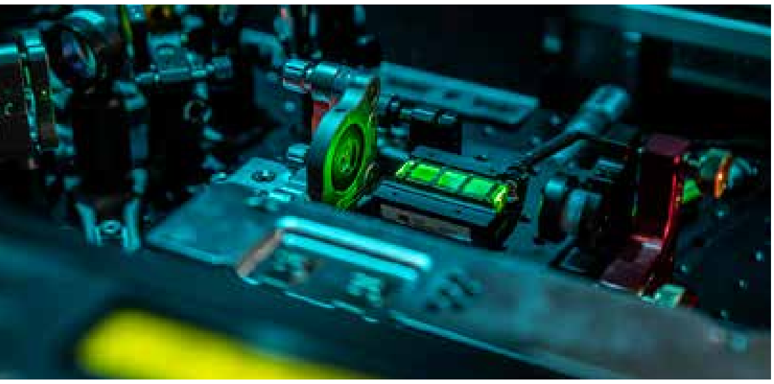
In 2020, DFM received a new contract from the Ministry of Higher Education and Science for core funding during the four-year period 2021 – 2024. DFM is pleased with the continued strong support for metrology from the Ministry. This will allow us to continue to maintain and develop new metrology services ensuring industry access to recognized and quality assured traceable calibrations, critical to industry competitiveness. In the period 2021 - 2024 DFM will focus on developing new services and infrastructure supporting the green - and digital transition of society. DFM plans to further increase investments in new metrology equipment for the green - and digital transition.

**Bjarne Fjeldsted**
Chairman of the Board

**Michael Kjær**
CEO

# CALIBRATION OF PHOTO-ACOUSTIC SENSORS FOR PRACTICAL APPLICATIONS WITH HUMIDITY





Photoacoustic setup

**The photoacoustic spectroscopy (PAS) technique receives increasing interest as a powerful, yet simple, trace-gas detection method. The absorbed optical energy translates into kinetic energy, which generates an acoustic wave that can be detected with a pressure transducer, such as a simple microphone or a quartz tuning fork (QTF).**

The intensity of the generated photo-acoustic (PA) wave depends not only on the concentration of the target molecule, but also on the entire gas-sample composition. Other molecules may alter the relaxation kinetics of the various excited ro-vibrational states, causing a change in the PA signal strength. The measured PA signal is gas-matrix dependent, and although the sensors can be extremely sensitive, they can become inaccurate without adequate calibration taking into account the necessary gas-matrix corrections. Measurements of gas concentrations using PAS becomes highly nontrivial in wet (water-containing) gas mixtures. Although water molecules do not, necessarily, directly contribute through optical absorption, they influence the relaxation mechanisms of other absorbing molecules in the mixture. This effect is apparent from Figure 1, in which the PA signal is seen to be enhanced by more than a factor of 1.5 as a result of the humidity levels. This enhancement factor is not a simple linear function of absolute humidity. It is this inconsistency that results in the inaccurate correction performed in Figure 1(c), and which ultimately means that the linear model hypothesis must be discarded as being too simple to describe the physics. We have developed a calibration method based on a simple learning-based method for quantifying the influence of humidity on photoacoustic carbon-dioxide concentration measurements. Using this approach, the model is only required to be locally accurate (within the observed values), which is a highly relaxed assumption.

We compare the long-term performance of a commercial NDIR $CO_2$ sensor with that of a quartz-enhanced photoacoustic (QEPAS) module resonantly pumped by pulsed radiation at a wavelength of 4.32 µm. Carbon-dioxide was monitored during six days exposed to atmospheric humidity levels. The $CO_2$ level was deduced from the PA signal, corrected for the atmospheric water content using a model based on "historical" training data (illustrated by the shaded period). The shaded regions around each curve represent the calculated 1 σ confidence regions for each time series. With this method we find very good agreement with the NDIR sensor when calibrated using atmospheric measurement data as training data for the calibration algorithm and we also demonstrate the importance of a correct calibration.

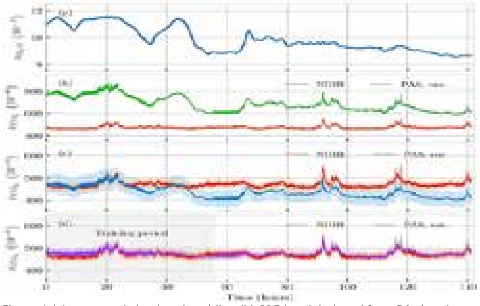
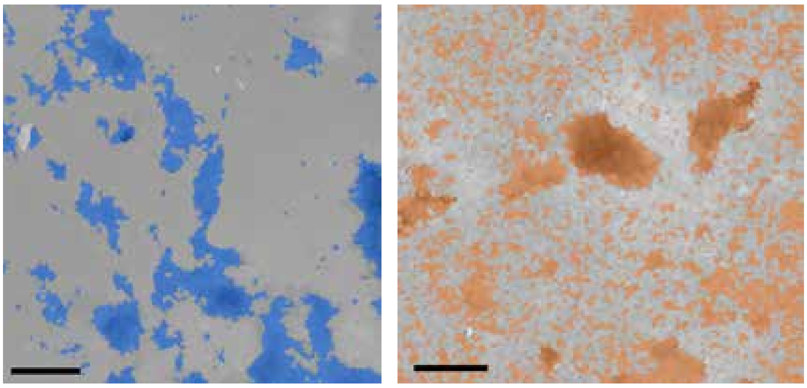


Figure 1 (a) measured absolute humidity; (b) CO2 level deduced from PA signal, uncorrected for the atmospheric water content; (c) CO2 level deduced from PA signal, corrected for the atmospheric water content using linear model; (d) CO2 level deduced from PA signal, corrected for the atmospheric water content using historical training data from the shaded time period.

# NEW SERVICES TO SUPPORT ADVANCED PRODUCTION IN DANISH COMPANIES



Surface morphology of 3D printed samples in bone-like material before (left) and after sintering (right).

**Surface proberties are of vital importance for a number of Danish industrial strongholds such as production within plastics, drugs and food. Companies need to constantly develop new and better surface properties in their products and to document the quality of these surfaces.**

In 2020, DFM has developed several new services to support advanced production in collaboration with mainly small Danish companies within the activity "Surface Metrology for Production in the Future" supported by the Danish Agency for Institutions and Educational Grants.

Functionalized surface modification by chemical or physical means to form e.g. hard or soft coatings is of growing interest to innovative small- or medium-sized companies. To measure e.g. the so-called hardness number of the surface with accurate traceability to internationally recognized standards, DFM has developed a service based on a unique so-called MEMS force sensor developed by the German National Metrology Institute (PTB, supported by NanoWires 19ENG05). These sensor chips are made in a few prototypes and DFM has integrated one into an atomic force microscopy system.

The setup has been tested on samples of thin layers of quartz-based coatings from REL8 A/S. These coatings potentially have many advanced applications. In combination with relevant mastering methods, they can be used to transfer nanostructures on to injection molded parts in a cost-efficient production process.

Danish companies were among the first who realized the potential of 3D printing . Surface porosity of 3D-printed surfaces can be an important measure of quality, especially in the case of smooth or deliberately rough surfaces. Using confocal microscopy, DFM has developed a service which can accurately quantify the number of pores in a manufactured surface deeper than a predetermined threshold, and hereby determine the area porosity. This can be used to e.g. quantitatively determine the change in surface quality as a result of a surface treatment after production.

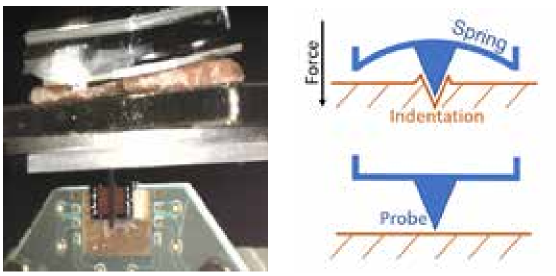



Figure: Unique so-called MEMS force sensor (left) and the principle of measuring the hardness number by indentation (right).

The setup has been tested on samples from the company Ossiform. They use a bone-like material to 3D print bone implants that are so lifelike that they deceive the body. In order to maintain a high standard of the 3D-printed bone implant surfaces, strict requirements are expected from authorities before approval to use in humans .

# UNIPHIED INTERLABORATORY COMPARISON: MEASURING ABSOLUTE PH IN ETHANOL



Setup for pH measurements

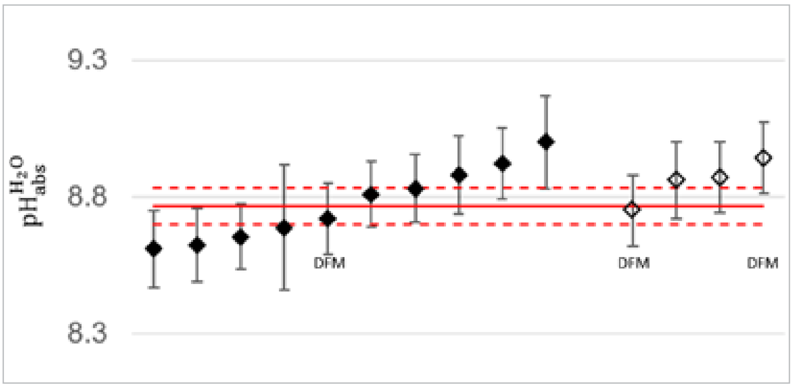



Figure 2. Ammonium formate buffered ethanol pH_abs^(H_2 O) values measured by participants in the UnpHied interlaboratory comparison. DFM send in two additional secondary results, including using the reference method (right).

**pH is one of the most important chemical properties measured in both science and industry, playing a vital role in health, environmental studies, and material reprocessing. With potential to impact an extensive range of sectors, accurate analysis and monitoring of pH is essential. The UnipHied project has put $pH_{abs}$ into practice by establishing a reliable and universally applicable procedure for measuring the acidity of any substance.**

The acidity of a solution is a property of interest in solvents beyond water. However, the current definition of pH is solvent-specific, i.e., each solvent, and solvent-water mixture, has its own pH scale. For example, bioethanol fuel has been assigned a scale denoted 'pHe' according to national quality assurance standards. pHe values cannot be understood in context of the conventional (aqueous) pH scale. There exist numerous challenges associated with measuring pH in non-aqueous solvents, including issues of: metrological traceability due to the lack of (primary) certified reference materials in diverse solvents, accounting for measurement contributions and uncertainties arising from the presence of liquid junction potentials of unknown sign and magnitude, and from the use of combination pH electrodes in contact with diverse media.

However, a step forward in the measurement of acidity in any media was proposed in 2010, as an absolute pH scale, which is inter-convertible with the conventional pH scale (denoted $pH_{abs}^{H_2O}$). The UnipHied EMPIR project brought together institutes from 10 countries, and had the goal of developing the metrological basis for practical $pH_{abs}^{H_2O}$ measurements.

A measurement system as shown in figure 1 was developed: a commercial glass half-cell electrode (GE) and a double junction reference electrode (RE), equipped with an ionic liquid (IL) outer filling solution, acting as a salt bridge. This ionic liquid has been shown to cancel out the contributions of the liquid junction potentials, allowing for a measurement of $pH_{abs}^{H_2O}$ values of non-aqueous solvent by differential potentiometry. Further, the GE-RE combination can readily be calibrated using pH buffers, giving metrological traceability to the conventional pH scale.

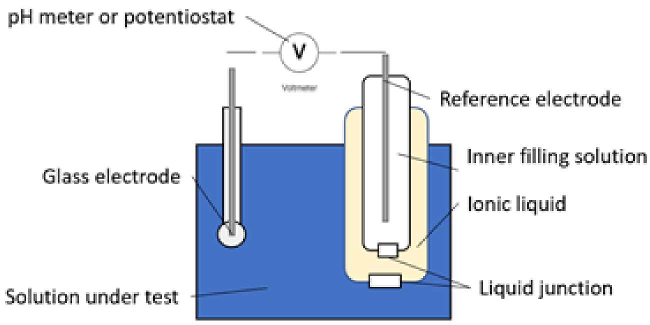
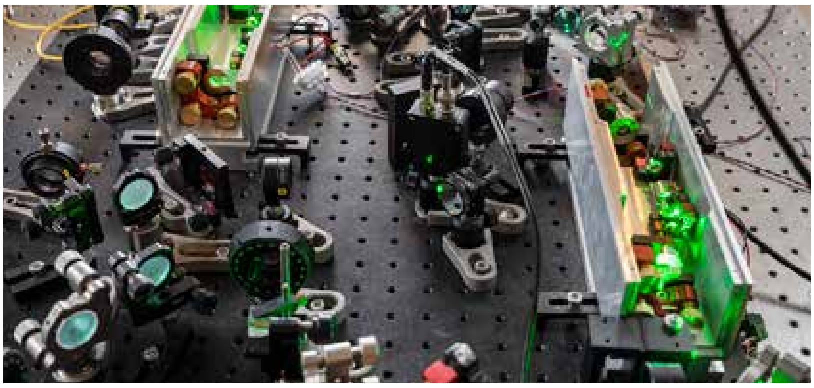


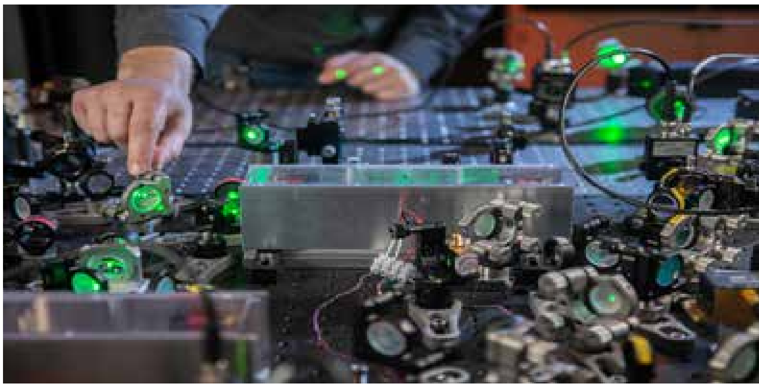

Figure 1: Glass half-cell electrode and double junction reference electrode setup for $pH_{abs}^{H_2O}$ measurements.

This measurement system was demonstrated by the members of UnipHied through an interlaboratory comparison on equimolal phosphate buffered 50-50 wt% ethanol-water, and formate buffered ethanol, each prepared according to preparation instructions. As shown in figure 2 (top og the page), all participants showed relatively good agreement. This stands in contrast to the results of a prior EMPIR project (BIOREMA) in which the inter-comparability of pHe measurements on bioethanol fuel showed much higher disagreement between participants in that project.

# QUANTUM MEASUREMENT ENHANCED GRAVITATIONAL WAVE DETECTION







Experimental setup for Q-GWD project

**The basic idea of quantum technology is to take advantage of the constitutions of quantum mechanics. In the Eureka turbo project "Quantum measurement enhanced gravitational wave detection" (Q-GWD) the goal is to develop a quantum laser system which, together with new measurement techniques using an atomic spin system, can improve the sensitivity of detectors to gravitational waves.**

The accuracy of classical optical detection is fundamentally restricted by the shot noise. Optical quantum sensing exploits the unique quantum correlations of non-classical light to enhance the detection of physical parameters beyond classical means. While several different quantum states of light can be used to provide such a quantum advantage, so far, it is only the ubiquitous squeezed states of light that have been demonstrated to be beneficial in practice due to their generation simplicity and relative brightness, with the crowning example being the detection of gravitational waves. The recent observation of gravitational waves is a landmark result of modern science. It opens the door to a new era of observational astronomy, in which gravitational signatures provide a unique window into the inner workings of our universe. Exploiting these opportunities is a worldwide endeavour that requires further significant improvements in the sensitivity of existing gravitational wave detectors.

In the Eureka turbo Q-GWD the main task was therefore to establish a novel non-classical laser technology that generates two-mode squeezed states for enhancing the sensitivity of gravitational wave detectors (GWD) and to demonstrate the enhancement of GWDs using the light source. The Q-GWD project was funded by the Innovation Fund and has 3 Danish partners: the Niels Bohr Institute, University of Copenhagen, DFM A/S and Therkildsen Development and an Austrian company Crystalline Mirror Solutions GmbH.

The main idea is to make use of quantum correlations (two-mode squeezing) between the gravity-wave interferometer light, the interferometer beam-spitter mirror motion, and an additional quantum system (a cloud of atoms). The key developed component is the doubly resonant optical parametric oscillator for the generation of two-mode squeezed states between 852 nm and 1064 nm with a noise suppression of more than 6 compared to the shot noise limit. This will potentially enhance the sensitivity of the GWD approximately a factor of 2.5. This may seem as a fairly small enhancement, but the consequence is that the GWD can measure 15 times more space and hereby increase the number of gravitational wave events.

# INCOME STATEMENT AND BALANCE SHEET



| INCOME STATEMENT (1000 DKK) | 2020 | 2019 |
|---|---|---|
| Commercial revenue | 10 049 | 10 187 |
| Project revenue | 6 834 | 6 502 |
| Government funding | 25 991 | 26 399 |
| **Total revenue** | **42 874** | **43 088** |
| Travel and out-of-pocket expenses | 11 800 | 13 183 |
| **Total out-of-pocket expenses** | **11 800** | **13 183** |
| **Gross profit** | **31 074** | **29 906** |
| Staff costs | 27 002 | 24 690 |
| **Total costs** | **27 002** | **24 690** |
| **Operating profit before depreciation and impairment losses** | **4 072** | **5 216** |
| Depreciation and impairment losses on property, plant and equipment | 3 038 | 3 909 |
| **Operating profit before financial income and expenses** | **1 034** | **1 307** |
| Financial income | 75 | 63 |
| Financial expenses | 183 | 75 |
| **Profit before tax** | **926** | **1 169** |
| Tax on profit for the year | 204 | 253 |
| | | |
| **Profit for the year** | **722** | **916** |
| Profit for the year to be carried forward | | |

## BALANCE SHEET AT 31 DECEMBER (1000 DKK)

| ASSETS | 2020 | 2019 |
|---|---|---|
| Deposits | 1 014 | 1 006 |
| **Total investments** | **1 014** | **1 006** |
| Equipment | 7 907 | 7 011 |
| Leasehold improvements | 14 796 | 15 979 |
| **Total property, plant and equipment** | **22 703** | **22 990** |
| **Total non-current assets** | **23 717** | **23 996** |
| **Contract work in progress** | **8 229** | **5 075** |
| Trade receivables | 1 128 | 3 461 |
| Prepayments | 152 | 73 |
| Other receivables | 139 | 169 |
| **Total receivables** | **1 419** | **3 135** |
| **Cash at bank and in hand** | **29 802** | **10 636** |
| **Total current assets** | **39 450** | **19 414** |
| **Total assets** | **63 167** | **43 410** |

| EQUITY AND LIABILITIES | 2020 | 2019 |
|---|---|---|
| Share capital | 1 000 | 1 000 |
| Retained earnings | 18 818 | 18 095 |
| **Total equity** | **19 818** | **19 095** |
| Prepayments from customers and of funding | 27 821 | 13 426 |
| Trade payables | 788 | 1 515 |
| Other payables | 14 740 | 9 374 |
| **Total current liabilities** | **43 349** | **24 315** |
| **Total equity and liabilities** | **63 167** | **43 410** |

# KEY FIGURES



| KEY FIGURES IN MILLION DKK | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|
| Net sales | 31.5 | 35.0 | 37.1 | 42.8 | 42.9 |
| Gross balance | 35.4 | 41.1 | 42.1 | 42.3 | 63.2 |
| Profit or loss for the financial year [1]) | 0.4 | 0.5 | 0.7 | 0.9 | 0.7 |
| Net capital | 17.2 | 17.7 | 18.2 | 19.1 | 19.8 |
| Commercial sale | 4.6 | 4.0 | 7.1 | 10.2 | 10.0 |
| - to small enterprises (less than 50 employees) | 0.6 | 0.5 | 0.9 | 1.0 | 1.0 |
| - to medium size enterprises (50-250 employees) | 0.9 | 0.9 | 1.5 | 1.9 | 1.9 |
| - to large enterprises (more than 250 employees) | 1.1 | 0.9 | 2.0 | 2.5 | 1.9 |
| - to Danish public institutions | 0.5 | 0.2 | 0.3 | 0.3 | 0.3 |
| - to foreign enterprises and institutions | 1.5 | 1.5 | 2.4 | 4.3 | 4.9 |
| Foreign net sales | 3.8 | 3.3 | 4.3 | 7.7 | 4.8 |
| **RESEARCH AND DEVELOPMENT** | | | | | |
| Number of collaborative projects | 29 | 29 | 23 | 24 | 29 |
| - thereof innovation consortia | 2 | 2 | 1 | 0 | 0 |
| - thereof international projects | 21 | 27 | 20 | 20 | 27 |
| R&D activities (million DKK) | 26.9 | 30.6 | 29.6 | 32.8 | 35.0 |
| - thereof self-funded | 1.8 | 3.0 | 2.6 | 2.8 | 3.2 |
| R&D work (man-year) | 17.3 | 17.6 | 19.7 | 21.1 | 31.2 |
| **NUMBER OF CUSTOMERS** | | | | | |
| Danish private enterprises | 59 | 57 | 146 | 168 | 142 |
| - thereof small enterprises (less than 50 employees) | 29 | 3 | 67 | 59 | 55 |
| - thereof medium size enterprises (50-250 employees) | 10 | 7 | 32 | 51 | 37 |
| - thereof large enterprises (more than 250 employees) | 20 | 17 | 47 | 43 | 34 |
| Danish public institutions | 10 | 3 | 20 | 15 | 16 |
| Foreign enterprises and institutions | 20 | 33 | 44 | 52 | 43 |
| Total customer base | 89 | 90 | 210 | 220 | 185 |
| **NUMBER OF STAFF CATEGORIZED BY EDUCATION (MAN-YEAR)** | | | | | |
| Dr & PhD | 20 | 25 | 26 | 27 | 31 |
| MSc | 2 | 3 | 1 | 1 | 1 |
| Other technical staff | 2 | 2 | 2 | 3 | 3 |
| Administrative staff | 4 | 4 | 4 | 5 | 5 |
| Average number of staff | 27 | 34 | 33 | 36 | 39 |
| **NUMBER OF PUBLICATIONS** | | | | | |
| Refereed publications | 19 | 21 | 19 | 10 | 19 |
| PhD and Master theses | 3 | 0 | 0 | 1 | 0 |
| Other reports | 15 | 7 | 2 | 0 | 0 |
| Conference papers | 18 | 17 | 17 | 24 | 10 |
| Calibration certificates and measurement reports | 582 | 717 | 1543 | 1 645 | 1 622 |
| Press cuttings | 28 | 15 | 11 | 35 | 1 |
| **EDUCATION** | | | | | |
| DFM courses (number of days) | 3 | 3 | 4 | 2 | 0 |
| DFM courses (number of participants) | 18 | 21 | 28 | 21 | 0 |
| Supervision/teaching at universities (number of students/courses) | 3 | 6 | 3 | 4 | 4 |
| Co-supervision of master thesis students (number of theses) | 3 | 0 | 0 | 1 | 1 |
| Contribution to teaching at universities (number of days) | 3 | 6 | 3 | 4 | 4 |
| Committee work (number of committees) | 29 | 29 | 29 | 28 | 27 |
| - thereof international committee work | 23 | 25 | 25 | 24 | 23 |
| **EFFICIENCY** | | | | | |
| Turnover per employee (1000 DKK) | 1 066 | 1 129 | 1 126 | 1 147 | 1 102 |
| Profit per employee (1000 DKK) | 14 | 16 | 17 | 24 | 29 |
| Commercial turnover per DKK of governmental funding | 0.2 | 0.2 | 0.3 | 0.4 | 0.4 |
| R&D turnover per DKK of governmental funding | 1.3 | 1.4 | 1.4 | 1.3 | 1.4 |

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 for Calibration and Measurement Capabilities. The fields covered by the appointments are indicated in the table on the next page.**

## DFM

DFM A/S, Danish National Metrology Institute
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DK 2970 Hørsholm

Contact: Jan Hald
Phone: +45 7730 5800
jha@dfm.dk

## BKSV-DPLA

Brüel & Kjær Sound & Vibration Measurement A/S
Skodsborgvej 307, DK 2850 Nærum
Contact: Erling Sandermann Olsen
Phone: +45 7741 2000
erlingsandermann.olsen@hbkworld.com

## FORCE

FORCE Technology
Park Allé 345, DK-2605 Brøndbyvester
Contact: Peter Bo Mortensen
Phone: +45 4325 0457
pbm@force.dk

## DTI

Danish Technological Institute
Kongsvang Allé 29, DK 8000 Århus C
Contact: Jan Nielsen
Phone: +45 7220 2000
jnn@teknologisk.dk

## TRESCAL

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

## DTU

Technical University of Denmark
Frederiksborgvej 399, Building 201, room S41,
DK-4000 Roskilde
Contact: Jørgen Schøller
Phone: +45 2043 7665
jorsch@dtu.dk

# THE 12 SUBJECT FIELDS OF METROLOGY



**Fundamental metrology in Denmark follows the EURAMET division into 12 subject fields, while the subfields reflect a Danish subdivision of metrological activities.**

| SUBJECT FIELD | CONTACT PERSON | SUBFIELDS | METROLOGY INSTITUTE |
|---|---|---|---|
| **MASS AND RELATED QUANTITIES** | Lars Nielsen, DFM | Mass measurement | DFM |
| | ln@dfm.dk | Force and Pressure | FORCE |
| | | Volume and Density | FORCE |
| **ELECTRICITY AND MAGNETISM** | Carsten Thirstrup, DFM | DC electricity | DFM |
| | cth@dfm.dk | AC electricity | TRESCAL |
| | | HF electricity | TRESCAL |
| **LENGTH** | Jan Hald, DFM | Basic length measurements | DFM |
| | jha@dfm.dk | Dimensional metrology | DFM & DTI |
| | | Micro/Nano | DFM |
| **TIME AND FREQUENCY** | Jan Hald, DFM | Time measurement | |
| | jha@dfm.dk | Frequency | |
| **THERMOMETRY** | Jan Nielsen, DTI | Temperature measurement by contact | DTI |
| | jnn@teknologisk.dk | Non-contact temperature measurement | DFM |
| | | Humidity | FORCE |
| | | Moisture in materials | DTI |
| **IONISING RADIATION** | Arne Miller, DTU | Absorbed radiation dose - Industrial products | DTU |
| | armi@dtu.dk | Absorbed radiation dose - Medical products | |
| | | Radiation protection | |
| | | Radioactivity | |
| **PHOTOMETRY AND RADIOMETRY** | Anders Brusch, DFM | Optical radiometry | DFM |
| | ab@dfm.dk | Photometry | |
| | | Colorimetry | |
| | | Optical fibres | |
| **FLOW** | Jesper Busk, FORCE | Gaseous flow (volume) | FORCE |
| | 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 |
| | sbf@dfm.dk | Acoustical measurements in solids | BKSV-DPLA |
| | | Acoustical measurements in liquids | |
| **METROLOGY IN CHEMISTRY** | Lisa Carol DeLeebeeck | Electrochemistry | DFM |
| | ldl@dfm.dk | Laboratory medicine | |
| | | Products and materials | |
| | | Food chemistry | |
| | | Pharmaceutical chemistry | |
| | | Microbiology | |
| | | Environmental chemistry | |
| **INTERDISCIPLINARY METROLOGY** | David Balslev-Harder | No subdivisions | |
| | dbh@dfm.dk | | |
| **QUALITY** | Kai Dirscherl, DFM | No subdivisions | |
| | kdi@dfm.dk | | |

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