The need for the project

Developments in the fields of nanomagnetism and spintronics include a wide range of applications such as ultra stron
g magnets, spin polarized materials, ultra high density recording
media (hard disks, flash memories/MRAM), spin transistors and
DNA- and bio-sensors.

All of these developments urgently require measurement tools to
reliably and traceably characterise magnetic nanomaterials.

The aim of this project was to establish a metrological basis for
the field of nanomagnetism and to provide reference samples
and measurement methods to industrial and academic end-users.

Technical achievements

Reference Nanomaterials:
The project produced thin films of Permalloy integrated in
coplanar waveguides for time and frequency domain dynamics
measurements, Gallium Manganese Arsenide (GaMnAs)
diluted magnetic semiconductor samples for precessional
dynamics, size monodispersed nanoparticles for high resolution
scanning probe microscopy and ultra sensitive magnetic
moment detection and samples of hard magnetic materials
with perpendicular anisotropy for high resolution scanning
probe microscopy.

Time and frequency domain dynamics:
The project developed the inductive metrology of ferromagnetic
resonance frequency (fFMR) and the Gilbert damping (\(c\)) of soft
magnetic thin film have been established and validated and a
set of calibrated soft magnetic reference samples is available for
external inductive measurements of fFMR and \(c\). Metrology for
the Spin Torque precession of individual nanodevices in time
and frequency domains has also been established.

High Resolution Scanning Probe Microscopy:
Quantitative Magnetic Force Microscopy with a
resolution of less than 50 nm has been demonstrated
using magnetic nanoparticles.

Ultra sensitive magnetic moment detection:
A prototype magnetic detector based on nano-SQUID magnetic
moment sensitivity and a nanosized (~500 nm) metallic and
semiconductor (i.e. two dimensional electron
gas heterostructures) Hall sensors were developed.

New techniques and samples

New reference samples and techniques were developed and
transferred to industrial and academic end-users, such as:
• time resolved damping techniques - used by Singulus
Technologies AG and University of Bielefeld, Germany
• damping reference samples – used by Tohoku University, Japan
• nano-SQUID detection technique of a single nanoparticles –
used by University of Tubingen, Germany
• Hall sensor detection techniques for single nanoparticles/
nanowires – used by University of Duisburg, Germany and
CSIC, Spain

Dissemination through end-users

A ‘Nanomagnetism’ group, involved in a wide range of scientific
activities and their dissemination, was created with project
collaborators, e.g:
reference nanomaterials: University of Duisburg, Trinity College
Dublin, University College Cork, University of Vienna
sensor fabrication and nanomanipulation: Imperial College
London, Cambridge University, Surrey University
preparation of hard magnetic thin films for hard magnetic
reference samples: TU Chemnitz, Hitachi and IMEM Parma
ferromagnetic resonance and damping for microwave
applications: Tohoku University, NIST Boulder, University of
Colorado, Northeastern University Boston
tunneling Magnetic Junctions dynamics
and point contacts for memory/sensor
applications: Singulus AG, University
of Bielefeld, NIST Boulder
high resolution magnetic
microscopy/MFM
 calibration: TU Chemnitz,
Hitachi GST, University
of Parma, University
of Göttingen, IFW
Dresden, TU
Braunschweig,
Magnicon GmbH