Experimental Surface Science;
Nano-chemistry, Nanomagnetics and Quantum confinement/transport

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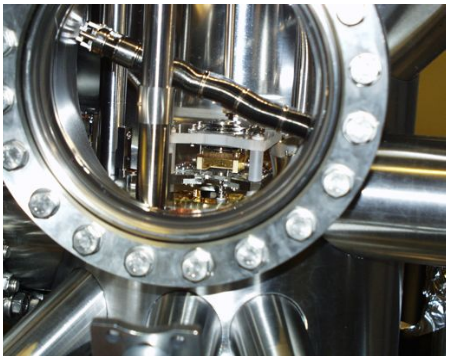
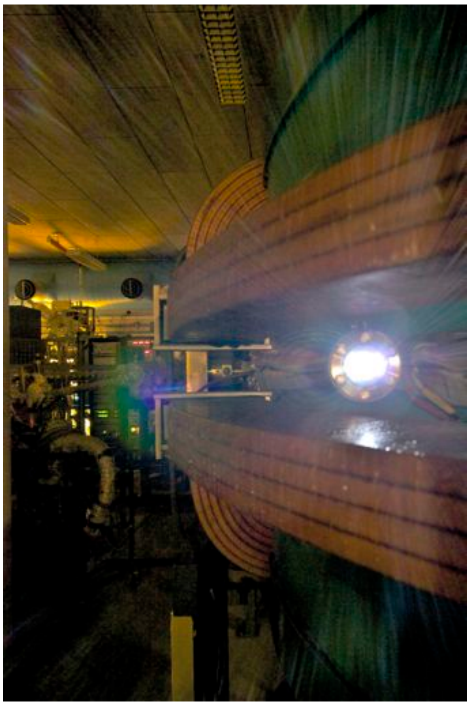
Overview:
The experimental surface science group has three major research interests: nanochemistry, nanomagnetics and quantum confinement/transport. Being an experimental group, most of the projects have a strong practical aspect to them, and involve the students performing their own measurements.



One of our in-vacuum STM instruments used for surface chemistry experiments.

In our home laboratory, the main techniques are scanning tunnelling microscopy (STM) and photoemission spectroscopy (PES). We have several STMs for different applications: for example in-vacuum instruments for studying surface reactions, and instruments for studying quantum transport and magnetodynamic phenomena on a very small scale through forming point contacts to the surface. We also have a PES setup which is currently conjoined to the vacuum STM, and allows core level and valence band spectroscopy, such that chemical and electronic properties can be found. We plan to upgrade the instrument to a stand-alone system were spin and angle resolution will also be possible, giving further information on electronic and spintronic structure.



Synchrotron light from a bending magnet at the Danish facility 'ASTRID'

In addition to our home laboratories, we are frequent visitors to the synchrotron facilities MAX and ASTRID in Lund, Sweden and Aarhus, Denmark, respectively. Using synchrotron light allows a wide range of PES based measurements to be made which cannot be done at home: for example variable polarisation, and studying quantum confined layers.

Master/Project Assignments:
We offer a range of projects - some suggestions are described in the following pages. Please feel free to contact us to discuss these projects, or to suggest your own.

Experimental probing of buried quantum wells

Using in-vacuum preparation methods, we will fabricate semiconductors with unusual doping profiles - such as an atomically thin layer of subsurface dopants (see figure).

Such structures support quantum wells and are of interest in quantum computation applications.

In this project, we will characterize these structures using photoemission spectroscopies (XPS, AES, ARPES, etc), exposing their physical and electronic properties.

The student is expected to carry out measurements at our laboratory at NTNU, with the option to participate in additional measurements at the Danish or Swedish synchrotron facilities "ASTRID' and 'MAX-lab'.

Qualifications: a basic understanding of solid state physics, and an interest/aptitude for experimental techniques is required.

Supervision: Assoc. Prof. Justin Wells
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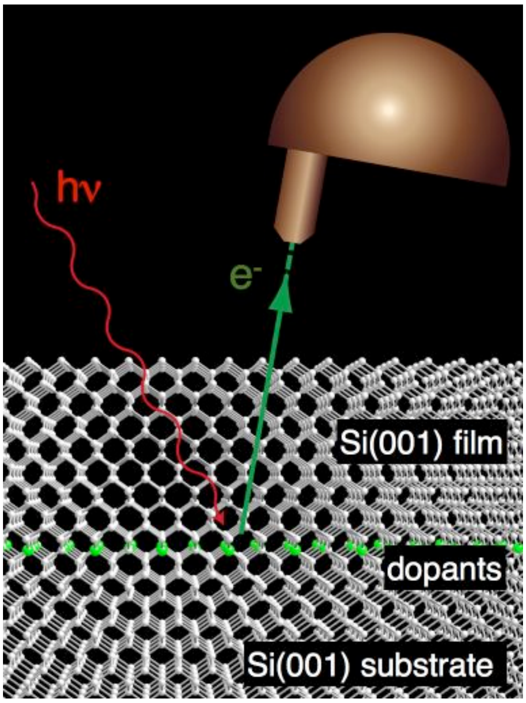

Photoemission spectroscopy of a buried dopant profile in silicon - giving information on the quantum confined electronic states.

Building of a microscale magnetic field mapper

In this project we will construct and commission a 2D stray field scanner to study the stray fields of polished geo-magnetic samples. Using ordinary hard drive magnetic sensors the aim is to build a machine that can map the magnetic field of samples reproducibly, so that the stray fields can be compared to compositional maps of the same samples.

This will give invaluable information to our understanding of the geography and the composition of magnetic ores found in geographic surveys.

The instrument will be built utilizing standard components, accordingly this is mainly a task to assemble and program the instrument.

Qualifications: a solid knowledge and interest for instrumentation, a basic understanding of magnetism and a keen interest to build an instrument.

Supervision: Assoc. Prof. Erik Wahlström in collaboration with Suzane Mcnroe.
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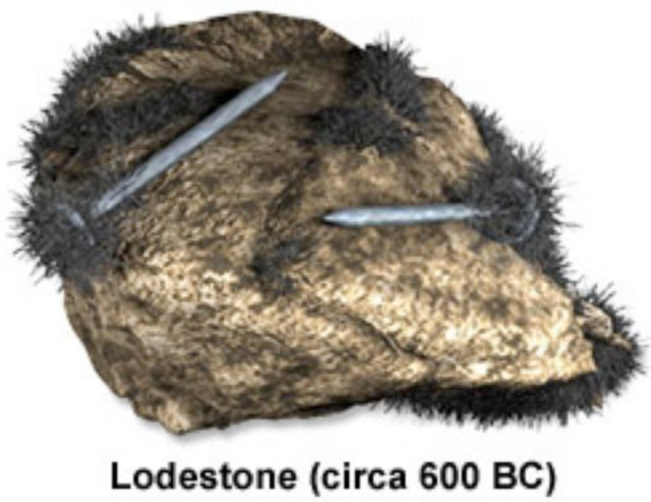
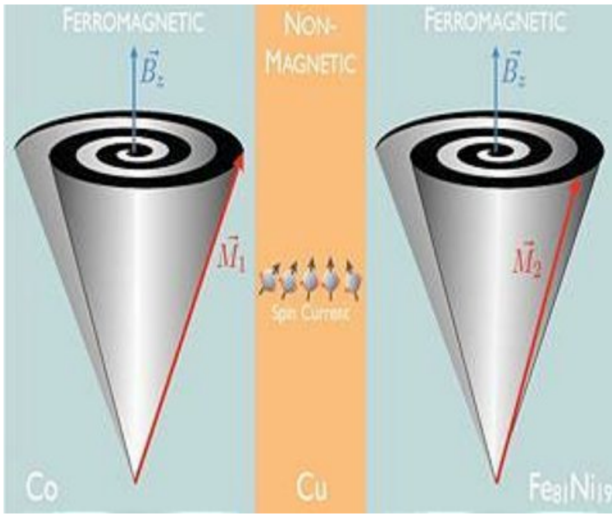


Lodestone magnetically mapped through the use of a more traditional technique than the one proposed in the assignment.

Spin pumping at ferromagnetic/antiferromagnetic interfaces

In this project we will generate spin currents through the excitation of a ferromagnet with a RF field and investigate how the presence of an anti-ferromagnet in the vicinity affects fate of the spin current. The task involves both characterization of already grown thin films, interpreting the results and possibly growth of new films using the NTNU NanoLab facilities.



Example of spin pumping in a similar system: the two ferro-magnetic layers are put into precession in the vicinity of each other and are inter-connected through a coupling mediated via the Cu layer, which affects the energy loss and transfer of energy

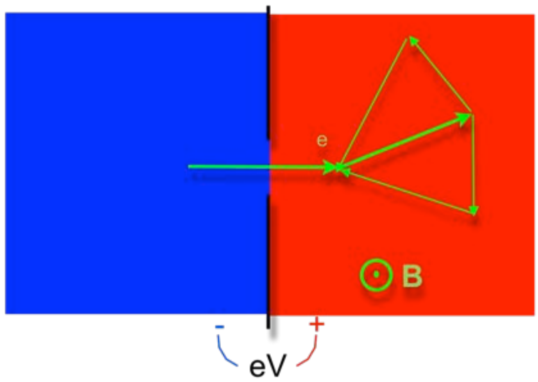
This yields information on how anti-ferromagnets can be used to control and alter the dynamics of ferromagnets in the GHz regime, which is important for possible future devices.

Qualifications:.A good background in solid state phyiscs is required.

Supervision: Assoc. Prof. Erik Wahlström
erik.wahlstrom@ntnu.no

Study of quantum interference through the use of point contact spectroscopy

In this project we will utilize point contacts to inject currents at different energies into a material. These currents are sensitive to quantum interference effects, which can be altered by applying magnetic fields. we will work on graphite/grapheme in combination with materials that are grown on top of these materials which have highly anistropic electron structure.



Schematic view of weak localization close to a point contact. The current passing the through the pint contact can interfere with itself, leading to a high resistance which can be lowered by breaking the interference through passing a magnetic field through the interference loop.

This yields fundamental information on quantum transport in these materials and how it is affected be different scatterers within the system.

The measurements will be done utilizing home built scanning tunneling microscope operated in vacuum where we can grow atomic layer by layer films to construct model systems of interest.

Qualifications:. A good background in solid state physics is required as well as an interest in the use of advanced instrumentation.

Supervision: Assoc. Prof. Erik Wahlström
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Study of current driven magnetic oscillators in single magnetic layers

In this project you will investigate how a magnetic layer can be put into oscillation utilizing the high current from a point contact. This can ordinarily not be done in a single layer unless the material is magnetically textured or the current is unevenly spread through the layer.

Typically the frequencies generated in oscillators of this type is very high >GHz, which makes them very interesting for applications and as a building block for magnonics.

The experiments involve using high frequency analysis equipment, and possibly growth of own ferromagnetic thin films.

Qualifications:.A good background in solid state physics is required as well as an interest in the use of advanced instrumentation.

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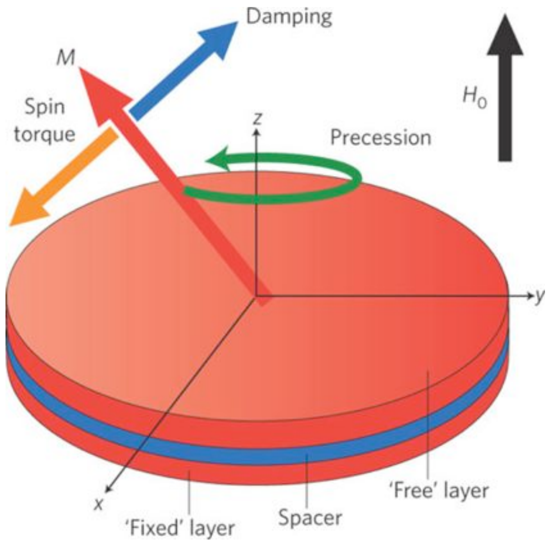

Typical layout of a ordinary spin torque oscillator utilsing the spin torque of bi-layer magnetic system. In the project we will explore how this can be done in a single magnetic layer. (from doi:10.1038/nnano.2009.213)