EPSRC Centre for innovative manufacturing in ultra precision

CDT-UP Newsletter

Centre for Doctoral Training in Ultra Precision Engineering

February 2016

National Physical Laboratory Module: Fundamentals of Metrology

The first 'Fundamentals of Metrology' NPL Module which was delivered as part of the MRes module for eleven Ultra Precision CDT students by staff from the National Physical Laboratory (NPL), over four days in January 2016. The lecture series was presented by seventeen NPL researchers and senior staff who are actively engaged in delivering metrology at the highest levels of accuracy and in ensuring international compatibility and traceability of the UK national measurement system.

The course consisted of twenty-two 45-minute lectures covering the following broad topics:

- metrology basics & international metrology;
- the SI & the transition to the new SI;
- uncertainty evaluation;
- fundamentals of dimensional metrology;
- dimensional metrology in practice;
- taking dimensional metrology beyond nanometrology;
- fundamentals of thermal and humidity metrology;
- practical temperature measurements;
- thermal metrology at extremes;
- fundamentals of mass metrology;
- implementation of the new kilogram;
- practical force and pressure metrology.

Each student received individual printed copies of the course presentation slides together with a selection of Good Practice Guides, developed by NPL. At the end of the last three days of the course, the students were given guided laboratory tours of the mass, dimensional and thermal laboratories at NPL, where they were able to see: examples of primary metrology instruments used at NPL for performing measurements at the highest levels of the traceability chain; the UK national copies of the prototype metre and kilogram artefacts; leading edge research into developing new metrology tools and progress towards the new International System of Units (SI) through NPL's work on the watt balance and the measurement of the Boltzmann constant.

Feedback from the course has been very positive and the course will be re-run yearly for the next few years as new cohorts of students join the CDT.

The CDT students were joined by two PhD students from the CERN PACMAN project (Particle Accelerator Components' Metrology and Alignment to the Nanometre scale). The CERN are studying for PhDs at ETH Zurich, Switzerland.

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Project Feature: Ordered Nanomaterials for Electron Field Emission

Electron emission is described by electrons that are transmitted from an electron dense material into a vacuum. A typical device in diode mode is seen in Fig 1a. The emitting material, located in high vacuum (10−7 mbar) conditions, is negatively biased and exposed to a high voltage on the anode.

1D materials have sharp tips. This reduces the vacuum potential barrier to a triangular barrier seen in Figure 1b. The physics of electron emission from 1D materials are not fully understood. The Fowler Nordheim equations, which are the commonly implicated in describing field emission, were derived for classical bulk materials, hence there are some areas of uncertainty. A better understanding of the emission process, and factors affecting field emission is the basis of my studies.

There are a number of factors that can affect field emission performance. One of these is surface morphology. Surface morphology can be influenced and carefully controlled using precision engineering. Carbon nanotubes can be patterned using electron beam lithography.

A number of different morphologies of carbon nanotubes have been patterned. The field emission from each of the variations will be tested using a custom built Scanning Anode Field Emission Microscope (SAFEM). They will be tested in both a parallel plate set up, where the entire emitting area of the chip is measured, and at individual locations, building up a map of the emission sites across a single chip. This will allow evaluation of where electrons are emitted and the overall performance from different surface structures.

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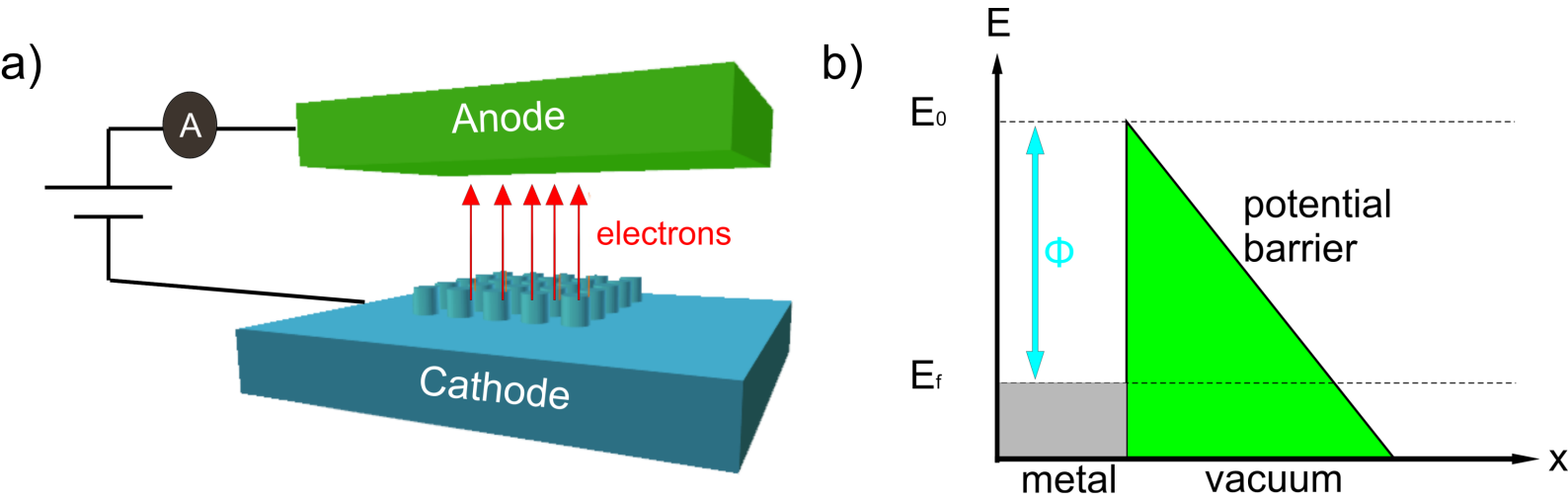

Figure 1 a) Field emitting device operating in diode mode. b) Triangular vacuum potential barrier seen by 1D materials.

Ultra Precision Manufacturing Conference 2016

The Ultra Precision MRes cohort will be holding a one-day conference and exhibition on the 9th of May 2016 at the Institute for Manufacturing to showcase advances in ultra precision engineering in fields such as aerospace, medical devices, metrology, non-conventional manufacturing processes, and photonics. The event is designed to provide an opportunity for industrialists and academic researchers to share their latest ideas and to explore future collaborative opportunities in the field of ultra precision engineering.

Registration is free, but places are limited. Please contact up.conference.2016@my-ifm.net to register.

Publications

Clare Collins, Richard Parmee, William Milne, Matthew Cole, High Performance Field Emitters, Advanced Science, February 2015, DOI: 10.1002/advs.201500318

Save the Date:

Science Festival, 19 March 2016 - Institute for Manufacturing

Ultra Precision Manufacfuring Conference, 9th May 2016 - Institute for Manufacturing