Applications of Energetic Ion Beams at Surrey Ion Beam Centre

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Thanks to:

Professors Satheesh Krishnamurthy
and Roger Webb
Dr. Geoff Grime
Drs Luke Antwis and Vlad Palitsin
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Adrian Cansell, Julian Fletcher, Jakub Jagiello and Angela Battley
Natasha Clifton

Many ex-colleagues and external collaborators

The UK National Ion Beam Centre

UK Research and Innovation

Quality Assurance and Standards at Surrey Ion Beam Centre

- *Extensive QA program*
- *ISO9001 certified since 2008*
- Working with both NPL and PTB on various fundamental studies

THE BRITISH ASSESSMENT BUREAU ISO9001

Certification No. 181855

ilac-MRA

UKAS CALIBRATION

8943

UKNIBC UK NATIONAL ION BEAM CENTRE

www.uknibc.co.uk

UNIVERSITY OF SURREY

Surrey and Ion Beam

First van der Graaff accelerator from Harwell was installed in mid 1960s

New University, new campus, new research team and new research area

SRC, SERC, EPSRC and UKRI supported national facility from 1980s

Increasing demand for irradiation of materials since 2000s

SURREY ADVERTISER AND COUNTY TIMES, FRIDAY, JUNE 6, 1969

UNIVERSITY OF SURREY

Research into ion implants

THE electrical and control engineering department of the University of Surrey has installed one of its research projects in an old paint spraying shed at Dennis Bros. The equipment installed is for research into high voltage ion implantation. Professor D. R. Chick, head of the department, said that he hoped the use of the industrial site would lead to further links and interchanges between Dennis's and the university.

Dr. K. G. Stephens, who is in charge of the project, said that the larger of the two high-voltage machines was a gift to the university from Standard Telecommunications Laboratories Ltd., Harlow, in August, 1967.

When it was given the machine had already been in use for about 10 years. The machine has been completely refurbished and is now worth about £35,000. It was originally mounted vertically but it will be placed in a horizontal position in the shed at Dennis's.

"It needed a good six months' work on it," said Dr. Stephens, "and it was in storage until we came to Guildford when we had the offer of the building from Dennis's."

The second machine is a high voltage generator, the major part of which is on loan from the Rutherford High Energy Laboratory at Harwell.

Research Council has paid the £8,900 for the refurbishing of the larger machine. The research itself is being financed by the department. On July 2nd 40 scientists from all over the United Kingdom who are interested in the project will be visiting the university for a conference and to look at the equipment.

Professor Chick said that he hoped that interaction between the university and Dennis's would grow at all levels and it is hoped that the university will be able to help in electrical training schemes for apprentices.

Dennis's are supplying the build-

The University of Surrey's Electrical and Control Engineering Department has installed its research project into high voltage implantation in an old paint-spraying shed at Dennis Bros., Guildford. In the shed, which has been altered at the firm's expense, and is being lent free of charge, are (left to right): Mr. Peter

Ion – Solid Interaction

1. Ion implantation, the stopping of ions

2. Ion irradiation, lattice damage created

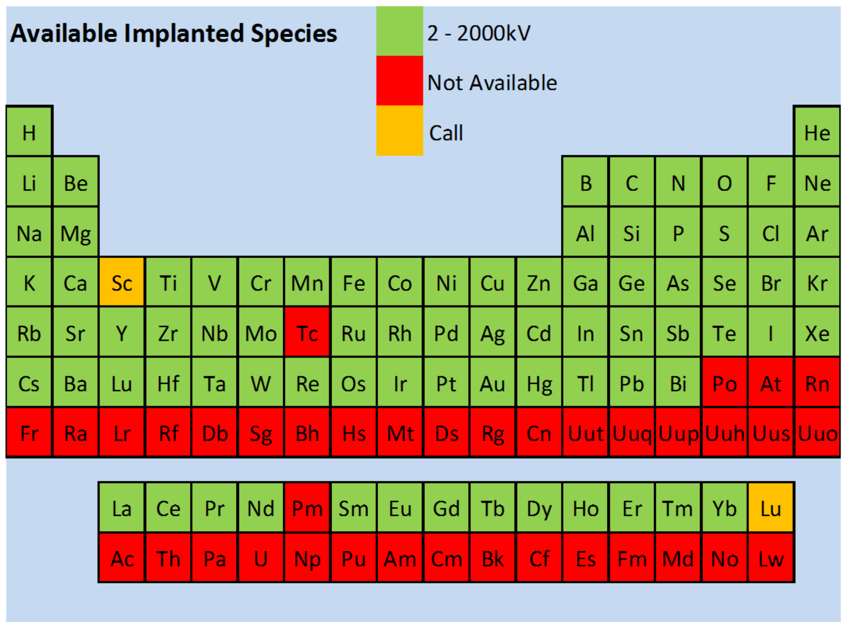
3. Ion Beam Analysis, ion induced effects
   RBS, EBS, ERD, PIXE, PIGE, NRD
   IBIL, IBIC, MeV-SIMS etc.

Perfect crystal is excellent, but crystals with fully understood defects are even better.

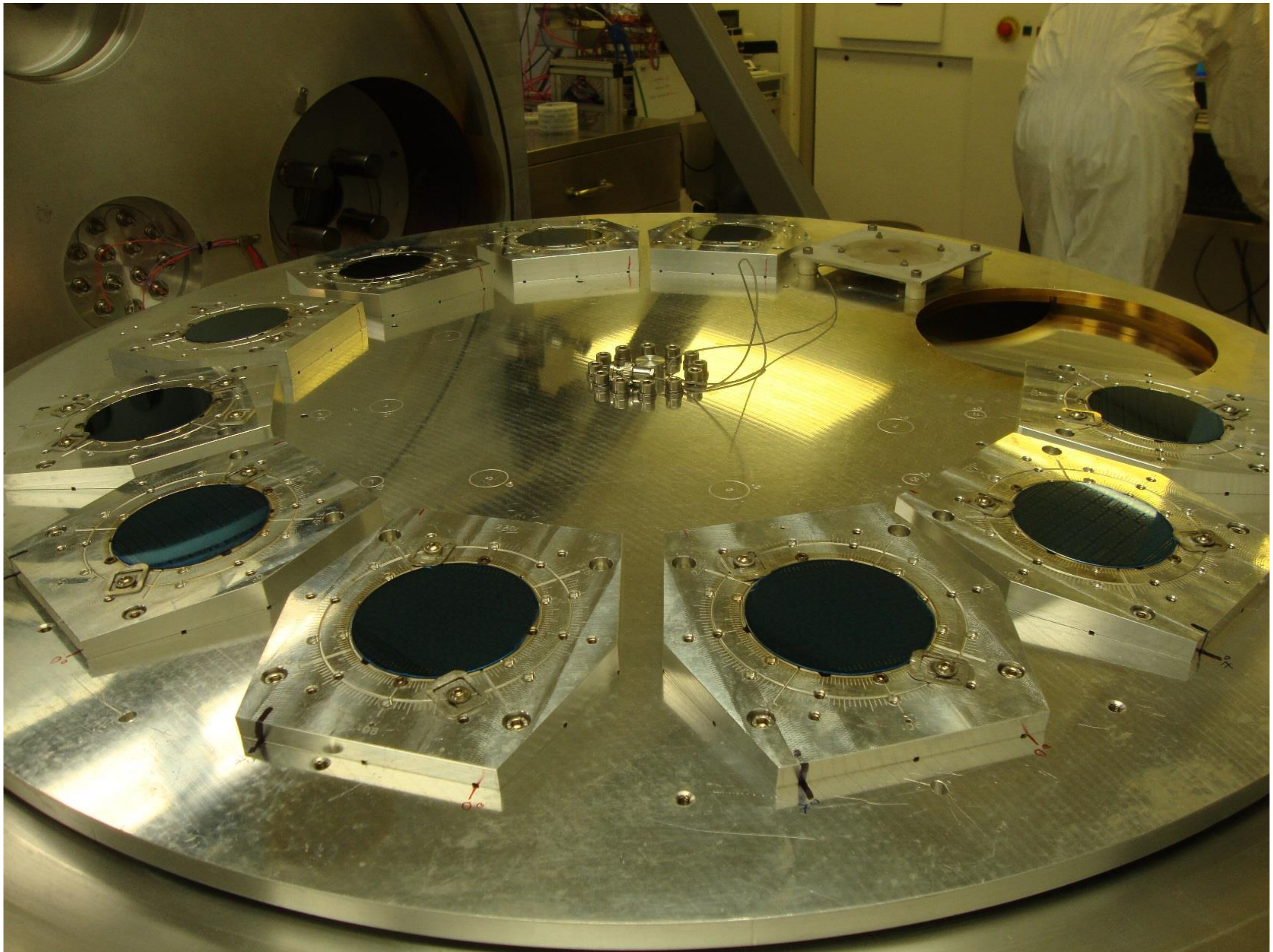
Surrey Ion Beam Centre: facility updates

- Broad beam: scanning of focused beam about 5 mm in beam spot size
  - 2 MV HVEE implanter, 200 kV to 2000 kV, over 36 years old
  - DF 1090 implanter, 1 kV to 200 kV, just 30 years old
  - 1.25 MV HVEE implanter, 90 kV to 1250 kV, new
- Focused beam: focused down to 20 nm level
  - SIMPLE 1 and SIMPLE 2, 25 kV
- IBA: 2 MV HVEE Tandem, 500 kV to 4000 kV
  - Broad beam RBS, PIXE, ERDA etc
  - Microbeam
  - TOF-ERDA
  - Super SIMS
  - External beam
- Sample processing and characterisation tools

Ions at Surrey Ion Beam Centre



Sample stage for room temperature implant: carousel

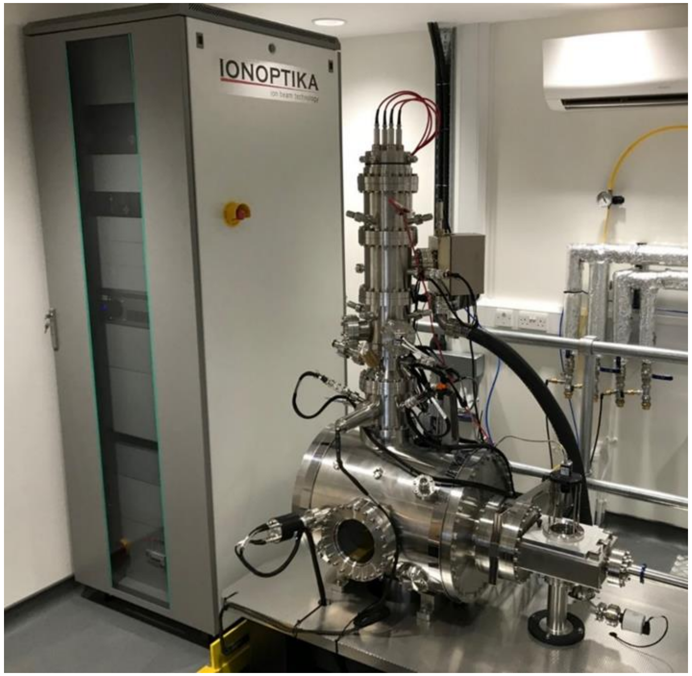


Applications of broad beam

Common materials modified with ion beams:

- Semiconductors: Si, InP, SiC, Ga_2O_3 etc.
  - Conductivity, refractive index
- Simulation of radiation effects
- Biomaterials
- Ceramic electrolytes for solid state battery
- Superconductors
- Smart cut: ion beam cut for making thin films

Applications of focused beam



Aim to support QT applications:
to be able to place **two atoms** such that they are **within 20nm of each other**.
Not one, and not three.
Repeat for a 100x100 array < 1hour

Capability	SIMPLE01
Ion species	**Si, P, Mn, Se, Er, Bi**, Ge…
Isotope selection	✔
Spatial resolution	<20 nm
Ion energy	5kV – 20kV
Deterministic doping	✔ (single ion)

Capability	SIMPLE02
Ion species	**N, O**, He, Ne, Ar…
Isotope selection	✔
Spatial resolution	<40 nm
Ion energy	5kV – 25kV
Deterministic doping	✔ (single ion)

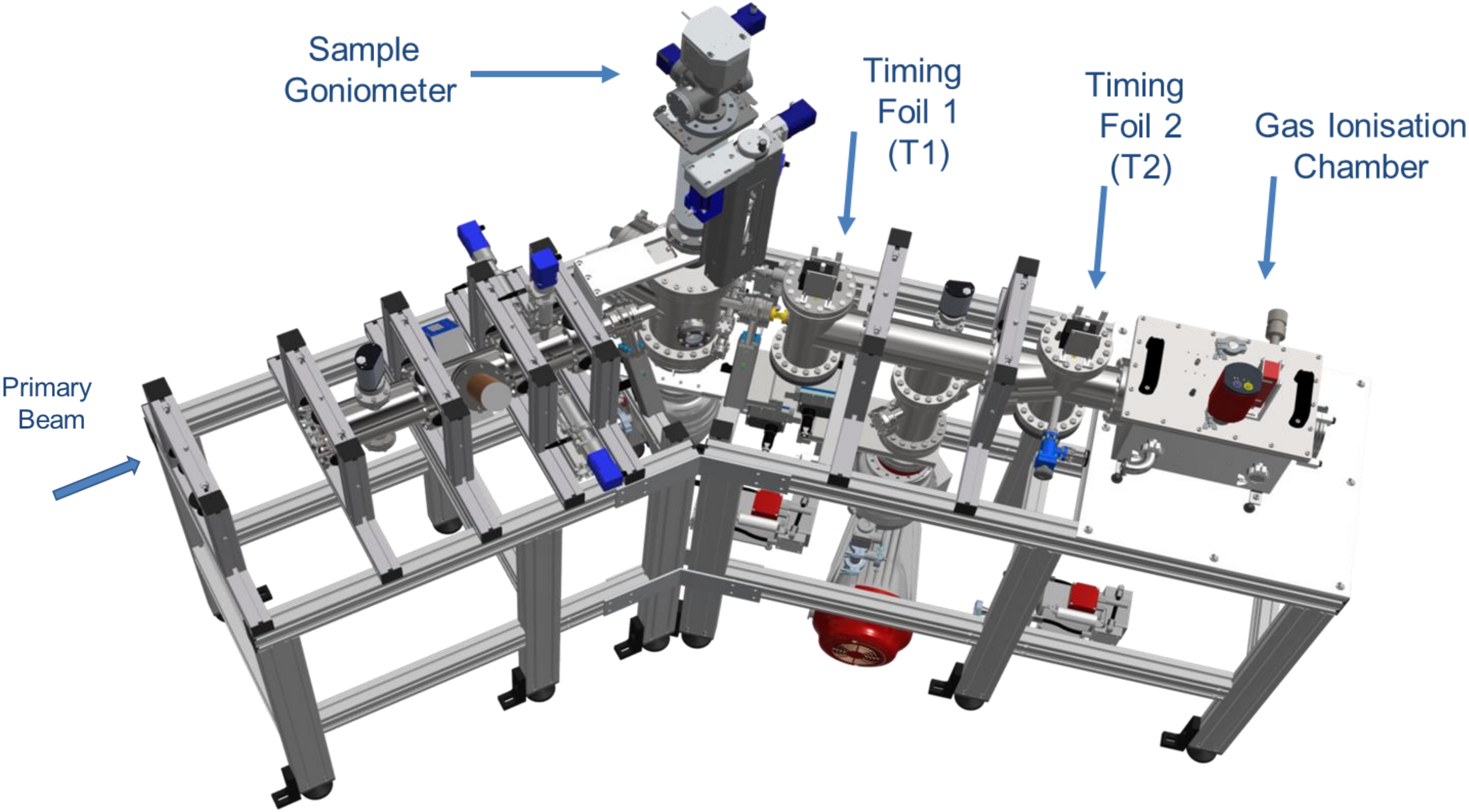
Low level ion implantation and irradiation for a small pre-selected area

Ion Beam Analysis

- **Advanced Materials Analysis**
  - 2MV Tandem
  - Techniques include RBS, ERD, PIXE, PIGE, NRA, IBIL, IBIC, MeV SIMS
  - Channelling Spectroscopy for damage analysis
  - Fully automated collection and analysis
  - External Beam for vacuum sensitive samples (~2um)
  - Horizontal nanobeam (~500nm)
  - Implantation line – heavy ion irradiation up to ~10MeV

Another reversed engineering project: derive original chemical structures (real space) from the energy loss data (momentum space)

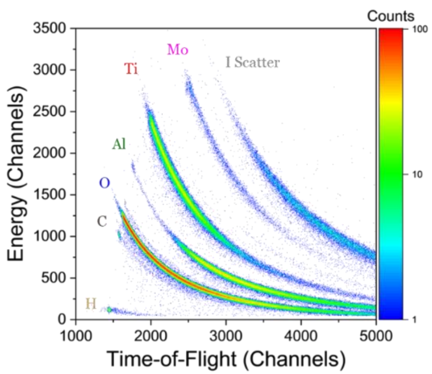
TOF-ERDA

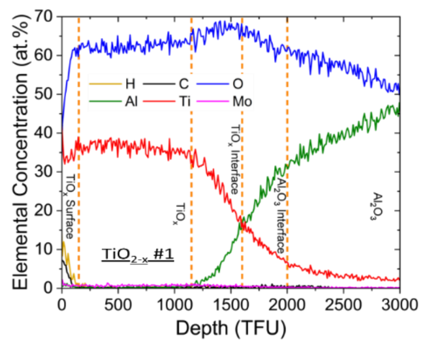


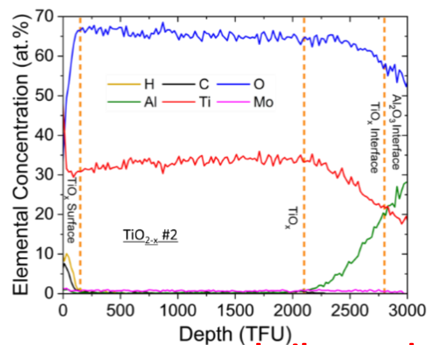
Sample
Goniometer
Timing
Foil 1
(T1)
Timing
Foil 2
(T2)
Gas Ionisation
Chamber
Primary
Beam

Superconductors

- Characterisation of oxygen concentration in superconducting TiO_{2-x} thin films

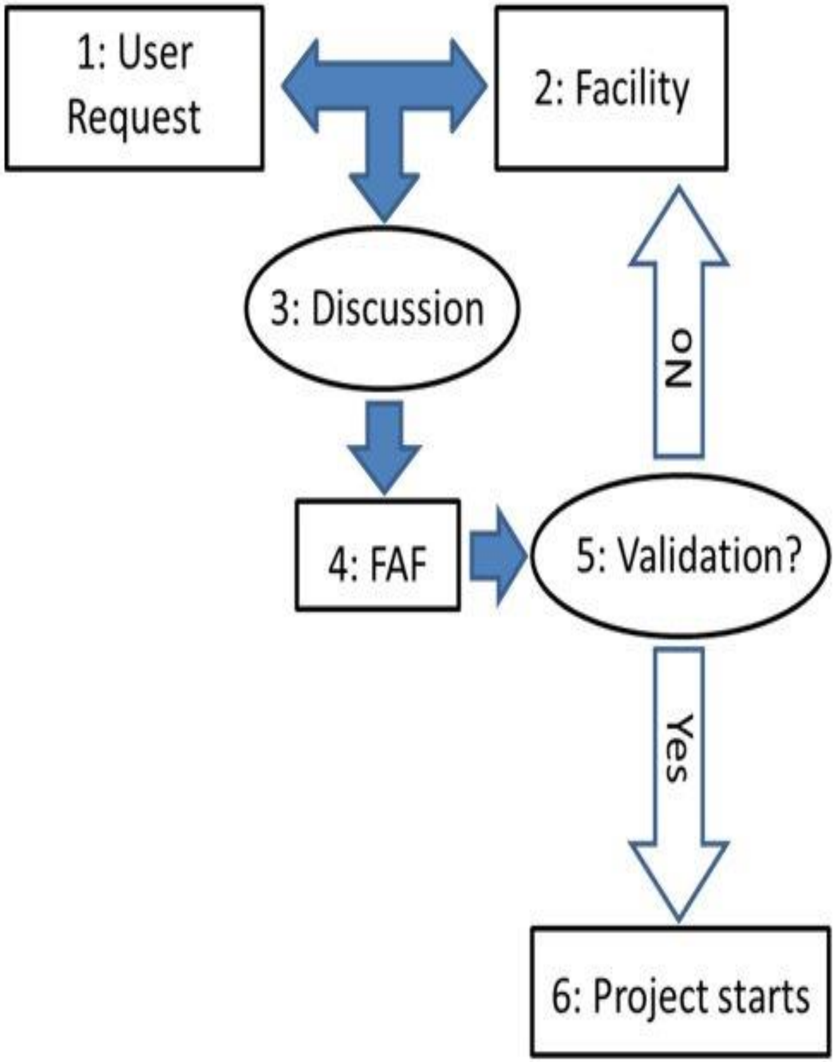






Sample	O partial pressure /Pa	TiO_{2-x} thickness /nm	O/Ti ratio	Interface thickness /nm	O/Al ratio in Al_2O_3
TiO_{2-x} #1	4.7E-4	126	1.63	84	1.5
TiO_{2-x} #2	4.7E-4	223	1.95 – 1.55	Not fully visible	Not visible
TiO_{2-x} #3	1.0E-2	320 (not see full layer)	1.93	Not fully visible	Not visible
TiO_{2-x} #4	5.2E-4	145	1.88	146	1.47
TiO_{2-x} #5	5.2E-4	130	1.74 – 1.94	140	Not visible
TiO_{2-x} #6	7.0E-3	200	2.07	Not fully visible	Not visible

How to get access to our facilities?



Funding mechanisms:

There are four mechanisms through which users can gain access to our facilities:

New EPSRC Application – access is requested as part of an EPSRC application. If the grant is awarded then access will be automatically provided by the UKNIBC – we supply Technical Assessment (FAF) to go with your application.

Commercial - the user pays for the usage of each facility.

A proportion (25%) of UKNIBC time is earmarked for new projects that have no current EPSRC support for using ion beam facilities:

- **EPSRC Students -** EPSRC funded students can access the UKNIBC in their own right.
- **Pump Priming and Existing EPSRC grants without beam time -** access granted via a simple validation process.

The UK National Ion Beam Centre

UK Research and Innovation

For more detailed information, please visit our new website:

www.uknibc.co.uk

Contact me via e-mail: n.peng@surrey.ac.uk
via telephone: 44-7480575509

Thank you for your attention!