Task 4.3: Mitigate beam-induced vacuum effects (STFC, CERN)

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EuroCirCol WP4 meeting, Saclay, France

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Science & Technology Facilities Council

Manpower – Task 4.3

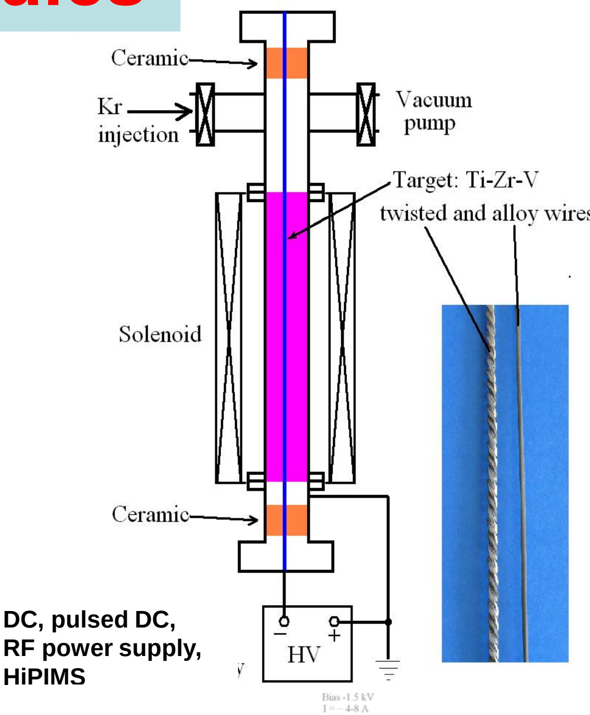
- Oleg Malyshev: 4 year × 3 months = 12 PM
  - Task coordination
  - PhD student supervision
  - Gas dynamics in cryogenic beam pipe, NEG coating and low SEY surfaces development and application
- Reza Valizadeh: 4 year × 3 months = 12 PM
  - PhD student supervision
  - NEG coating and low SEY surfaces development and application
- PhD student 1: 3 year × 12 months = 36 PM
  - NEG coating studies
  - New recruiting, interview in Dec, starting in January 2016, Reg in Loughborough University
- Taaj Sian, PhD student 1: 3 year × 12 months = 36 PM
  - Studies on low SEY surface engineering
  - Started on 1st Oct. 2015, registered at the Manchester University

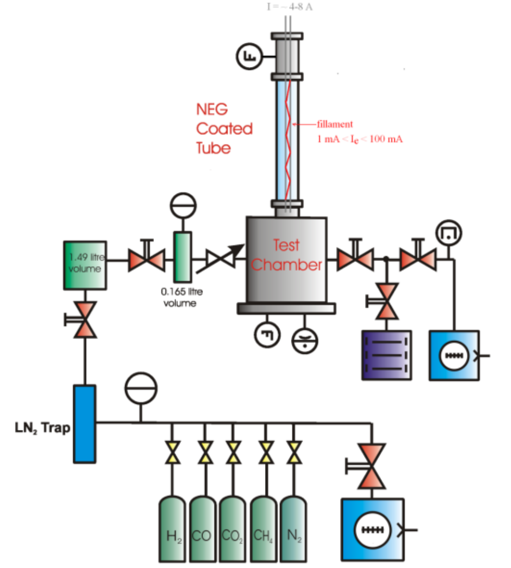
NEG coating studies

Room temperature studies

1st PhD student's work:

- Jan 2016 – Mar 2016 – familiarisation with NEG depositions and evaluation facilities
- Apr 2016 – Mar 2017
  - Studying various NEG coatings and their parameters at room temperature:
    - Depositing NEG coating on standard ASTeC sample tubes (ID=38 mm, L=0.5m)
    - Analysing coupons deposited together with tubes with XPS, SEM, XRD.
    - Measuring the ESD as a function of electron dose after activation to 150, 180 and 200 °C, then measuring H_2 and CO sticking probabilities and CO pumping capacity.
- Measuring the ESD and pumping propertied for samples from CERN (if provided)





Possibility for ESD studies at cryogenic temperatures in ASTeC:

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1st PhD student's work:

- Sep 2016 – Dec 2016
  - Design of a facility for ESD measurement at cryogenic temperatures
- Dec 2016 – Mar 2017
  - procurement of components and building up the facility for ESD measurement at cryogenic temperatures
- Mar 2017 – Dec 2018
  - Measuring the ESD (as-received) at cryogenic temperatures
    - Bare surface with and without NEG coating
    - Surfaces with condensed H_2, CH_4, CO and CO_2
    - Effect of unstable temperature
  - Temperature cycling of the samples

What is available:

- A cryo-pump compressor and a pump head
  - T $\geq$ 20 K
  - Max power 10 W at 20 K
- Present ESD facility layout limits:
  - ESD measurements at 10 W: 500 eV $\times$ 20 mA
  - Filament heat: ~30 W
    - Can be reduced to 10 W with thinner filament
- Another possibility is using an electron gun:
  - Advantage: no filament heat load on cryogenics
    - Disadvantage: bombardment will be less uniform along the tube

What can be studied in a collaboration using SR

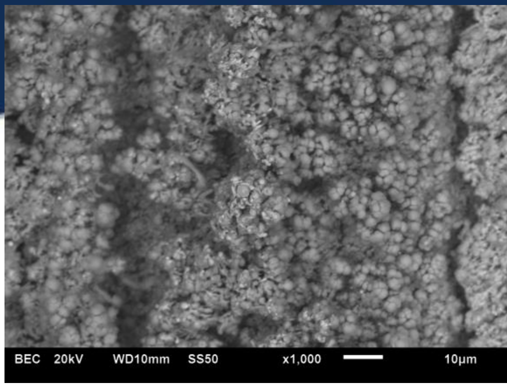
- Continuing studies at room temperature
  - Measure PSD for dense, columnar and dual layer
    - PSD after activation to 150-200 °C
    - Photon induced NEG activation
    - Compare of samples prepared at CERN and ASTeC
- PSD studies at cryogenic temperatures
  - PSD as a function of temperature
  - PSD from cryosorbed gas (H_2, CO, CO_2, CH_4)
  - NEG coated beam screen at various temperatures with a cold bore at 3.5 K
  - Effect of unstable temperature of a beam screen
  - ESD as a function of PSD dose
- Coordination with other WP4 members!
  - Dates, milestones? Available recourses?
  - Sample dimensions? If is it doable on existing deposition facility?

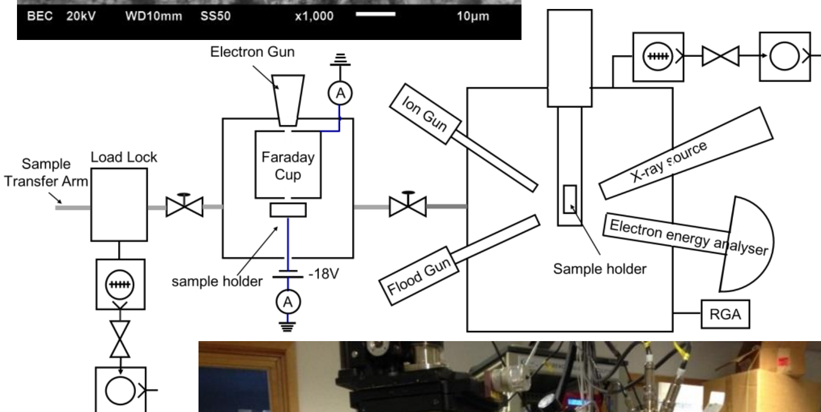
Use of results for modelling FCC vacuum

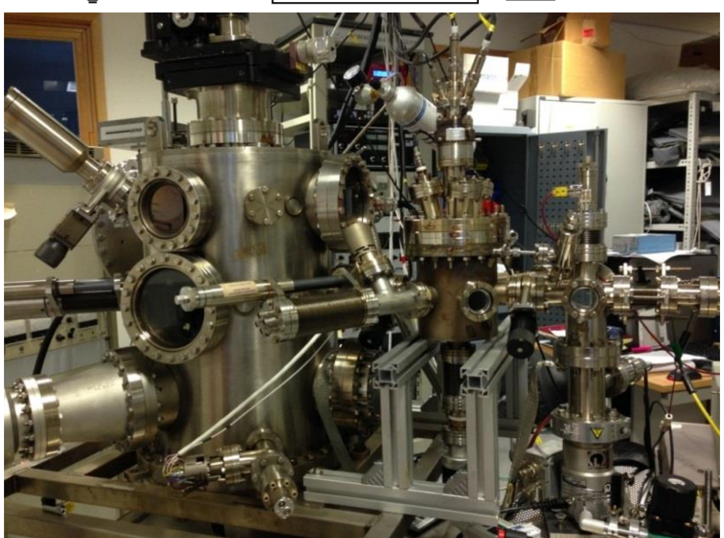
- These results can be applied to the FCC beam pipe vacuum modelling
  - Gas density with and without beam (and SR)
  - Ion induced pressure instability
  - ESD due to beam induced electron multipacting

Low SEY studies

Room temperature studies





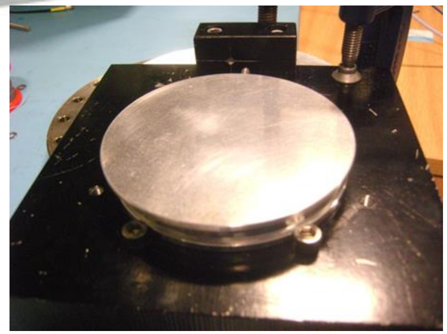


2nd PhD student's (Taaj Sian) work:

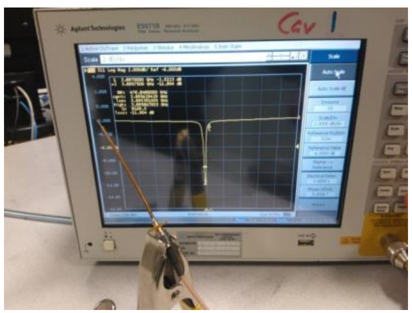
The main emphasis will be on the Laser Induced Micro/Nano Surface Structures (LIMNSS)

- Oct 2015 –Sep 2018
  - Studying various LIMNSS obtained with various lasers and their parameters at room temperature:
    - Measuring the SEY (as-received, after electron bombardment, after bakeout, after ion bombardment).
    - Measure surface resistance of LIMNSS
    - Measure ESD and thermal outgassing of selected LIMNSS with low SEY
    - Study the LIMNSS stability to ultrasound (measuring SEY before and after wash)
    - Study the particulates generation
  - Studying selected surfaces obtained by other techniques such as coatings, etching, etc., provided by sample exchange with other WP partners.

R_s measurements

A sample placed above a test cavity with a gap of 1-3 mm

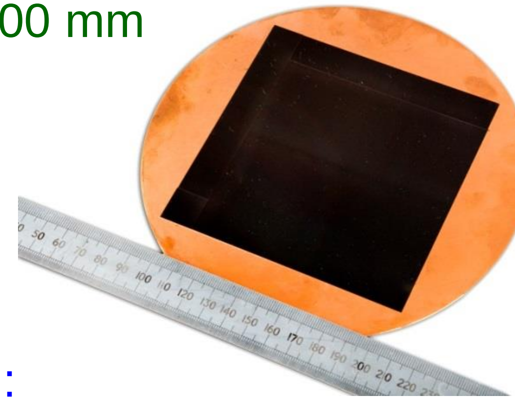


Coaxial antenna connected to Vector Network Analyser (VNA) is axially mounted, used to induce and or analyse resonance within the cavity.

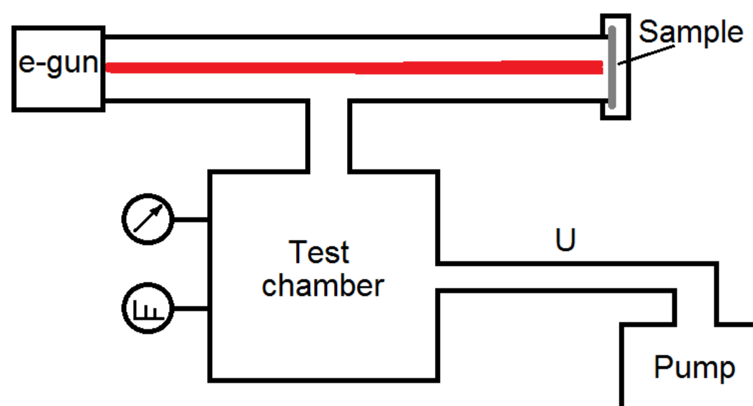
- R_s calculated with a formula:
  - $R_S = \frac{G/Q_0 - R_C r_C}{r_S}$

Thermal (TD) and Electron Stimulated Desorption (ESD)

- Thermal outgassing in comparison to untreated surface
  - For example on Cu blank gaskets ∅100-200 mm



- ESD on:
  - Cu blank gaskets ∅48 mm
  - E_{e-} = 500 eV



Possibility for low SEY studies at cryogenic temperatures in ASTeC:

2nd PhD student's work:

- June 2016 – Sep 2016
  - Design of a facility for SEY measurement at cryogenic temperatures
- Sep 2016 – Dec 2016
  - procurement of components and building up the facility for SEY measurement at cryogenic temperatures
- Jan 2017 – Sep 2018
  - Measuring the SEY (as-received) at cryogenic temperatures
    - Bare surface
    - Surface with condensed H_2, CH_4, CO and CO_2
    - SEY in 1.8 T magnetic field
  - Temperature cycling of the samples

What is available:

- A cryogenic head with a compressor:
  - T $\geq$ 4 K
  - Max power 1 W at 4.2 K

What is required:

- Magnet coil (£7,000):
  - Dry coil has been designed
  - 1.8 T with 30-mm bore diameter
- New e-gun (£30,000)

What else could be studied

- SEY as a function of initial angle α_0
  - requires a modification of an existing SEY measurement (£10,000)

What can be studied in a collaboration using SR

- Photo-electron emission yield (PEY)
  - PEY at room temperature
  - PEY in a magnetic field
  - Angular distribution (4-6 sectors)
- PSD at room temperature
  - as received
  - after bakeout
- PSD studies at cryogenic temperatures
  - PSD as a function of PSD dose
  - PSD as a function of temperature
  - PSD from cryosorbed gas (H_2, CO, CO_2, CH_4)
  - Effect of unstable temperature of a beam screen
- Coordination with other WP4 members!
  - Dates, milestones? Available recourses?
  - Sample dimensions? If is it doable on existing deposition facility?