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

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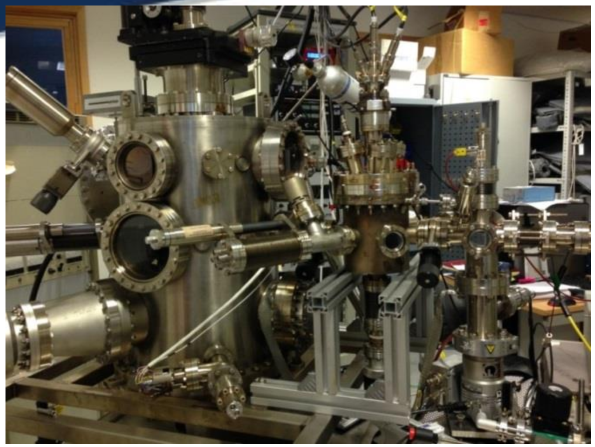
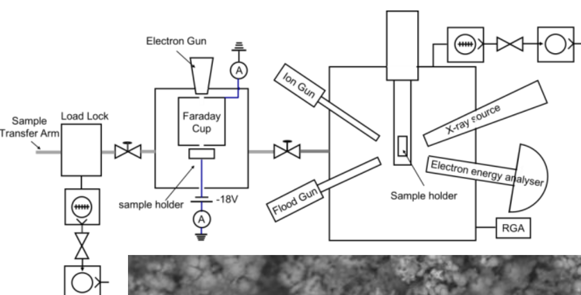
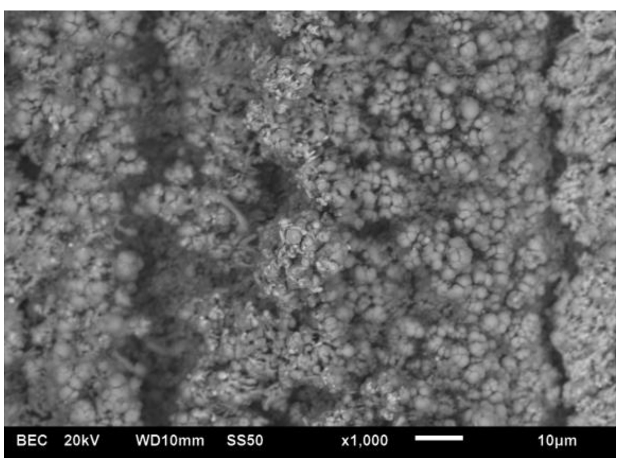
Low SEY studies







- Current work:
  - Several new surfaces were produced by different laser and their SEY were measured
    - To be reported by Reza Valizadeh
  - The data acquisition on the SEY facility is fully automated with LabVIEW
  - Design on a new cold stage (LN_2) facility has been almost completed
  - Design on a new cold stage (4-300K) facility started
  - Some parts are in a process of procurement
    - To be reported by Taaj Sian
- Next Steps
  - Building the new cold stage facility
  - Production of samples for other EuroCirCol partners (subject to the funds availability)
- Showstoppers
  - Finance to produce of samples for other EuroCirCol partners.
  - A delivery of a new electron gun for the new cold stage facility (there is none at the moment)

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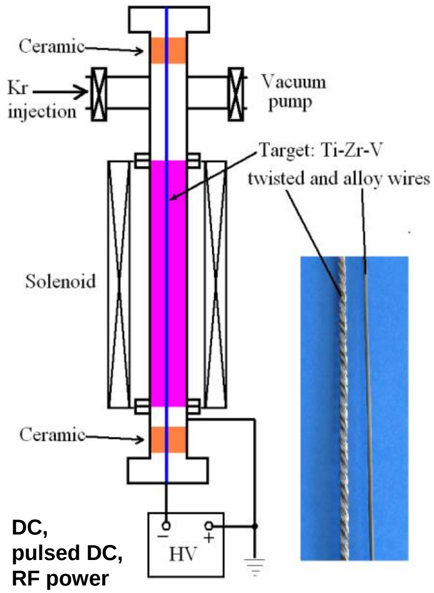
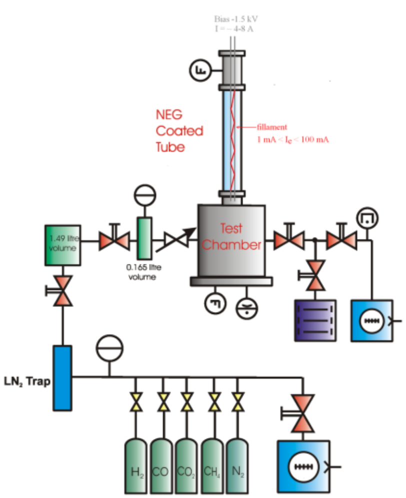
NEG coating studies

- Current work
  - **PhD student Rūta Širvinskaitė:**
    - July – Sep 2016 – familiarisation vacuum basics, literature survey, introduction to NEG depositions and evaluation facilities
    - Secondary calibration of UHV gauges
    - In-situ calibration of RGAs against the UHV gauges
  - Other activities (Reza and Oleg)
    - A study of dual NEG coatings completed
      - A dual-layer NEG coating consisting of a 0.5- μm-thick dense layer covered by a 1-μm thick columnar layer was evaluated for EDS and pumping activated at different temperatures.
      - The paper has been submitted to JVSTA
    - A study of NEG impedance (not a part of EuroCirCol but relevant to it)
      - The surface resistance of two types of NEG coating (dense and columnar) was investigated at 7.8 GHz. The bulk conductivity was obtained with the analytical model: σ_d = 1.4×10^4 S/m for the columnar NEG coating and σ_d = 8×10^5 S/m for the dense NEG coating.
      - The paper has been submitted to NIMA
    - To be reported by Oleg later
- Next Steps
  - Deposition of Zr on a sample tube, ESD and pumping measurements
  - Design of a facility for cryogenic (LN_2 and LHe) measurements
- Showstoppers
  - None at this stage



DC, pulsed DC, RF power supply, HiPIMS



O.B. Malyshev

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Milestone report

Proposal on surface engineering to mitigate electron cloud effects

A report describes two coupled problem: meeting vacuum specification on a beam vacuum and to mitigating electron cloud. Two most promising technologies were identified:

1) Low SEY laser treated surface. A recent invention that allows obtaining surfaces with SEY < 0.6 for complete eradication of the BIEM and e-cloud.
2) NEG coated surface. NEG film can be deposited to provide SEY < 1. After activation this film also provides a reduced PSD and ESD and distributed pumping speed.

Before choosing between these two options, both technologies have to be verified at cryogenic temperature and under synchrotron radiation bombardment.

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Main highlights for Option 1: SALT

- **What is known:**
  - The surface with SEY < 1 can be produced using laser treatment, the SEY may further be reduced with dose to ~0.6.
  - It has no vacuum problems at room temperature
    - ESD, TD, ultrasound wash
  - Surface impedance increases by factor 3
- **What is required to study:**
  - PSD data for SALT at room temperature
  - Data at cryogenic temperature
    - PSD and ESD
    - PEY and SEY
    - Effect of cryosrobed gases on PSD, ESD, PEY and SEY
    - Surface impedance

Main highlights for Option 2: NEG

- **What is known:**
  - The surface with SEY < 1 (after NEG activation) can be produced.
  - Vacuum:
    - Ti-Zr-V PSD data at room temperature only
    - Ti-Zr-Hf-V ESD is an order of magnitude lower than for Ti-Zr-V
      - The same reduction is expected for PSD
    - Ti-Zr-Hf-V ESD on vacuum fired tubes is two orders of magnitude lower than for the Ti-Zr-V film
      - The same reduction is expected for PSD
    - Dense vs columnar film
  - Surface impedance
    - increases with thickness and frequency
    - the bulk conductivity was obtained with the analytical model:
      - $\sigma_c = 1.4\times10^4\ S/m$ for the columnar NEG coating
      - $\sigma_d = 8\times10^5\ S/m$ for the dense NEG coating

Main highlights for Option 2: NEG

- **Modelling das density for H_2 after dose D = 10^{22} photons/m**
  - Ti-Zr-V
    - $n_{Ti\text{-}Zr\text{-}V}$ = 1×10^{18} molecules/m^3
  - Ti-Zr-Hf-V (dense)
    - $n_{Ti\text{-}Zr\text{-}Hf\text{-}V}$ = 1×10^{17} molecules/m^3
  - Ti-Zr-Hf-V (dense) on vacuum fired tubes
    - $n_{Ti\text{-}Zr\text{-}Hf\text{-}V}$ = 1×10^{16} molecules/m^3
  - Including photon induced pumping allows to reduce 10 times lower:
    - $n_{Ti\text{-}Zr\text{-}Hf\text{-}V}$ = 1×10^{15} molecules/m^3 on vacuum fired tubes

Main highlights for Option 2: NEG (cont.)

- **What is required to study:**
  - PSD data for dense and columnar Ti-Zr-Hf-V film at room temperature
  - Data at cryogenic temperature
    - PSD, ESD and sticking probability
    - PEY and SEY
    - Effect of cryosrobed gases on PSD, ESD, PEY and SEY
    - Photon induced activation
    - Surface impedance
  - Further reducing of NEG activation temperature
  - Possibilities of reducing of NEG surface impedance

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Conclusions:

- Two possible solutions could be used for the FCC beam chamber. These solutions should meet the specification to a maximum gas density, ion induced instability suppression and e-cloud and BIEM mitigation.
- Two most promising technologies were described in this report:
  - Option 1: A beam screen with pumping holes and low SEY laser treated surface.
  - Option 2: A beam screen without pumping holes with NEG coated surface.
- Both technologies are potentially feasible but both require further study at cryogenic temperatures.

Visit to Budker Institute of Nuclear Physics (Novosibirsk, Russia)

- SEY measurements in a weak magnetic field (~ 300 Gs)
  - Time-of-flight energy measurements of secondary electrons
    - Available now
- SEY measurements in a strong magnetic field (up to 10 T)
  - Update is possible
- Installing of either above on a SR beamline is possible

Following presentations

- Reza Valizadeh –
  - Low SEY laser treated surface results
- Taaj Sian
  - Laser treated surface vs microparticle
  - Design of cryogenic systems for SEY measurements
- NEG coating results - Oleg Malyshev