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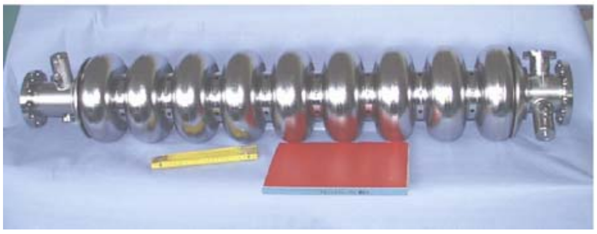

MODELLING OF MAGNETIC CHANNELS FOR MICRO-DROPLETS FILTERING AND TESTS OF THEIR EFFICIENCY IN UHV ARC-DISCHARGES

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Contribution to the 5th International Workshop and Summer School
“Towards Fusion Energy – Plasma Physics, Diagnostics, Spin-offs”
Kudowa Zdroj, Poland

Work supported by the European Community-Research Infrastructure Activity under the FP6 “Structuring the European Research Area” programme (CARE, contract number RII3-CT-2003-506395).

Modelling of magnetic channels for micro-droplets filtering and tests of their efficiency in UHV arc-discharges

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Vacuum arc discharge

Physical properties:

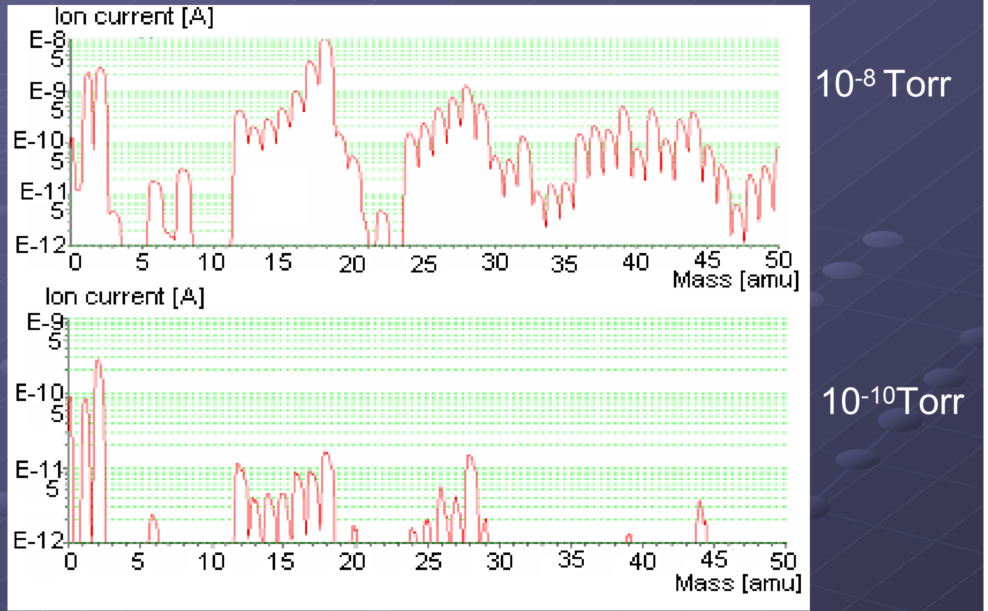
- full ionisation of the plasma,
- absence of a working gas sustaining the discharge,
- presence of multiple-charged ions,
- high kinetic energy of ions (18-150eV).

Film properties:

- very high density and smoothness (if filtered),
- high quality – strongly reduced film defects (i.e. voids),
- possibility of making pure metal films and compounds such as nitrides, oxides, carbonaceous,
- possibility of deposition on components with sophisticated shape.

Vacuum arc in UHV condition

- Its a new concept proposed recently by dr J. Langner
- The main goal – to obtain very clean layer by excluding any source of contaminants.
- Performing deposition by means of the arc discharge in UHV is complicated due to:
  - selection of appropriate materials,
  - selection of appropriate triggering system,
  - baking of whole vacuum system.

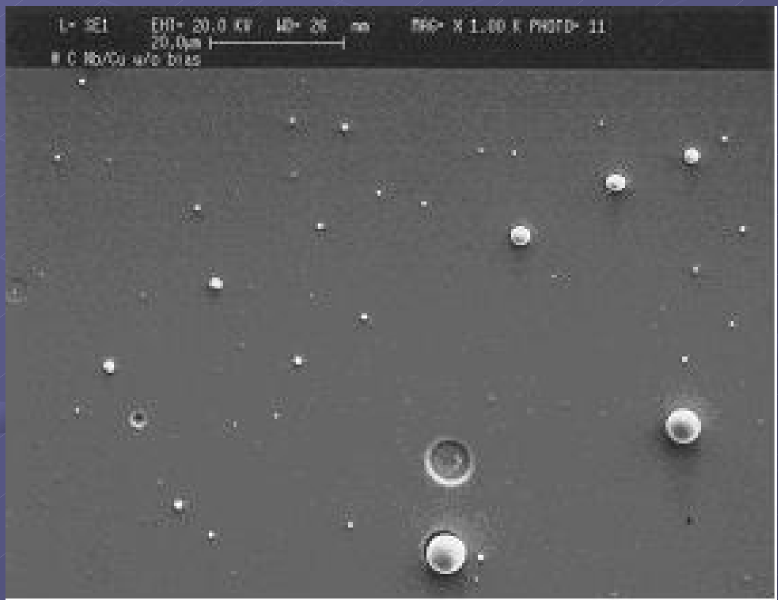


Pressure below 10^{-10} Torr makes possible the practical elimination of impurities, like water vapours, nitrogen and C_xH_Y

- First results show that superconductor Nb thin layer demonstrate similar properties (T_c, RRR) to pure bulk Nb and are very promising in view of coating RF cavities for particle accelerators (i.e. TESLA).

Vacuum arc vs. filtered vacuum arc

The main disadvantage of the arc coating is the production of micro-droplets (macro-particles). It's size ranges from 0.2 to 20µm. The adhesion of the micro-droplets to the substrate gets worse the uniformity of the film surface smoothness and consequently functions of the film. To eliminate the macro-particles from vacuum arc plasma, one could apply magnetic filters.

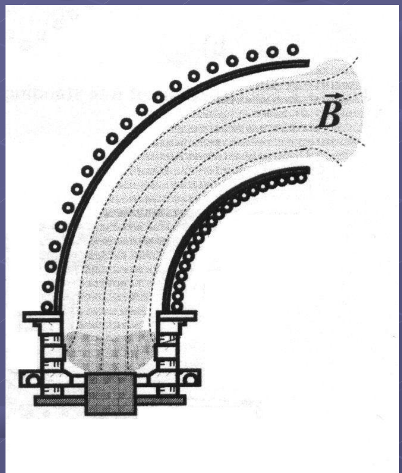


Surface of the Nb coating obtained without magnetic filtering.

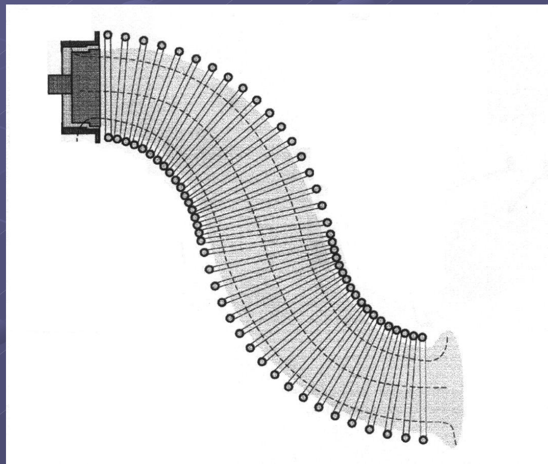
Surface of the Nb coating obtained with the use of the filtered UHV arc

Magnetic filters for micro-droplets

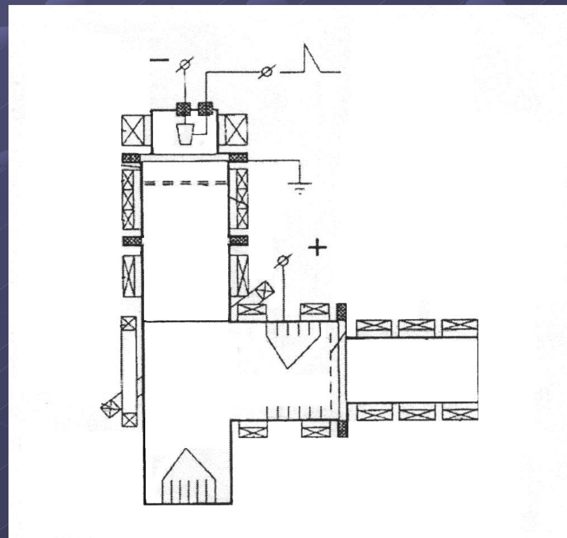
The main purpose of the filters is to prevent line-of-sight of the macro-particles and to guide plasma efficiently to the substrate.



„Aksenov-type"



„S-type"



„T-type" [1]

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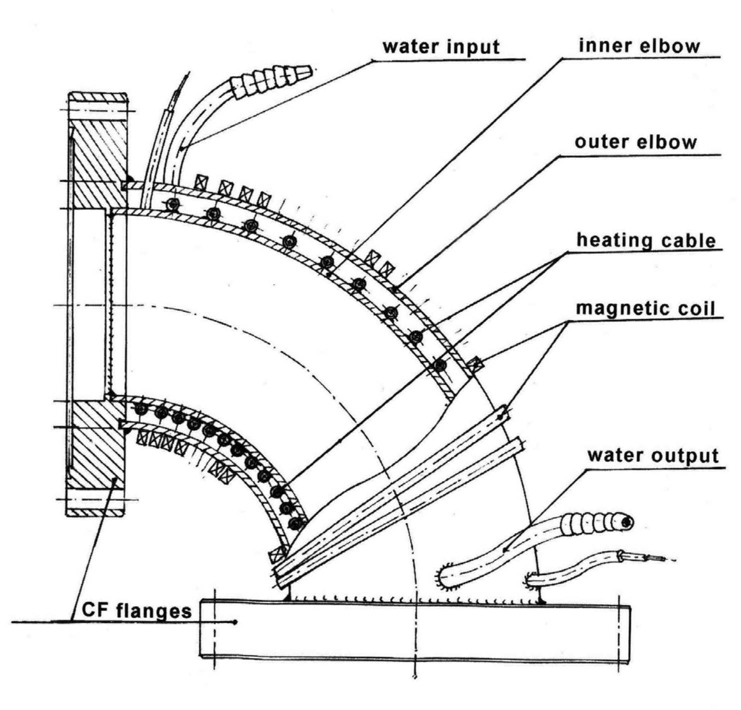
[1] Aksenov, I. et al., "High Efficiency Filtered Vacuum-Arc Plasma Source", XXIth International Symposium on Discharges end Electrical Insulation in Vacuum, Yalta, Ukraine, 2004, 491-494

Magnetic filter suited for UHV conditions

Difficulties in realization:
-selection of appropriate materials,
-baking system,
-cooling system.



Pictures show the Aksenov-type magnetic filter in accordance with UHV technology. Its inner radius is 65mm.
2 other filters have been designed and constructed at IPJ: the Aksenov-type with less curvature radius and the T-type.

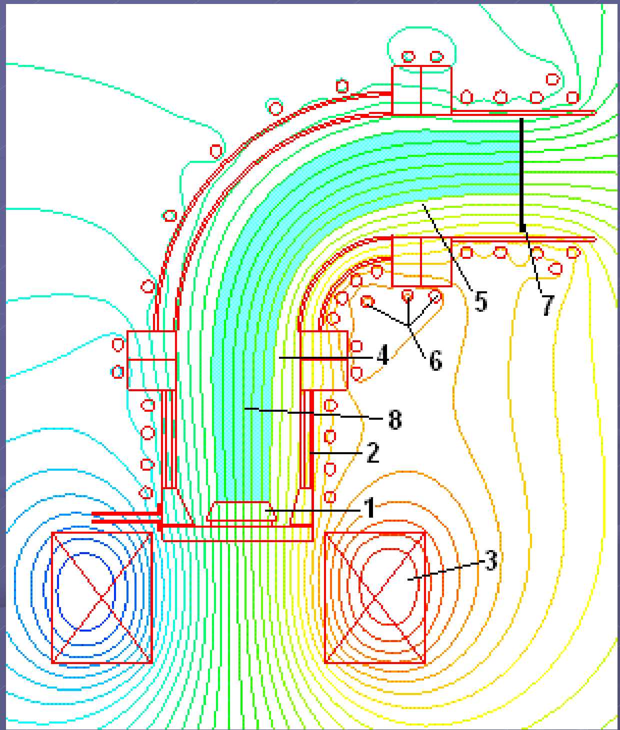
Modelling of a magnetic field distribution in the magnetic filters – part I

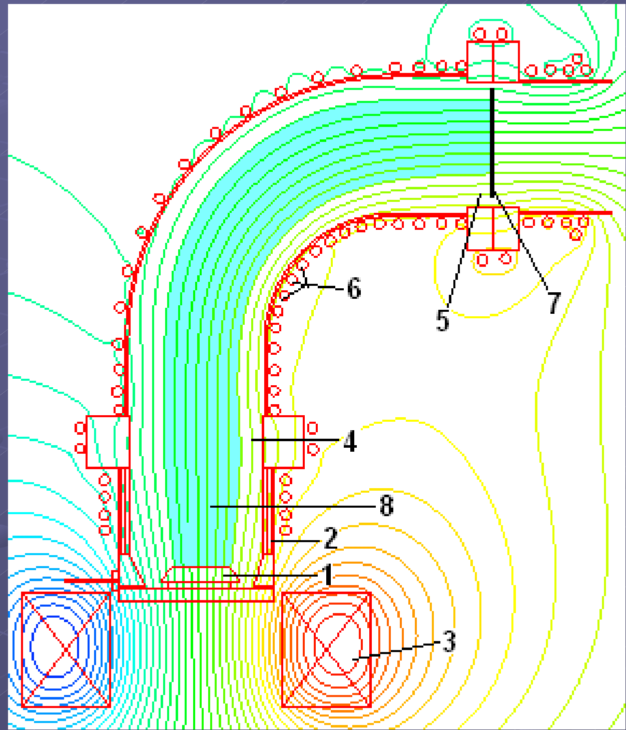
• Magnetic field distribution in the filters was calculated by means of a Maxwell 2D program using Finite Element Methodology.

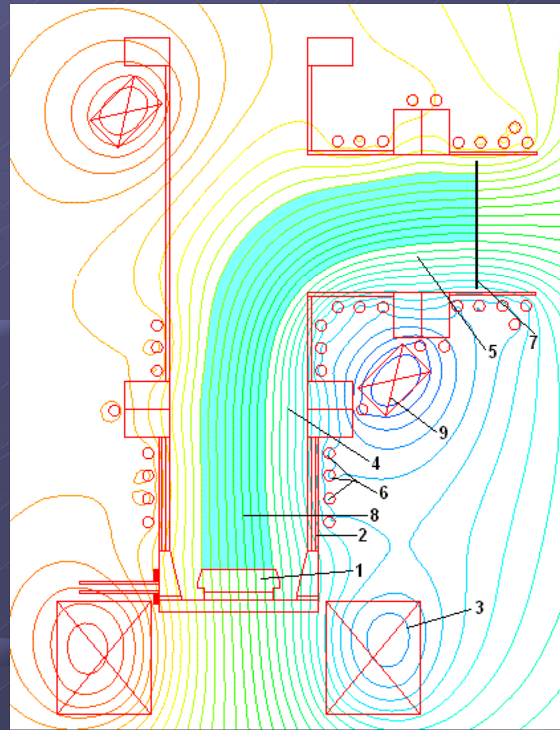
• Because, major plasma loss occurs in the curvilinear part of plasma duct in the filter, it was essential to design the magnetic fields very carefully. These losses are mainly due to contact of plasma stream with the filter walls caused by gradient and centrifugal drifts. By local fields corrections in the curved part of the filter one can noticeable reduce the drift losses.

• A guiding magnetic field in the both Aksenov-type magnetic filters was generated by current amounting to 20–200 A, which might flow in high-current cables wrapped around the plasma duct. Such approach ensured better field uniformity in the curvature filter than the typical coils, which formed local magnetic bottles (in the region between these coils).

Modelling of a magnetic field distribution in the magnetic filters – part II



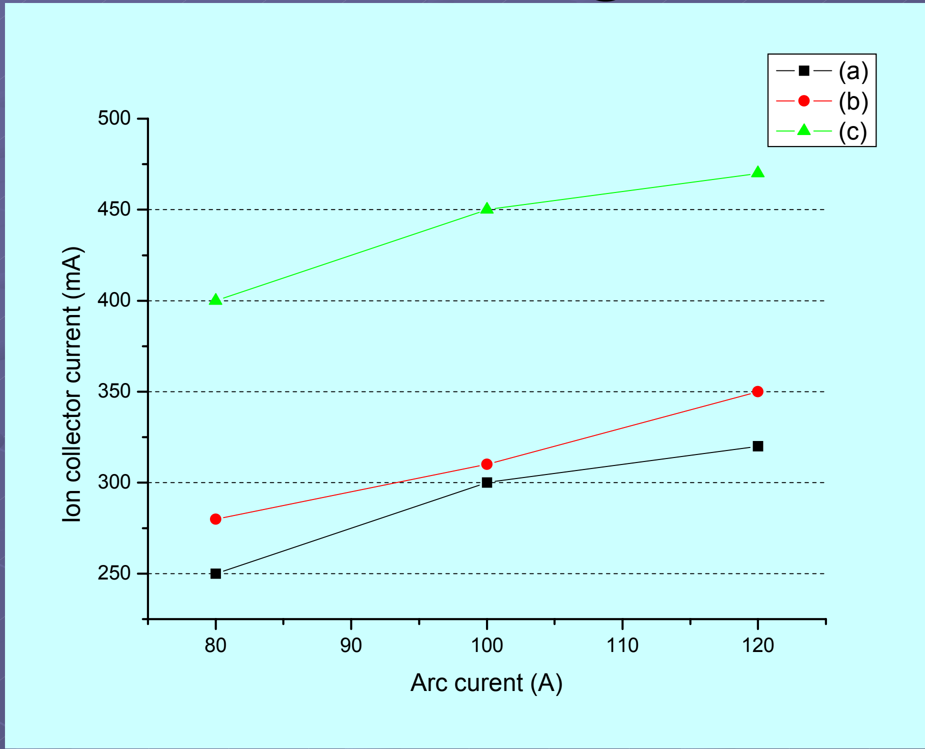




Magnetic field distribution in the Aksenov-type magnetic filters having different curvature radius and in the T-type magnetic filter; 1 – cathode, 2 – anode, 3 – focusing coil, 4 – filter inlet, 5 – filter exit, 6 – high-current cable, 7 – ion collector position, 8 – plasma stream, 9 - correcting coil.

Calculated magnetic filed strengths: - near-cathode region – 16 mT
- magnetic duct region – 12 – 14 mT

Experimental efficiency of ion-transport through considered filters



The T-type filter is characterised by the best efficiency of ion transport, which is typically 30%-40% higher than both Aksenov-type filters.

The arc discharge is the most stable when Aksenov-type magnetic filter with less curvature radius is applied.

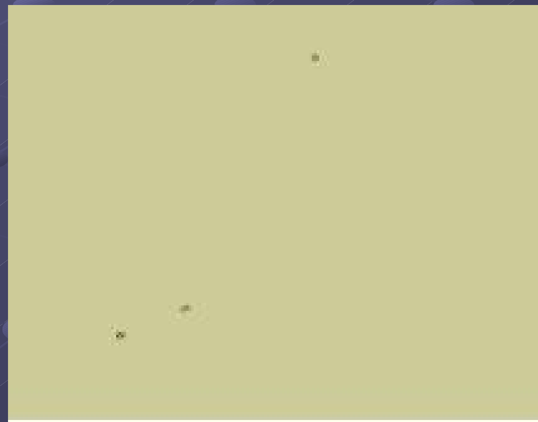
Ion current collected in the magnetic filters outlet for 3 different value of arc discharge current. (a,b – the Aksenov-type filters with respectively high and low curvature radius, c – the T-type magnetic filter).

Efficiency of macro-droplets filtering

Surfaces of thin niobium layer obtained after filtering in considered filters in magnification of 500.

The Aksenov-type with big curvature radius.

The Aksenov-type with small curvature radius.



The T-type

Summary

- Three different prototypes of the magnetic filters for the UHV requirements were designed and made at the IPJ; two filters are of the Aksenov-type, but they have different curvature radius, and the third filter is the so-called T-type.
- After discussion two of considered three magnetic filters have been selected for further study and improvements: the Aksenov-type with less curvature radius and the T-type.

- Plans for the future:
  - 3D simulations of magnetic field distributions,
  - positive biasing of the filters – to improve ions transport,
  - set of fins and baffles - to improve micro-droplets filtering,
  - additional coil in the T-type filter – for better magnetic field bending.

Thank you for attention

and

Have a nice meal