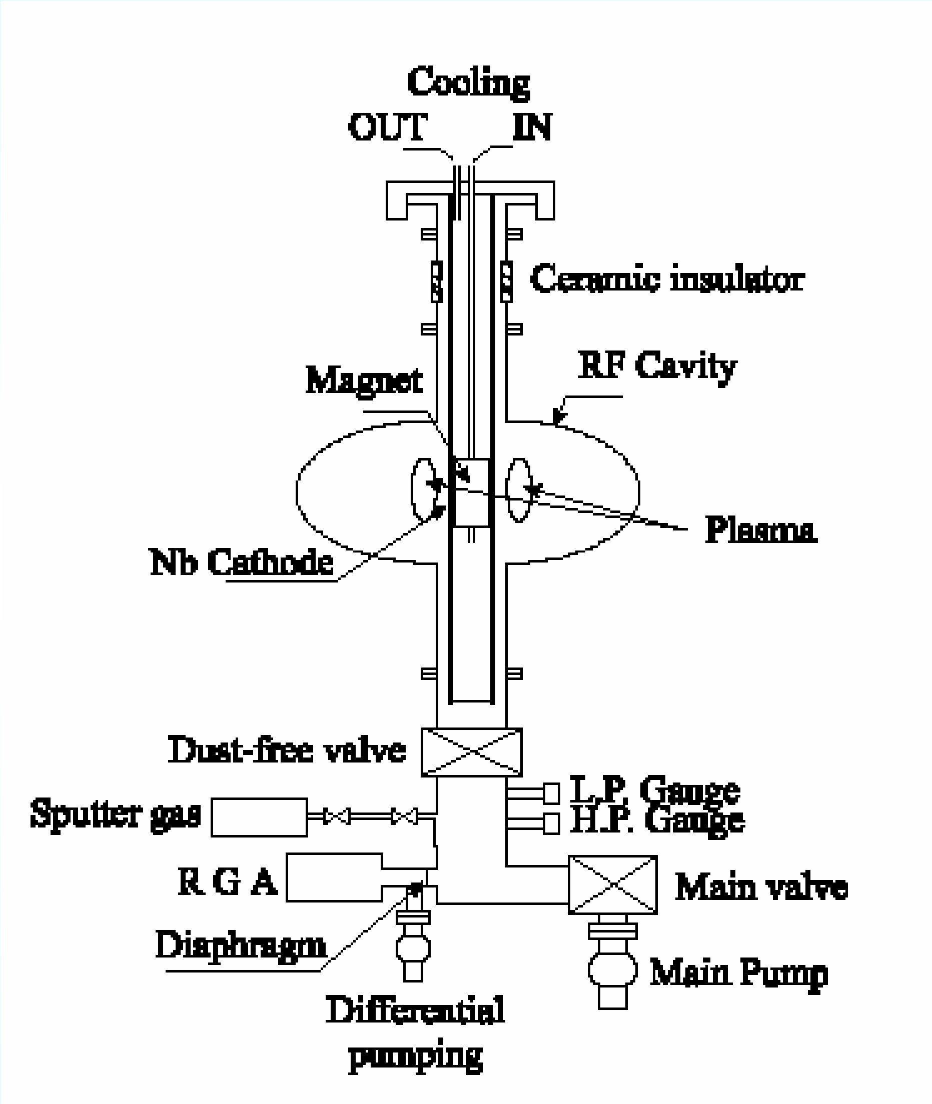
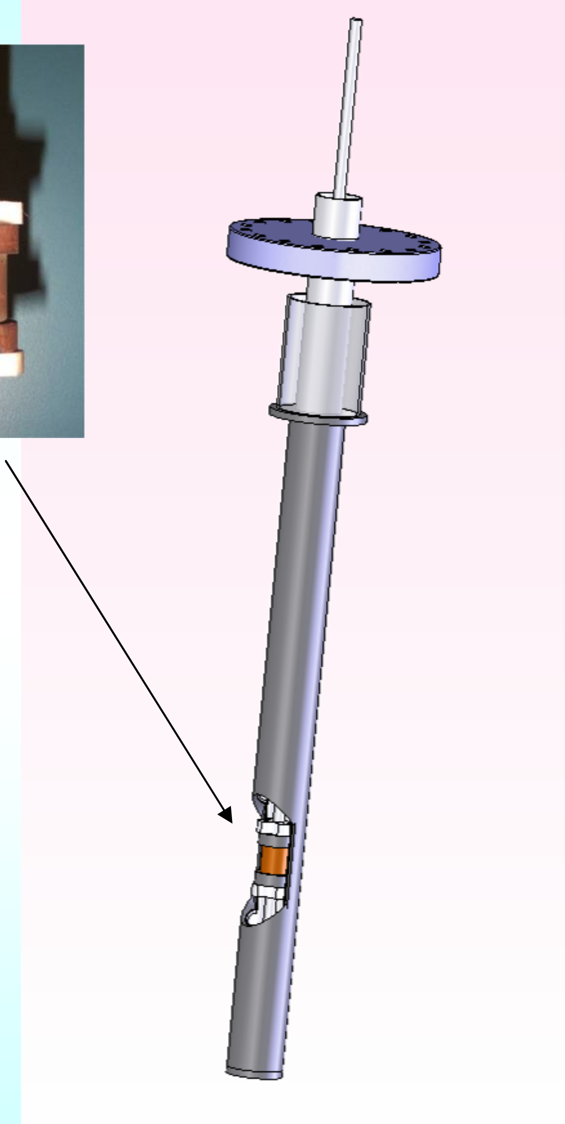
12th International Workshop on RF Superconductivity

New Magnetron configurations for sputtered Nb onto Cu

A.Frigo, G.Lanza, H.Padamsee, V.Palmieri, D.Tonini

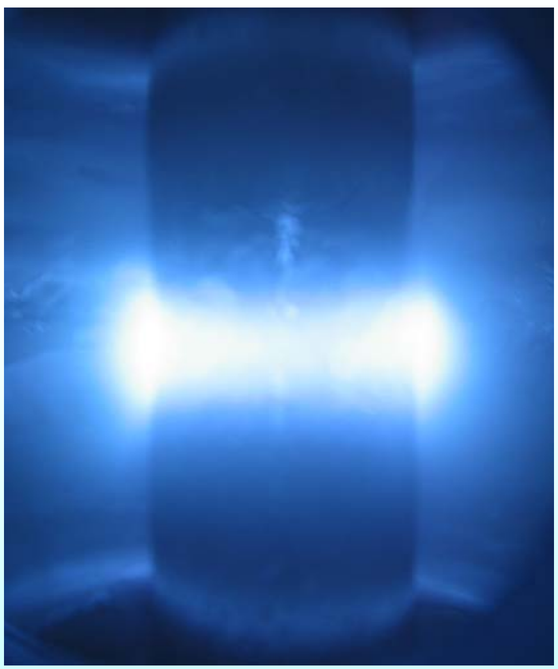
CERN geometry

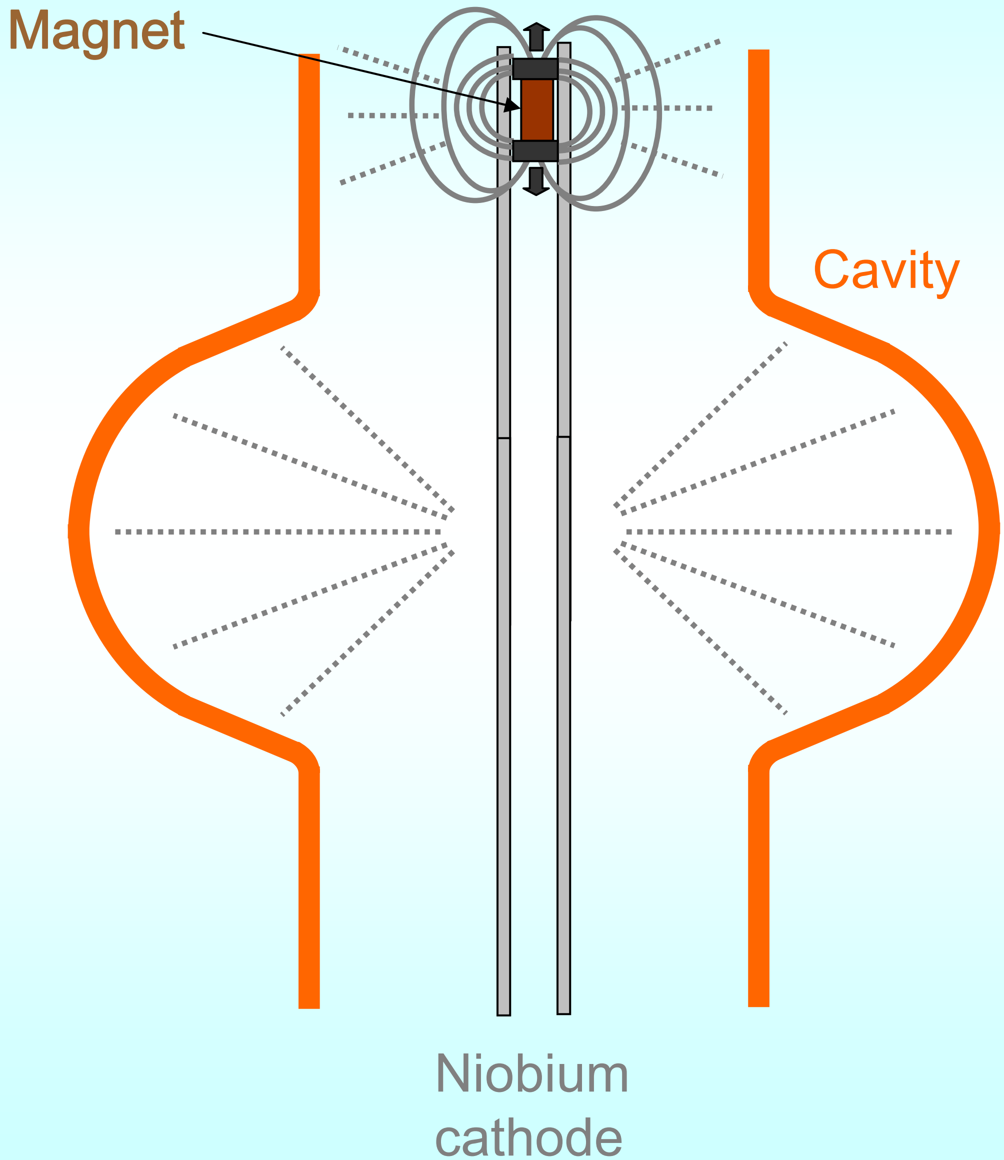




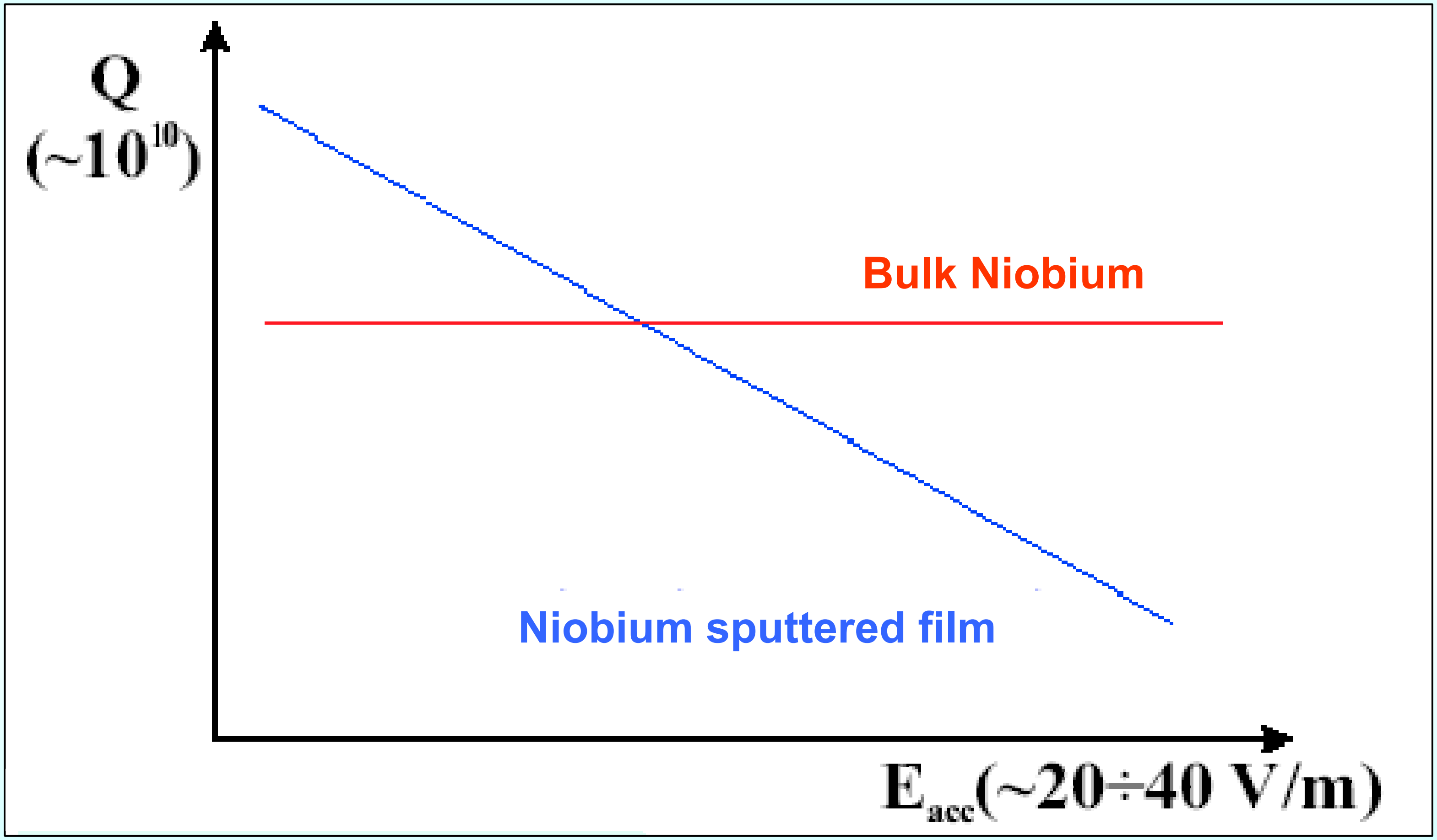
C. Benvenuti, S. Calatroni, I.E. Campisi, P. Darriulat, M.A. Peck, R. Russo, A.-M. Valente, "*Study of the surface resistance of superconducting niobium films at 1.5 GHz*", Physica C 316 (1999) 153-188.

Cylindrical Magnetron

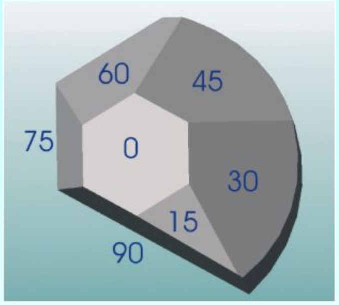


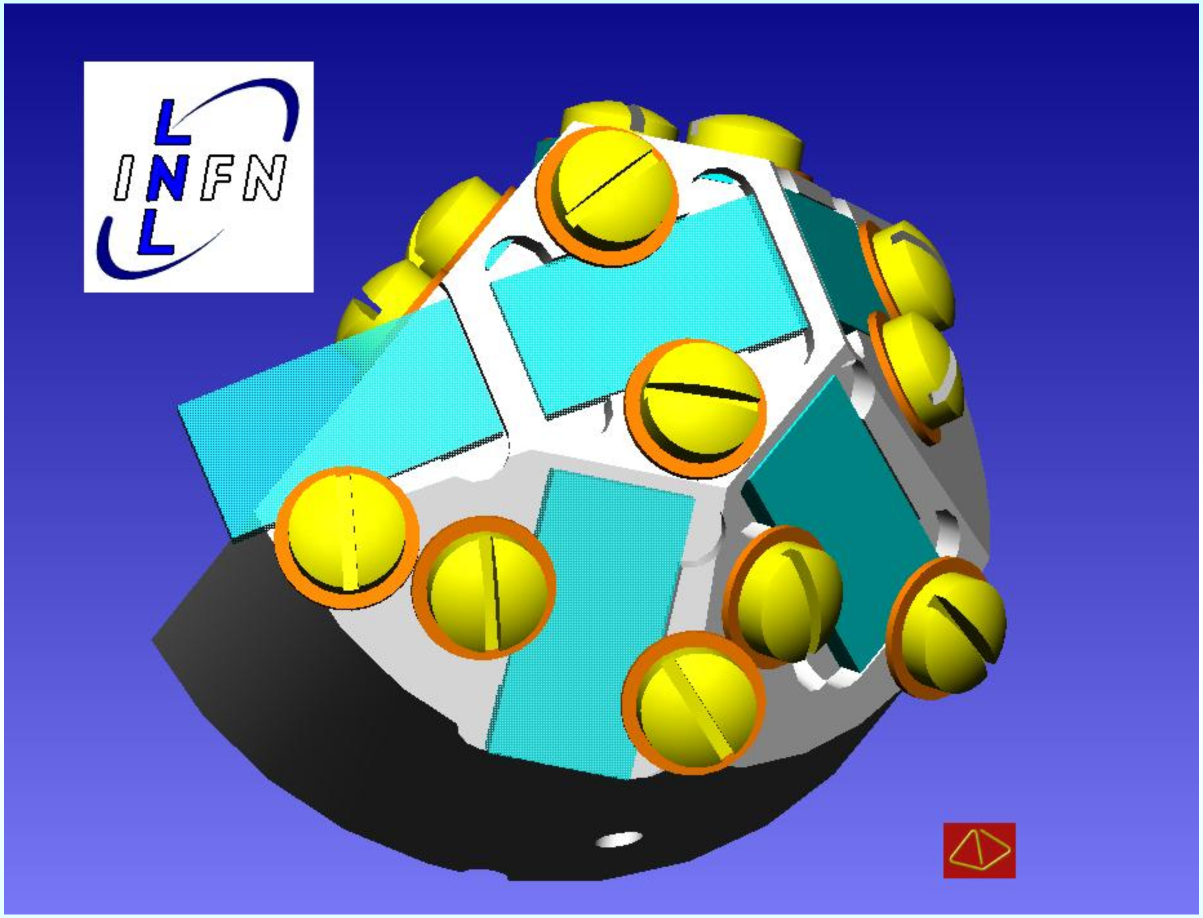


Q-slope problem



The INFN-LNL hypothesis

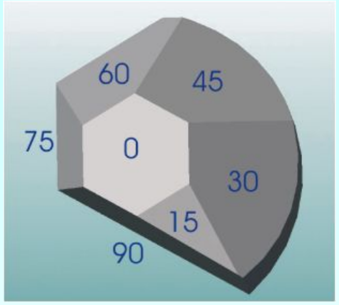


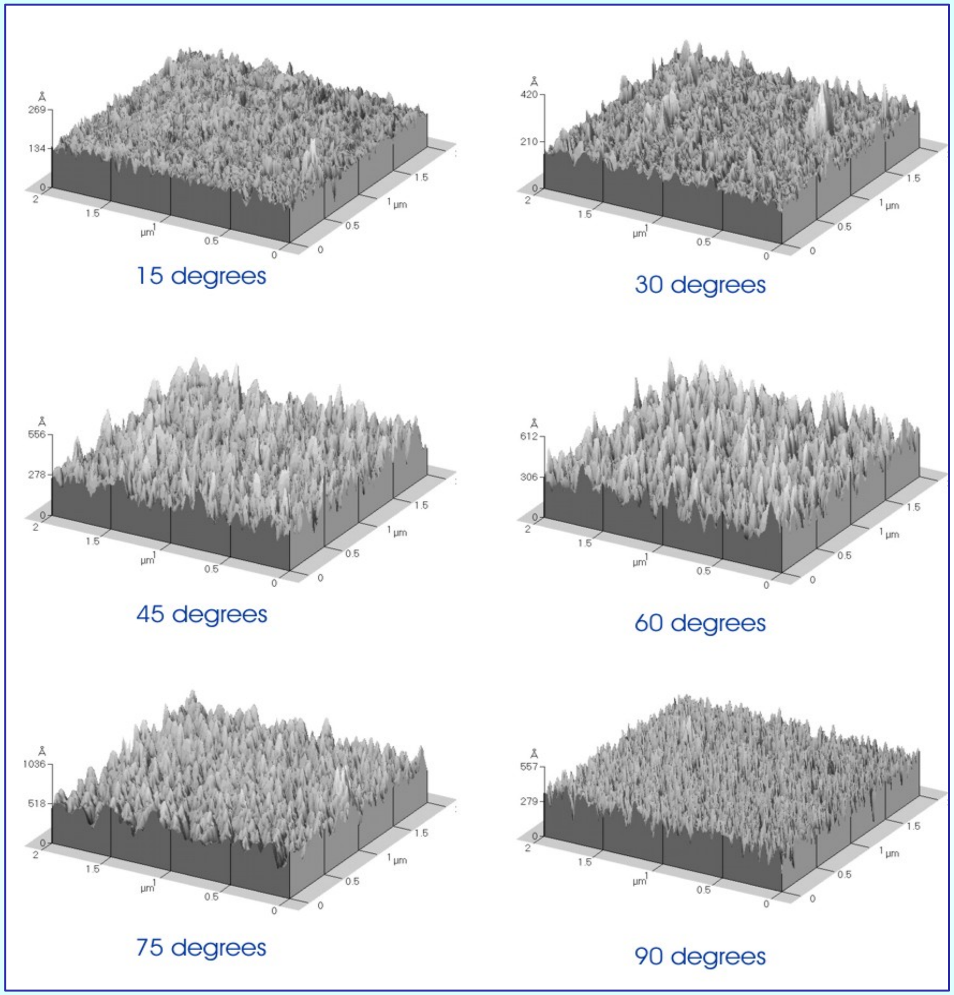


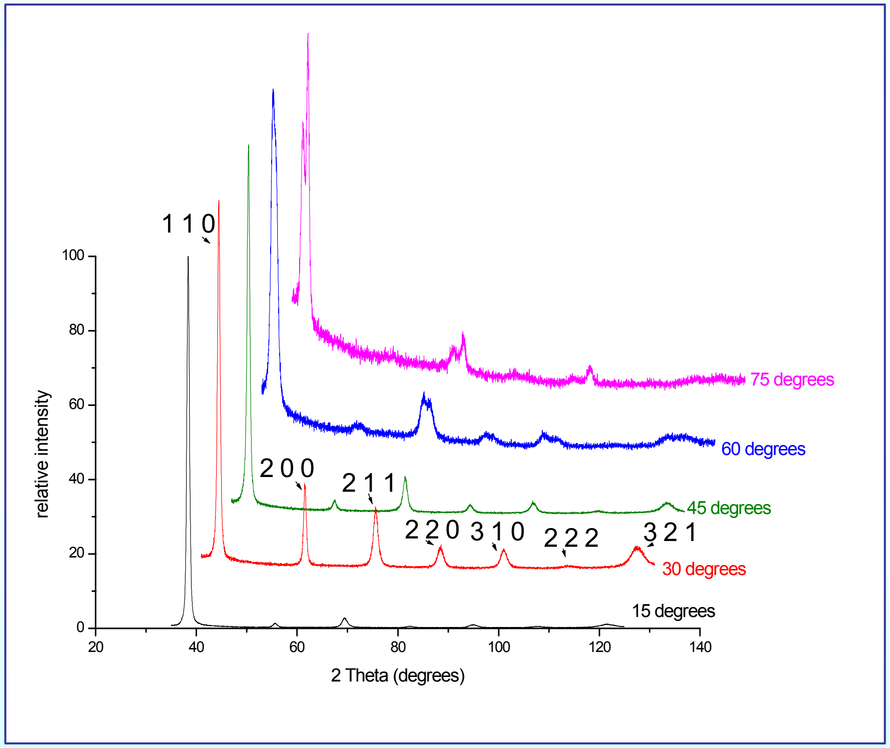
Sputtering at different target-substrate angle

Diploma thesis "*Morphology of Niobium Films Sputtered at Different Target-substrate Angles*" Diego Tonini, LNL-INFN, Material Science, Padova University.

At different target-substrate angle





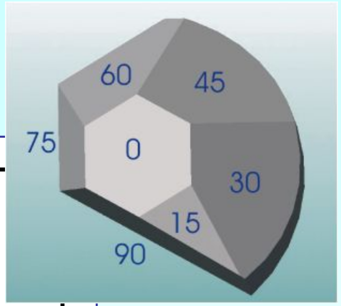


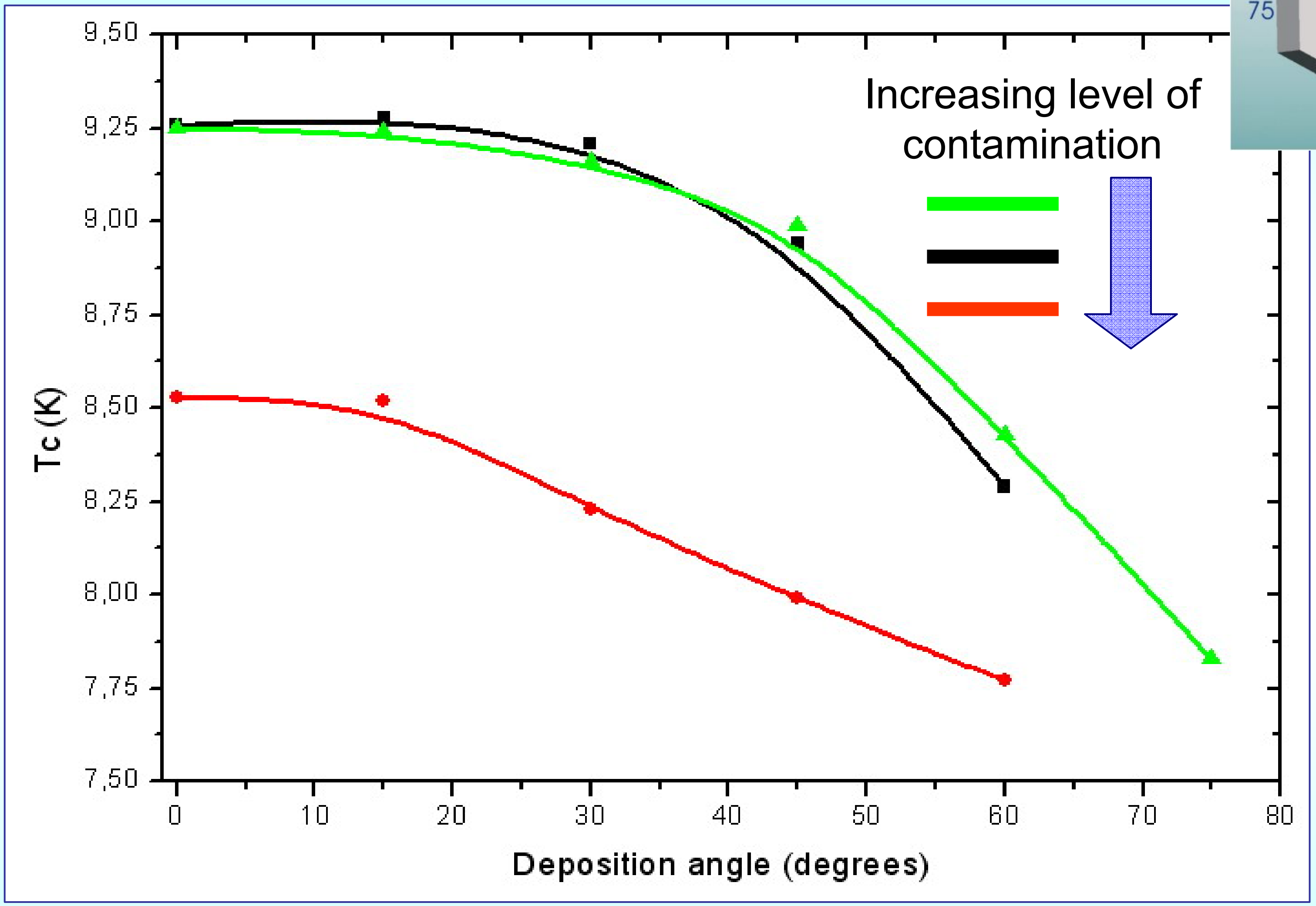
AFM Roughness images

XRD spectras

Diploma thesis "*Morphology of Niobium Films Sputtered at Different Target-substrate Angles*" Diego Tonini, LNL-INFN, Material Science, Padova University.

At different target-substrate angle

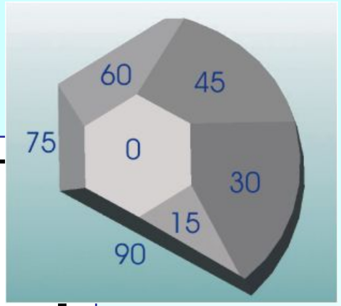


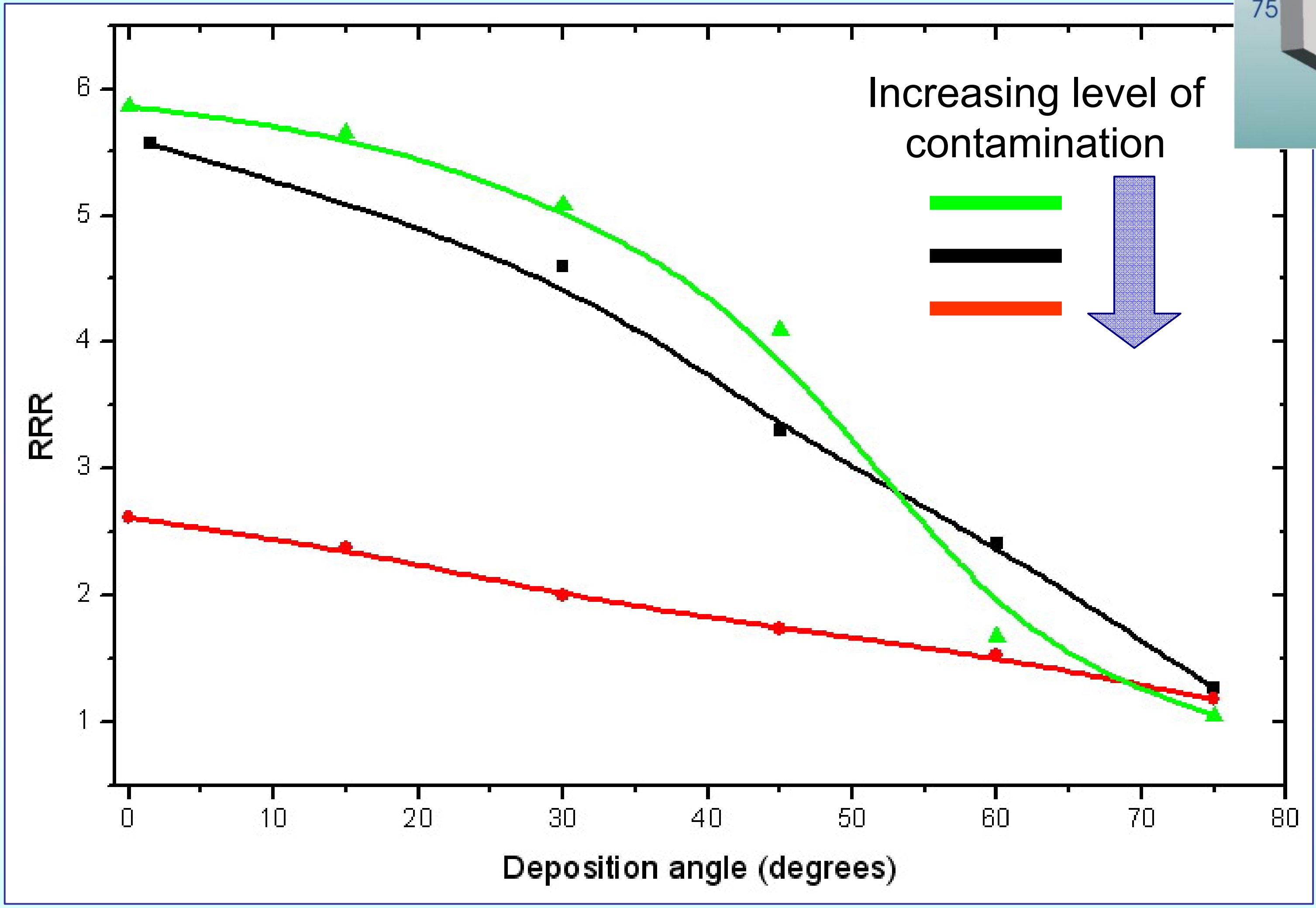


Superconducting properties

Diploma thesis "*Morphology of Niobium Films Sputtered at Different Target-substrate Angles*" Diego Tonini, LNL-INFN, Material Science, Padova University.

At different target-substrate angle

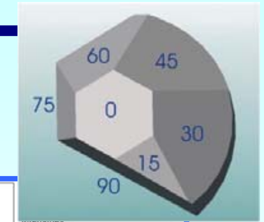




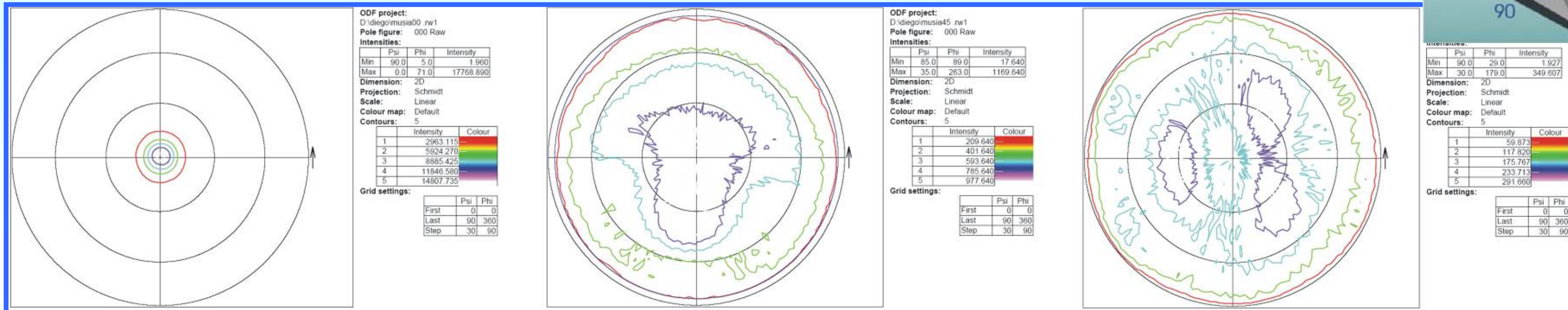
Electrical properties

Diploma thesis "*Morphology of Niobium Films Sputtered at Different Target-substrate Angles*" Diego Tonini, LNL-INFN, Material Science, Padova University.

Comparing **Sputtering** and **Cathodic Arc**

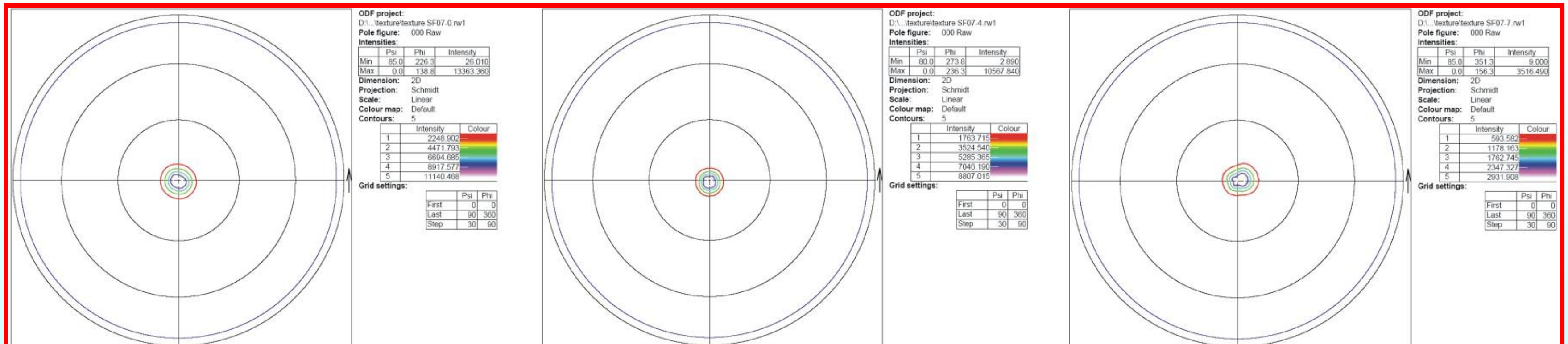


Sputtered films grow along the normal to 110 crystal planes according to the atom arrival direction



0 degrees | 45 degrees | 75 degrees

By cathodic arc, the substrate is biased; so ions always reach the substrate perpendicularly: <u>NO TEXTURE vs target-substrate angle</u>



0 degrees | 45 degrees | 75 degrees

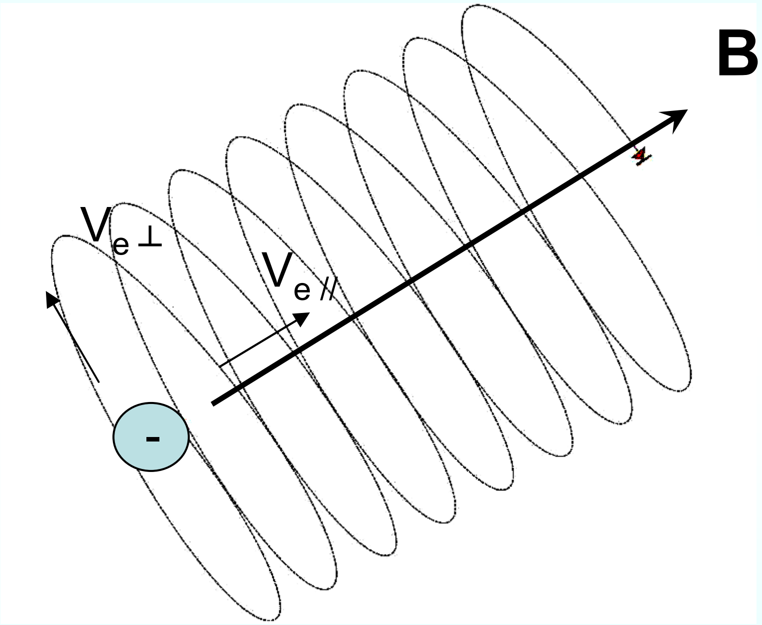
G. Keppel, V. Palmieri, N. Patron, D. Tonini, LNL-INFN

Understanding:

- Film morphology strictly correlated to the deposition angle
- Electrical and superconducting film properties degrade vs deposition angle

- Comprehension of sputtering principles is compulsory for conceiving new magnetron configurations

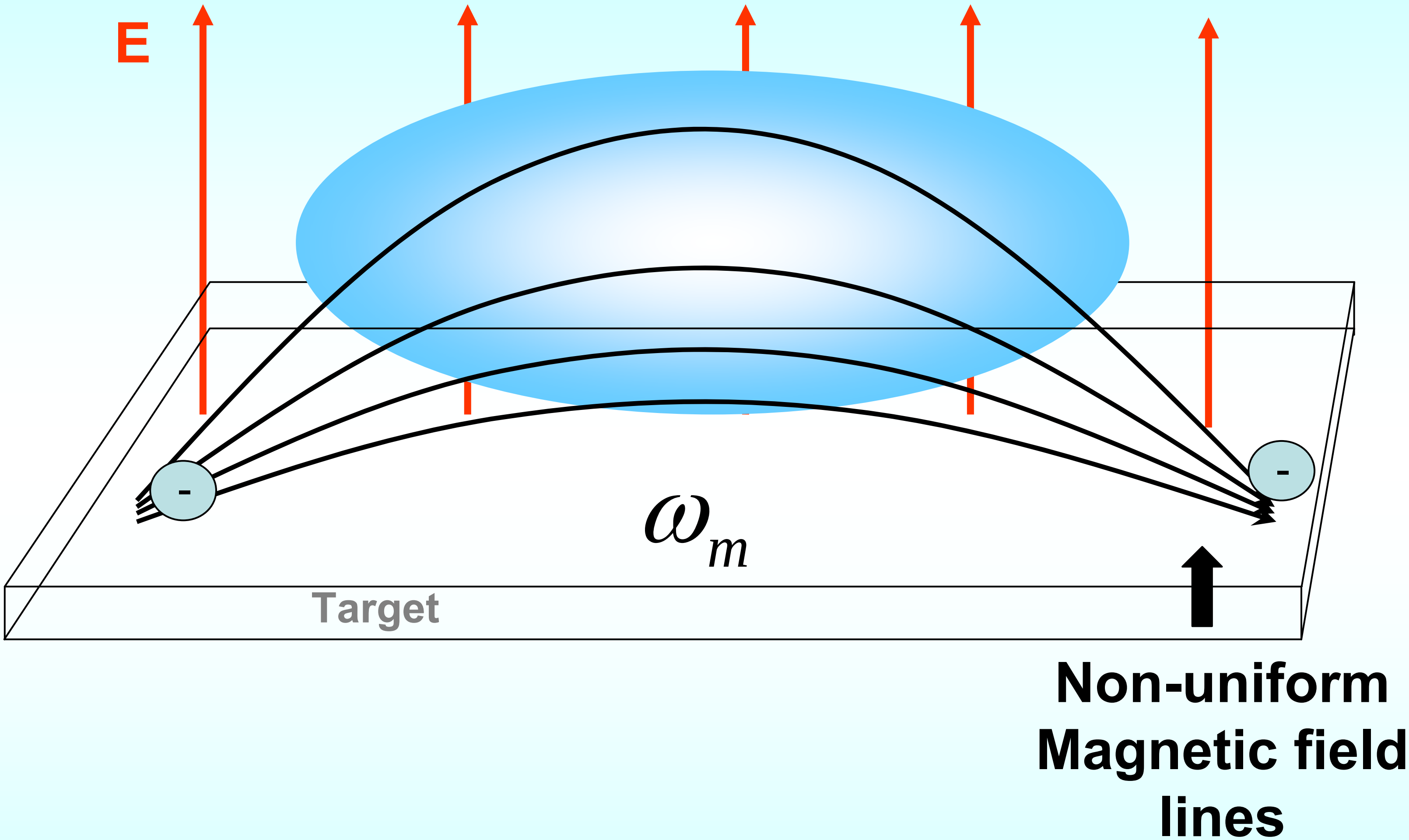
Deposition technique: magnetron sputtering



Uniform magnetic field lines

$$\omega_c \propto B$$

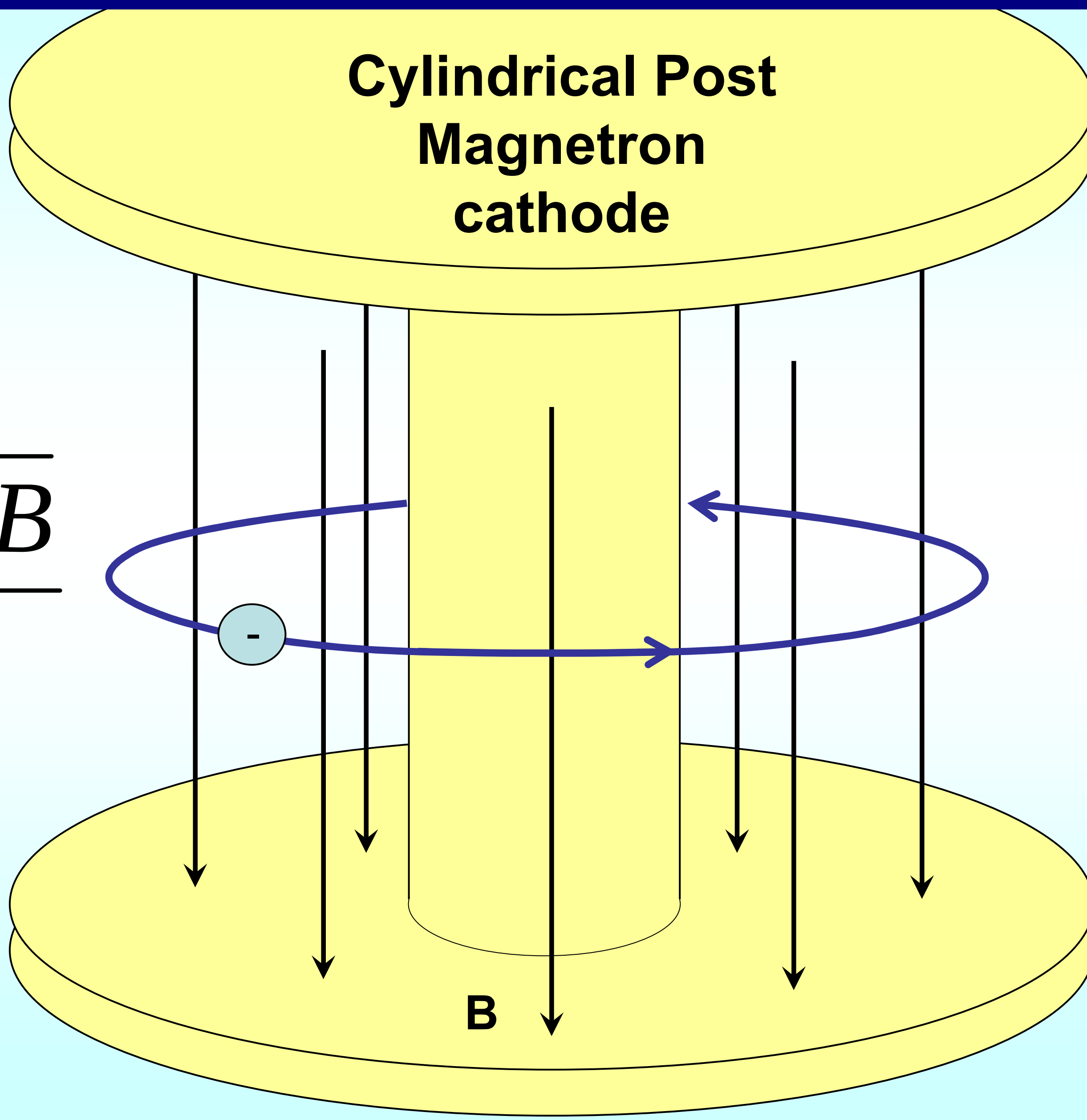
Deposition technique: magnetron sputtering



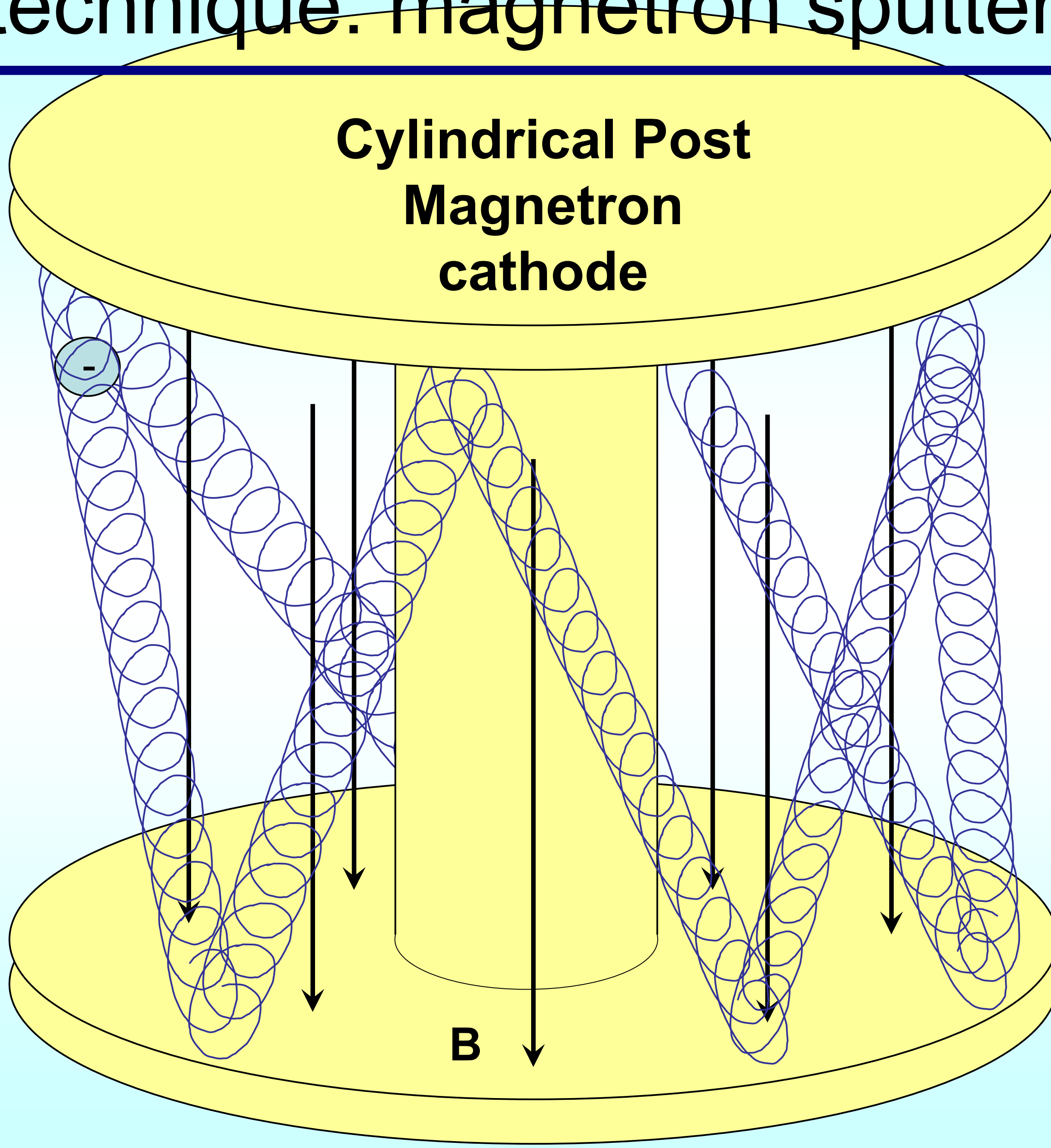
• Electron reflection is due to magnetostatic and electrostatic mirror

Deposition technique: magnetron sputtering

$$\omega_D \propto \frac{\overline{E} \times \overline{B}}{B^2}$$



Deposition technique: magnetron sputtering



If

E ⊥ B

Higher ionisation efficiency

Ideas to improve the film quality:

1. Increasing the sputtering rate R

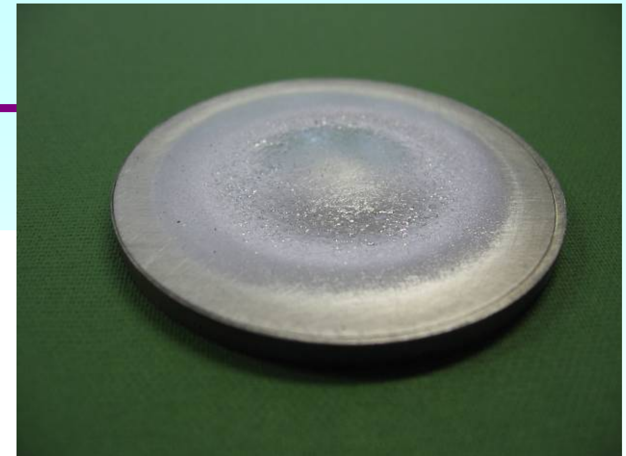
$$f_i = \frac{N_i \alpha_i}{N_i \alpha_i + R}$$

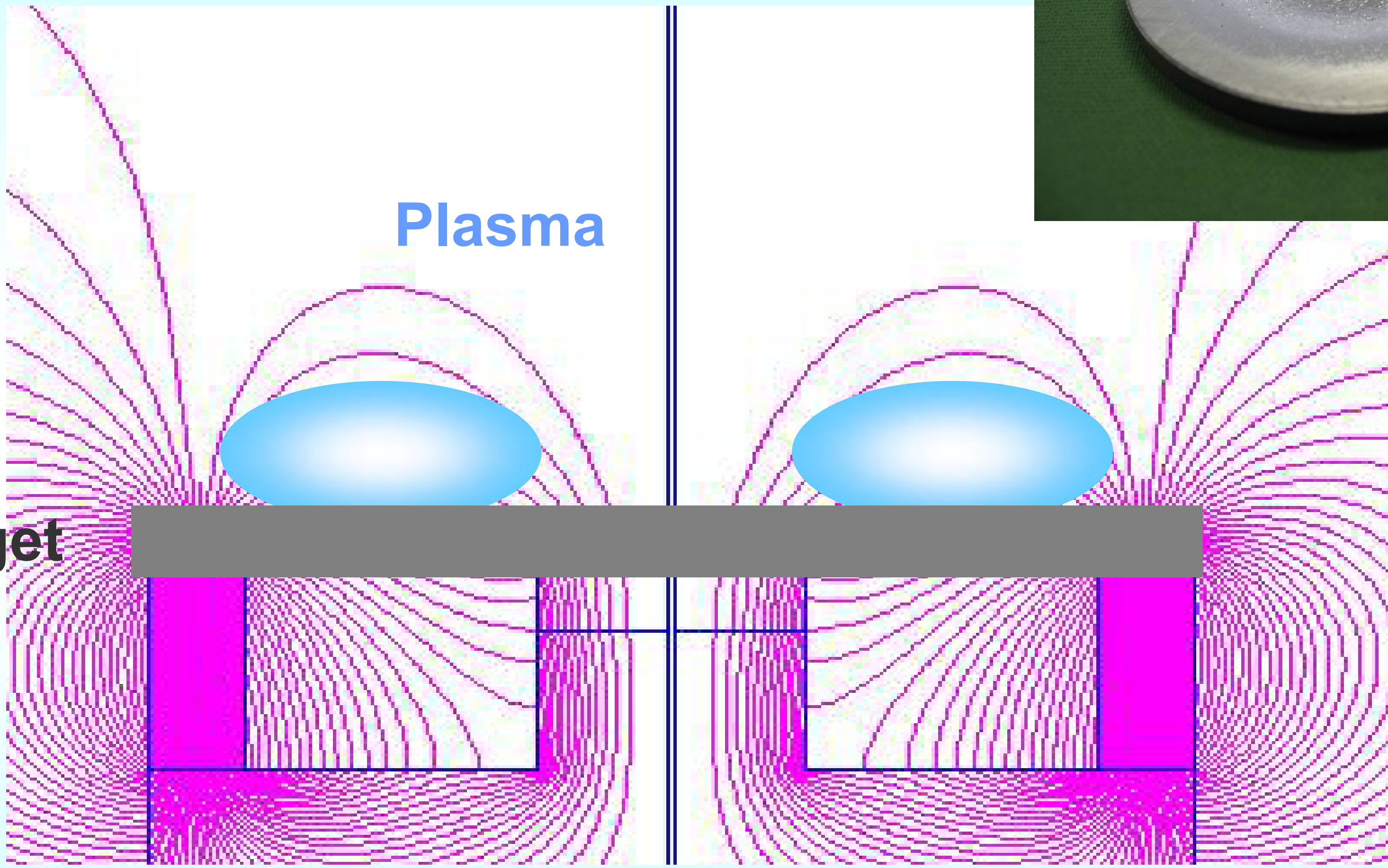
f_i **=** Fraction of impurities trapped into the film

α_i **=** Impurities sticking coefficient

N_i **=** Number of atoms impurities arriving on the film surface

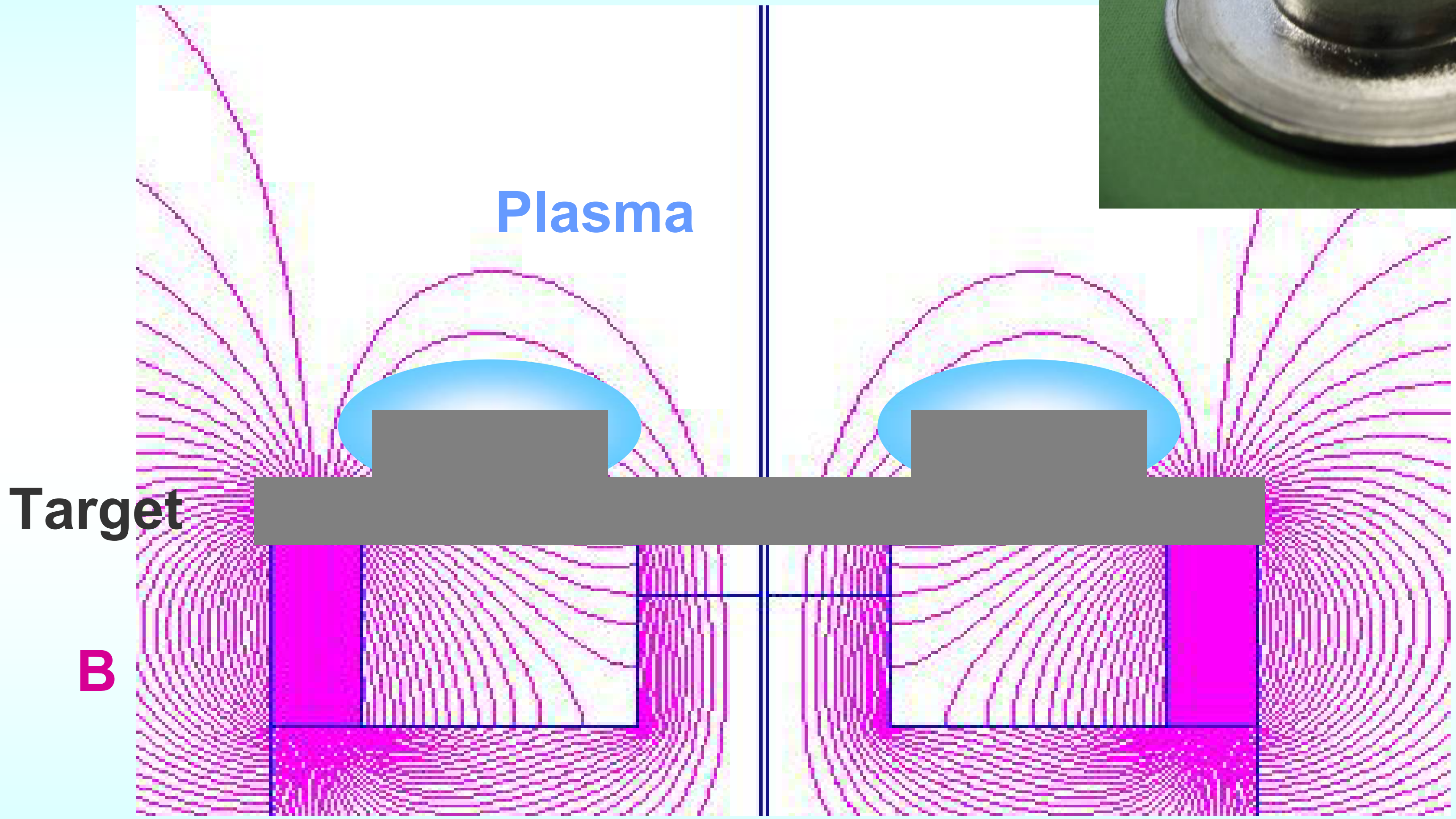
Target shape





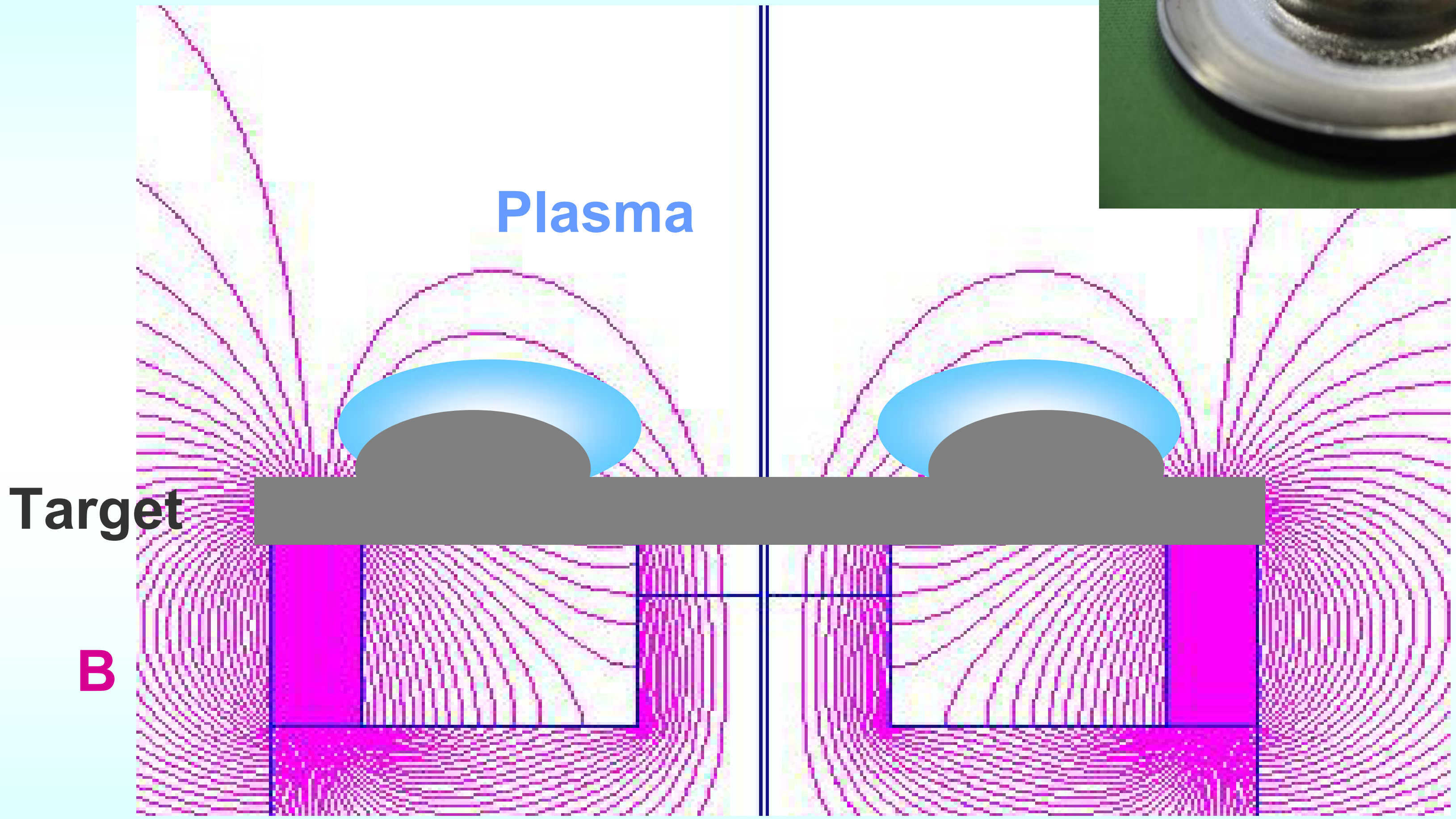
2 inches planar target

Target shape



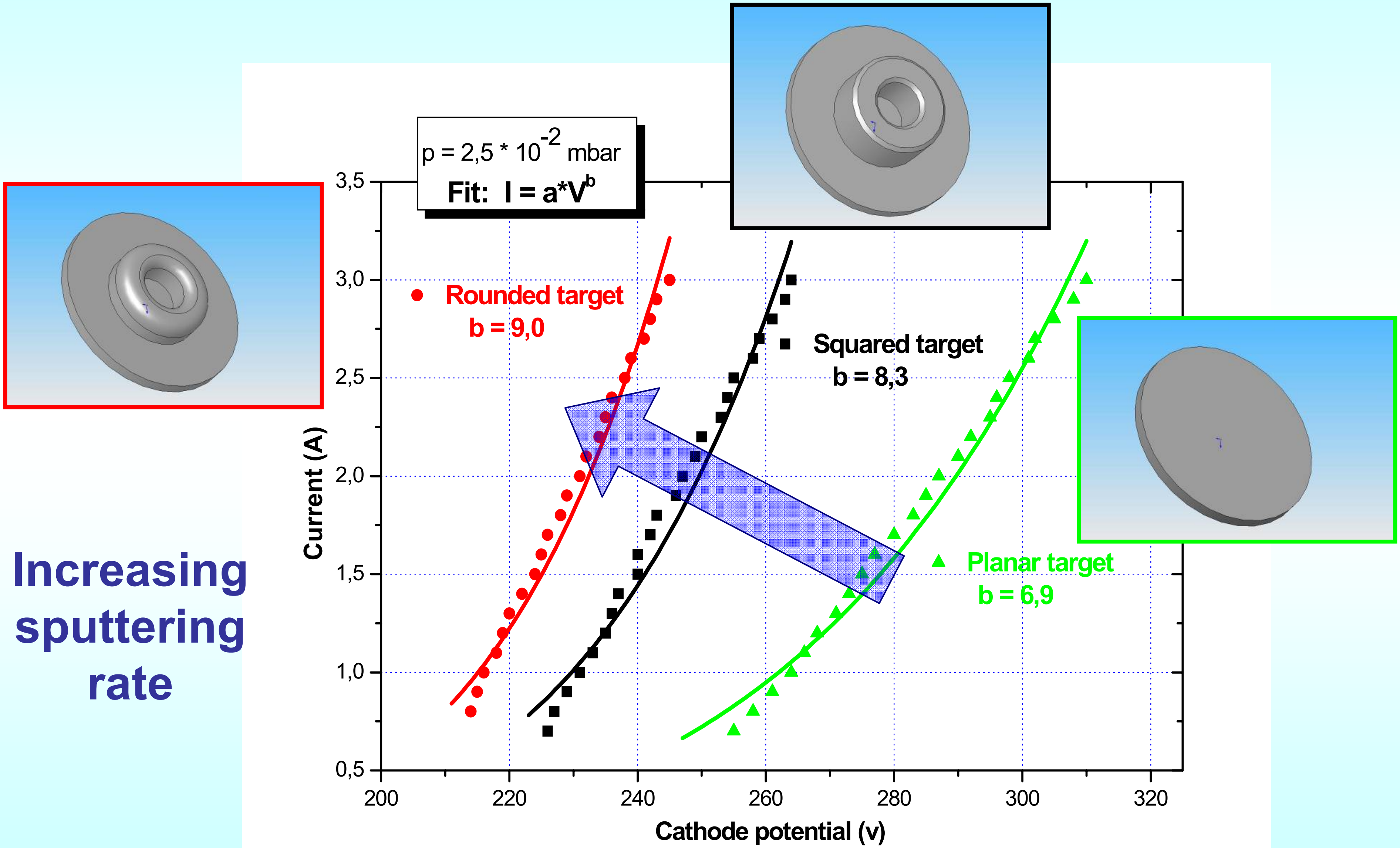
2 inches squared target

Target shape



2 inches rounded target

Cathode shape modification



Increasing sputtering rate

Ideas to improve the film quality:

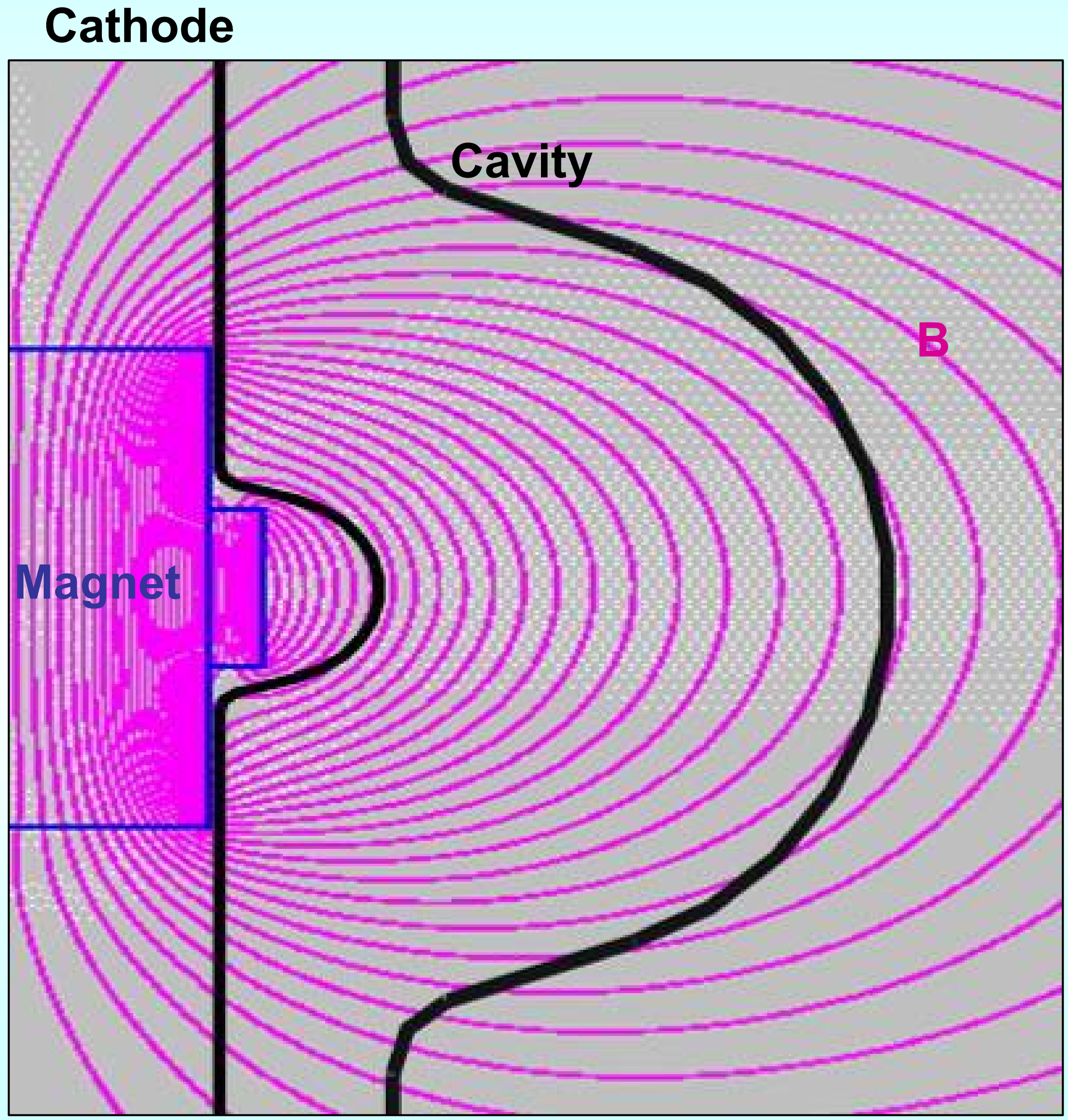
1. **Increasing the sputtering rate R**

2. **Reducing the deposition angle**

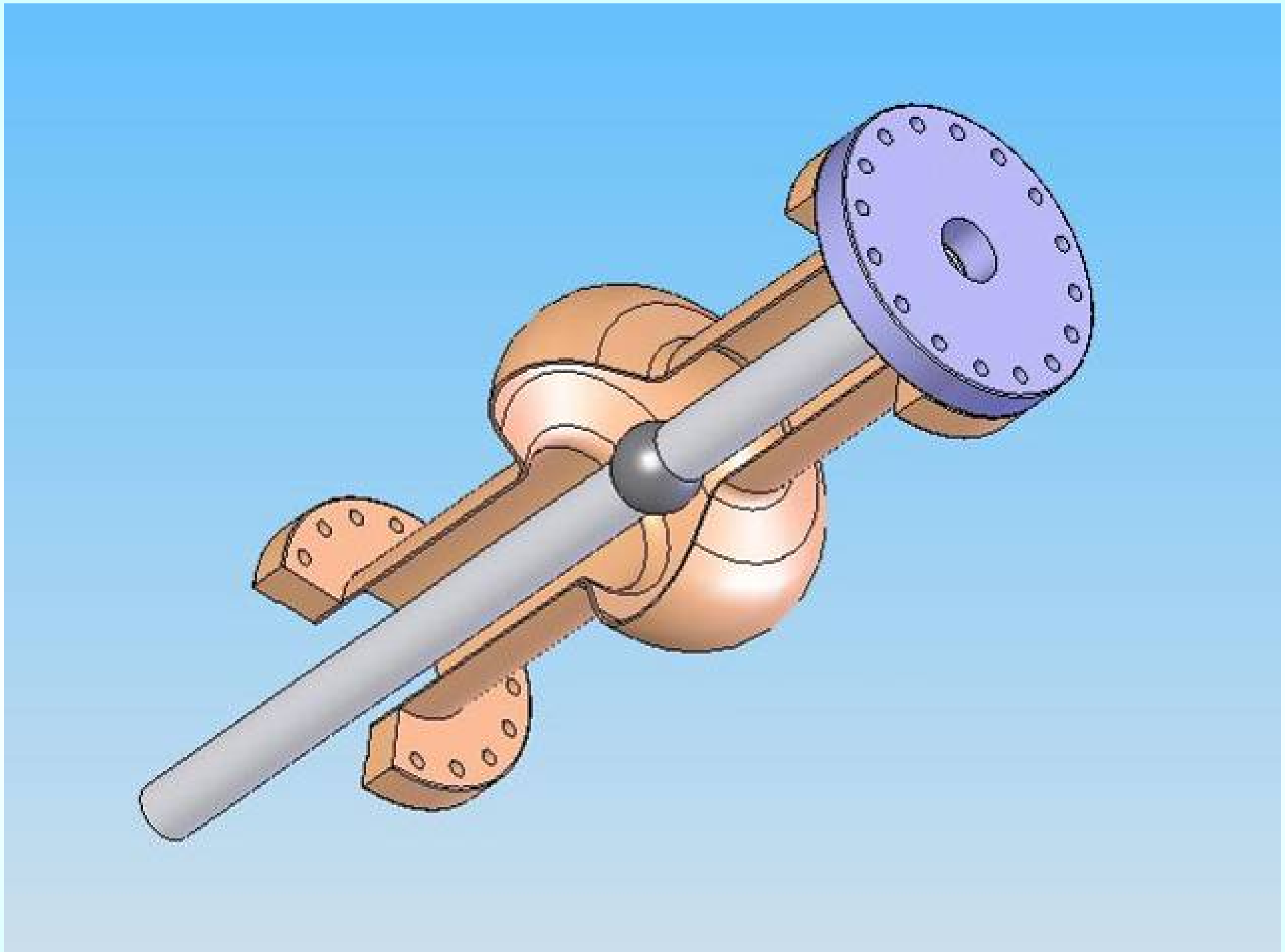
Cathode shape modification

- $B \perp E$
- B // cathode surface

Higher deposition rate

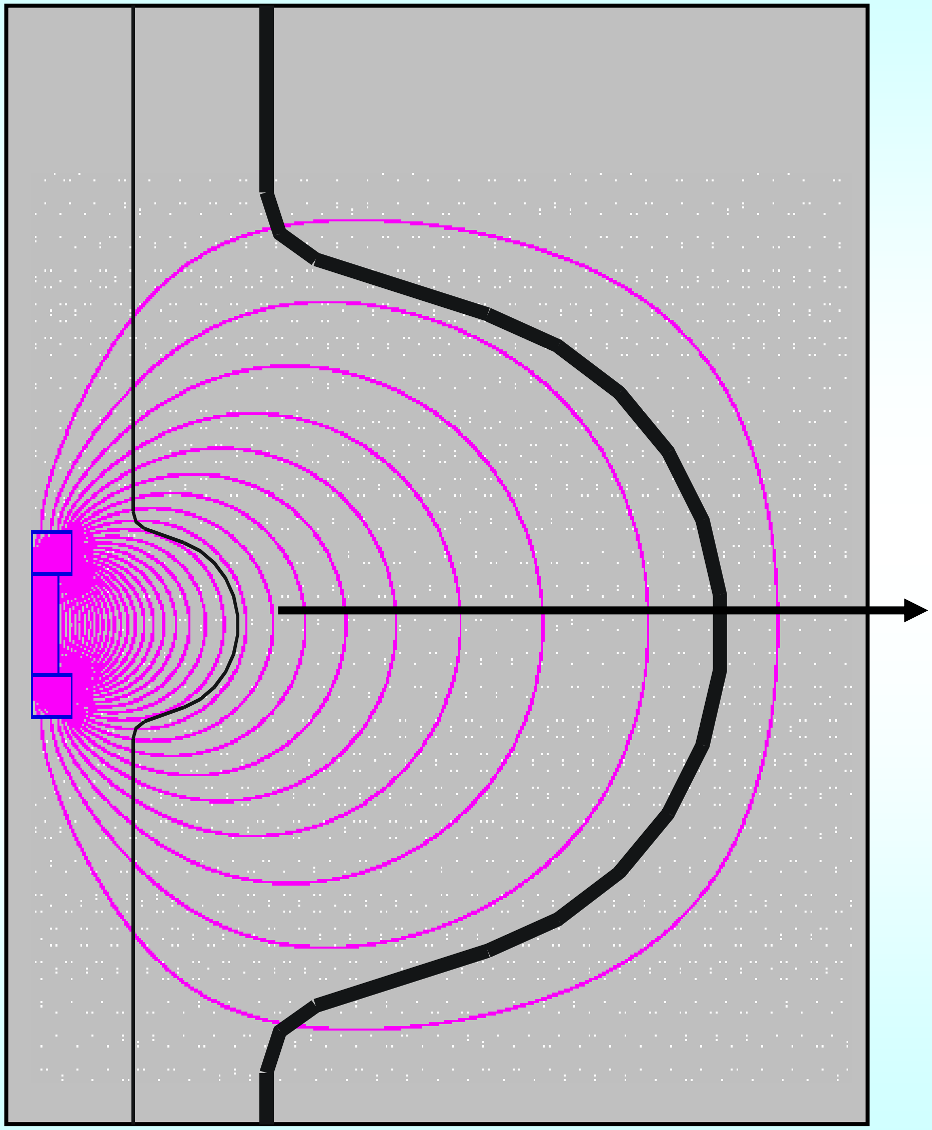


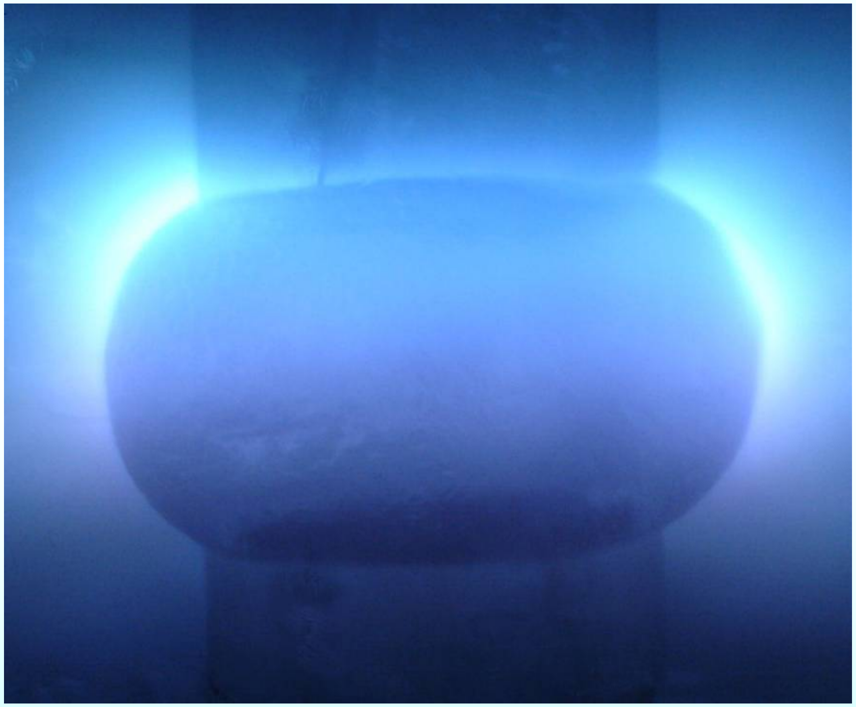
Cathode shape modification



Niobium ring positioned in the cell center

Cathode shape modification





Ideas to improve the film quality:

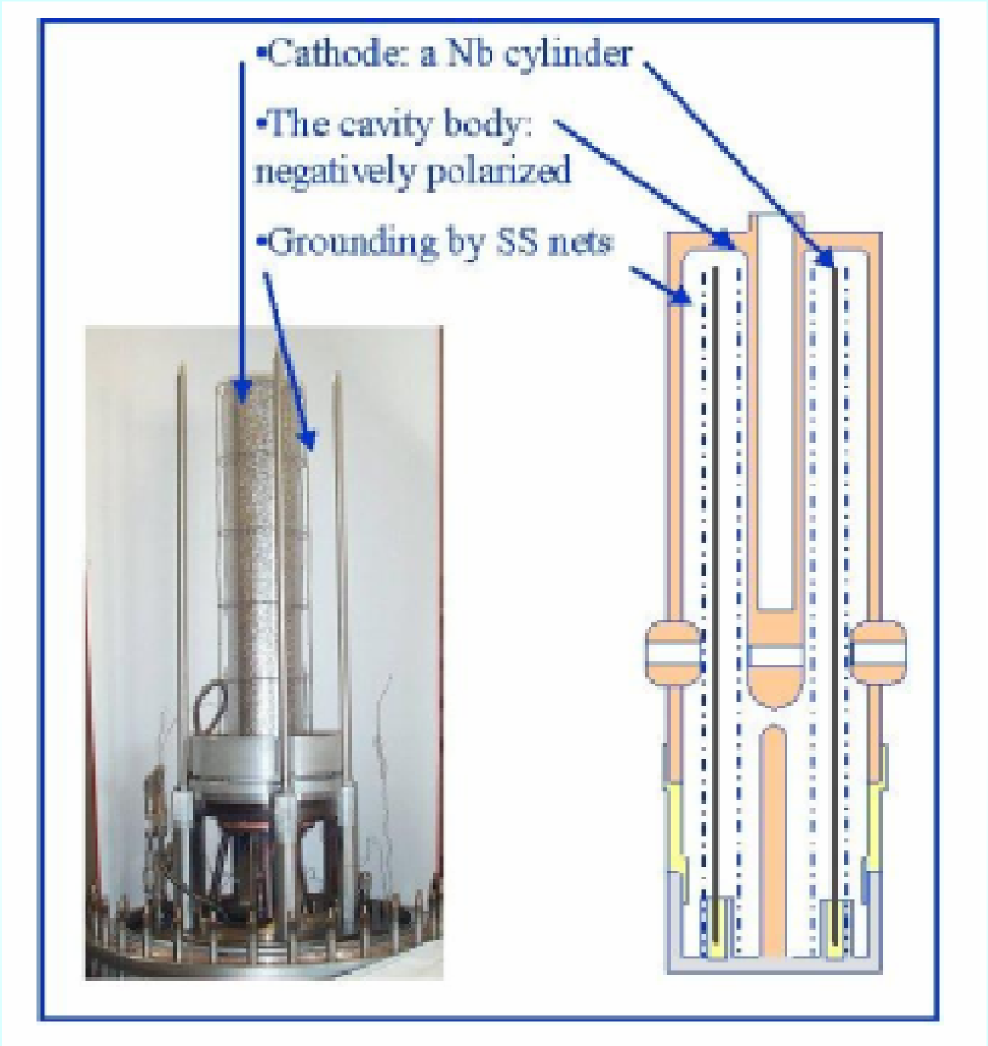
1. **Increasing the sputtering rate R**
2. **Reducing the deposition angle**
3. **Promoting atoms rearrangement and impurities re-sputtering during film growing**

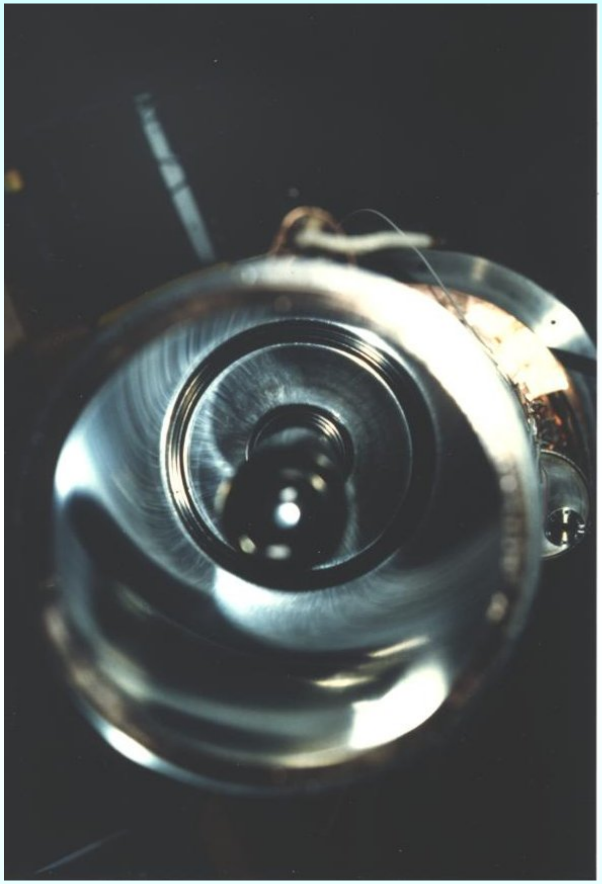
$$f_i = \frac{\left(N_i \alpha_i - \beta\right)}{\left(N_i \alpha_i - \beta\right) + R}$$

f_i = fraction of impurities trapped into the film

α_i = impurities sticking coefficient
N_i = atoms impurities arriving on the film
β = function of the bias current due to impurities ions
R = sputtering rate

Biased Diode Sputtering

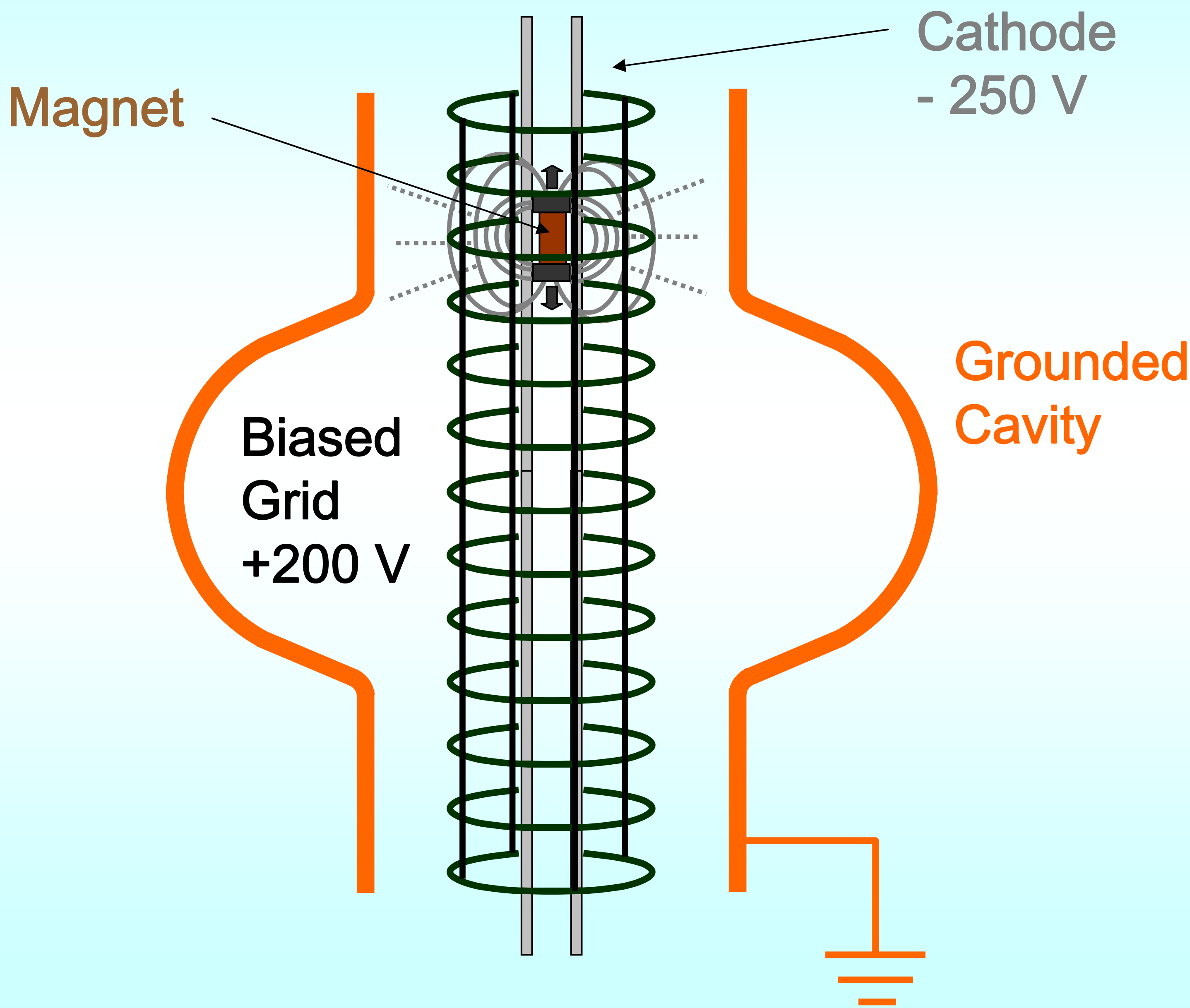




Bias LNL
Up to now

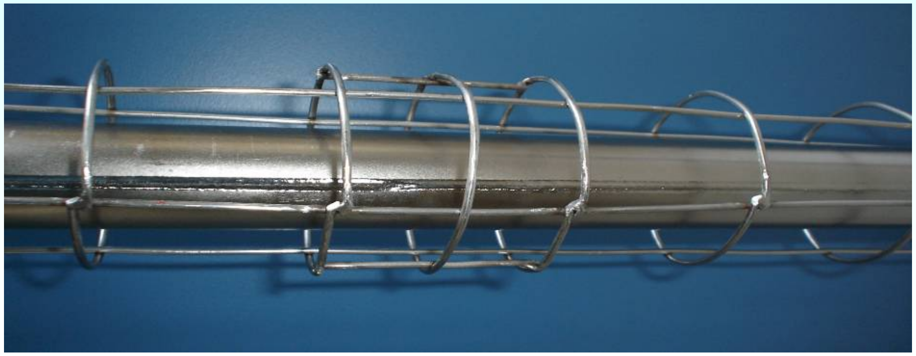
The bias technique is highly reliable: over 40 QWRs are installed and working at LNL

Biased Magnetron Sputtering

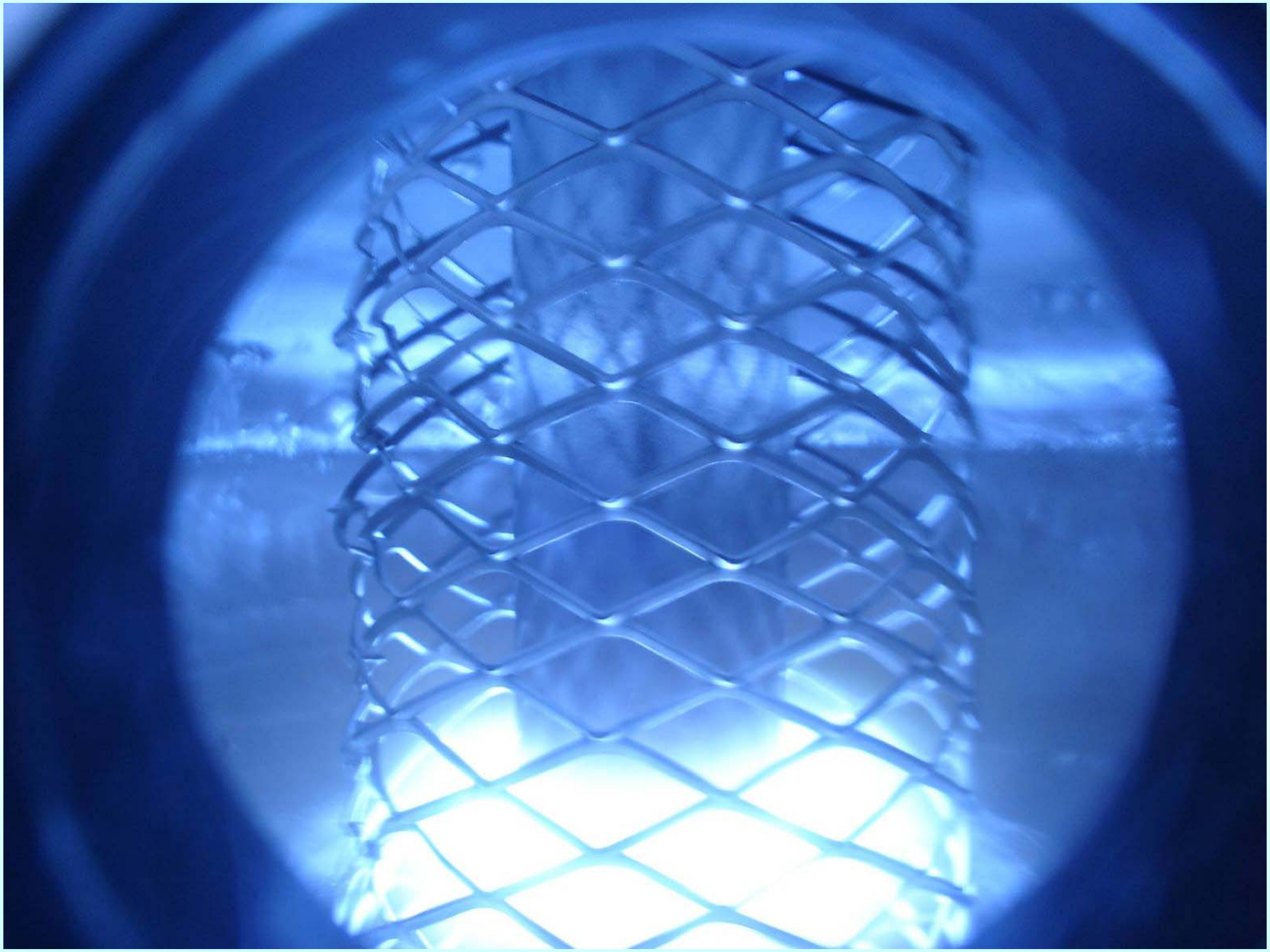


Biased Magnetron Sputtering

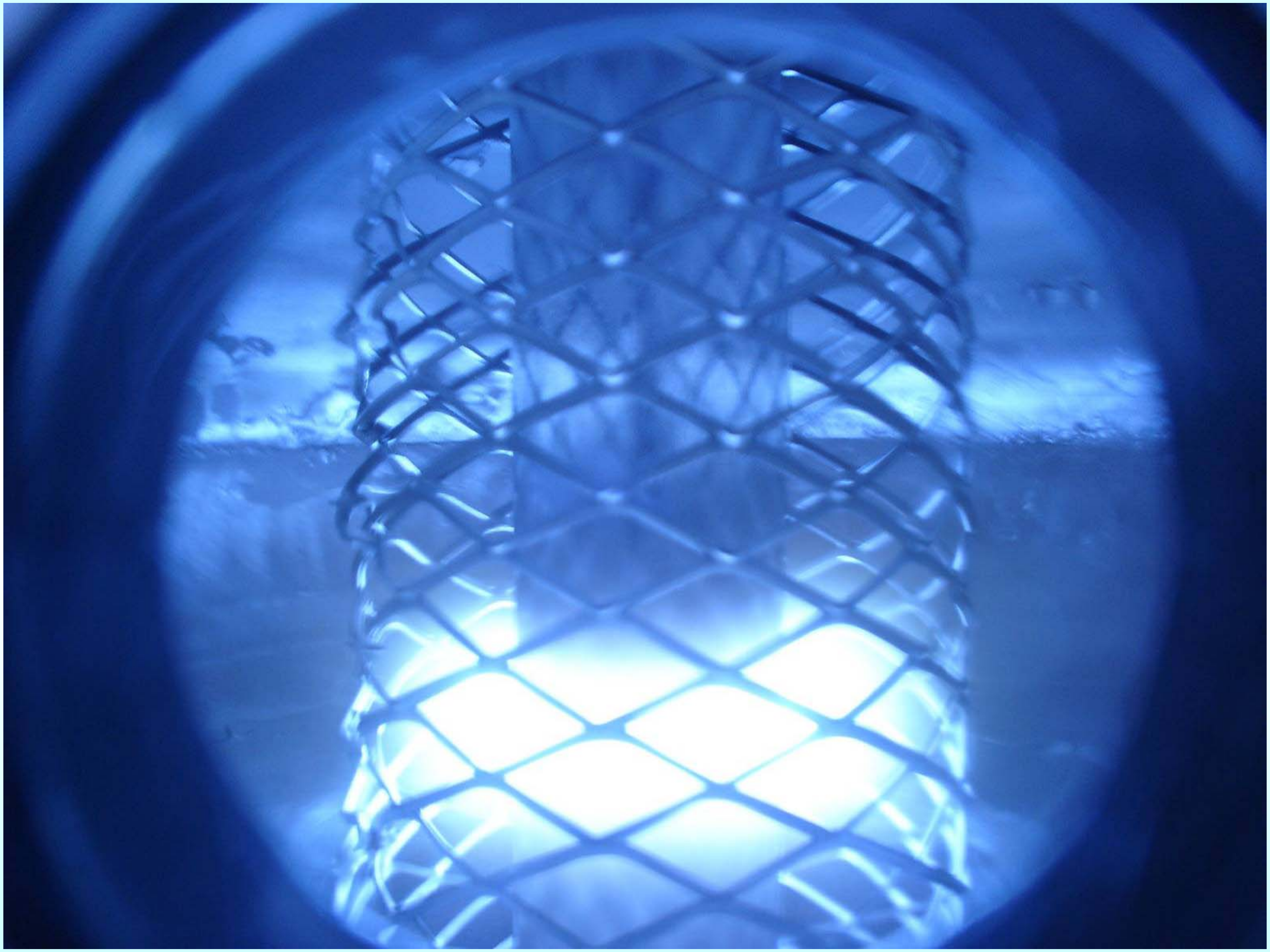
Biased grid



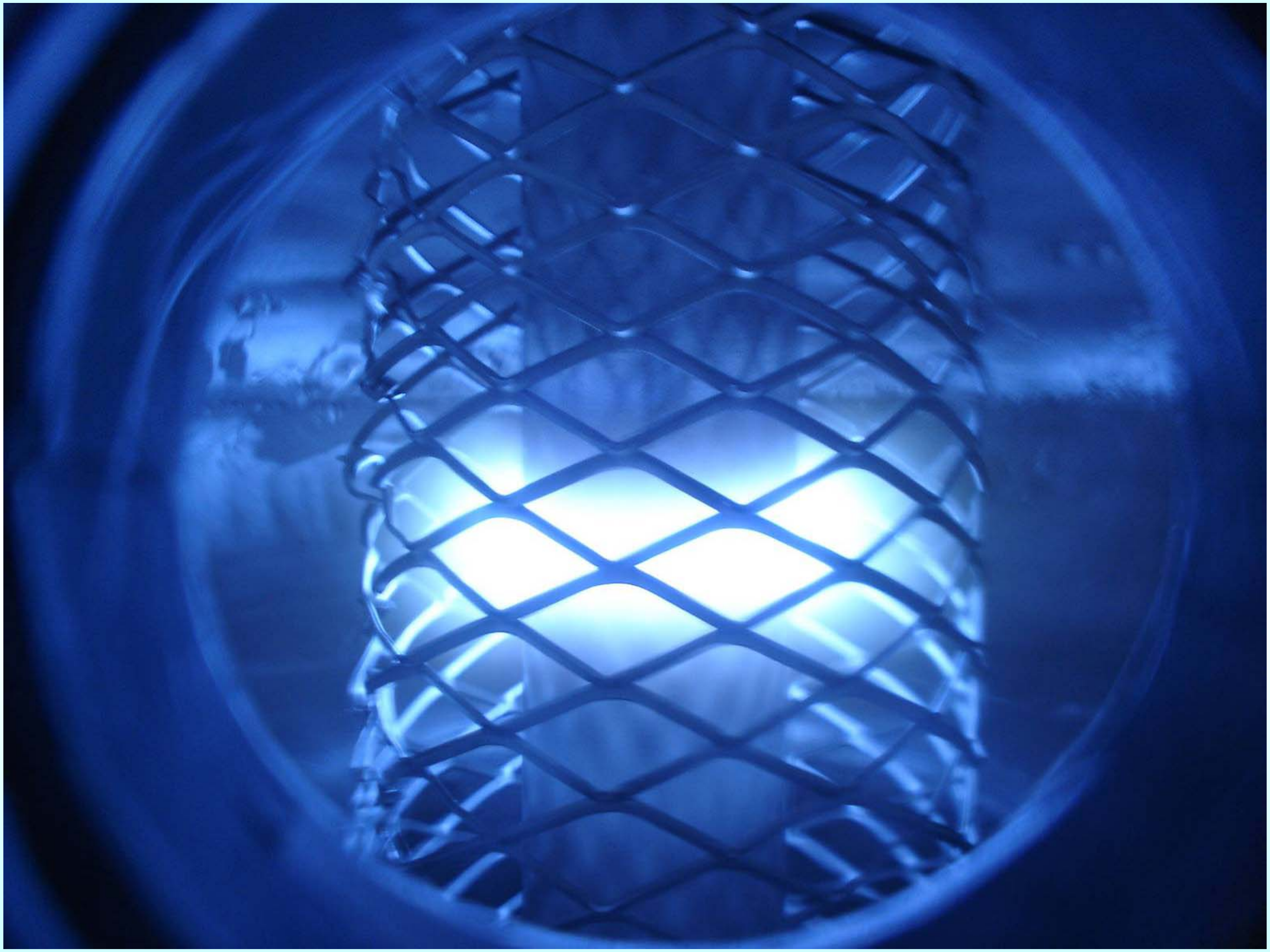
Biased Magnetron Sputtering



Biased Magnetron Sputtering



Biased Magnetron Sputtering



Biased Magnetron Sputtering

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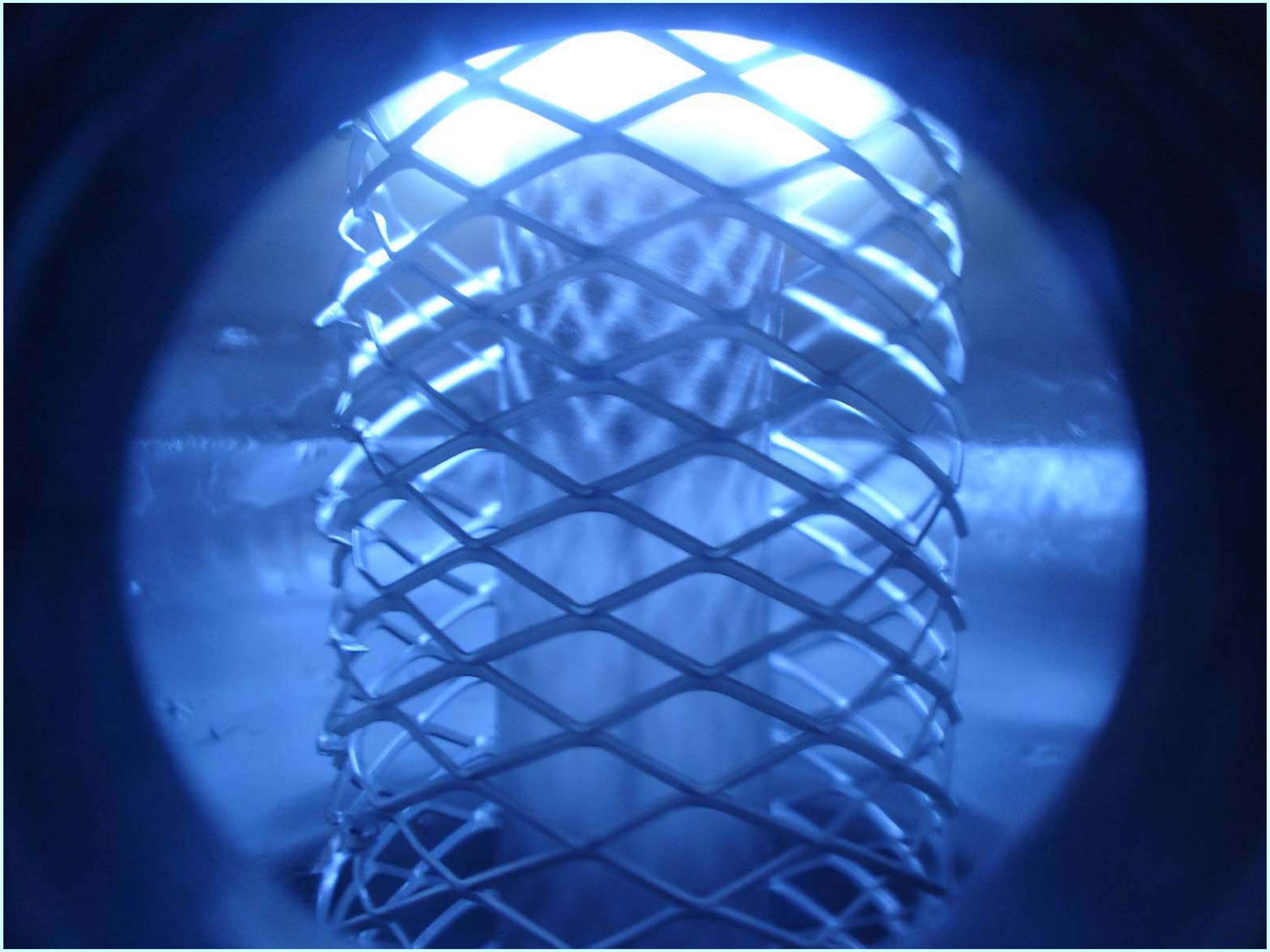


Ideas to improve the film quality:

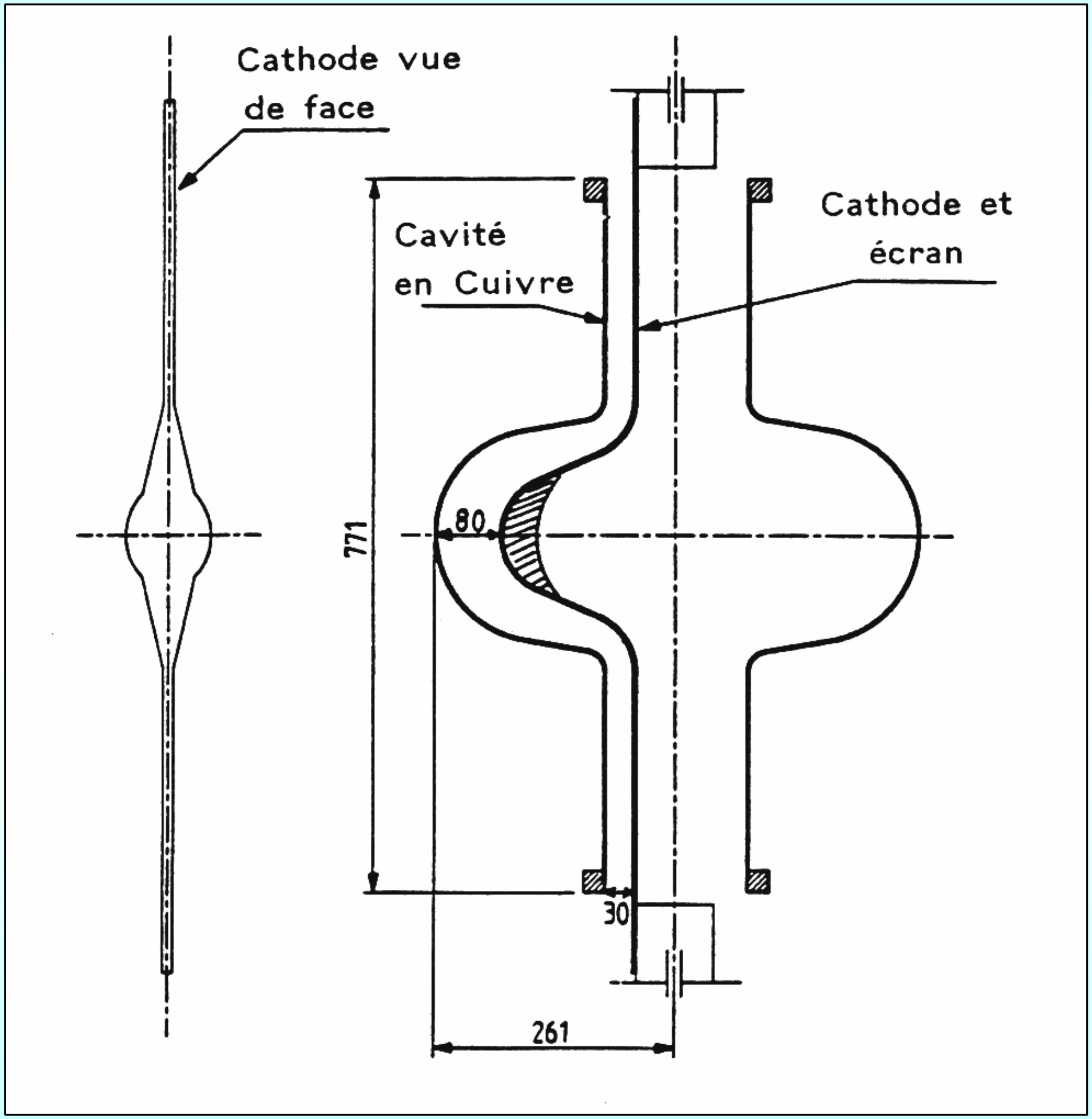
1. **Increasing the sputtering rate R**
2. **Reducing the deposition angle**
3. **Promoting atoms rearrangement and impurities re-sputtering during film growing**
4. **Increase the cathode/substrate area ratio**

Biased Diode Sputtering

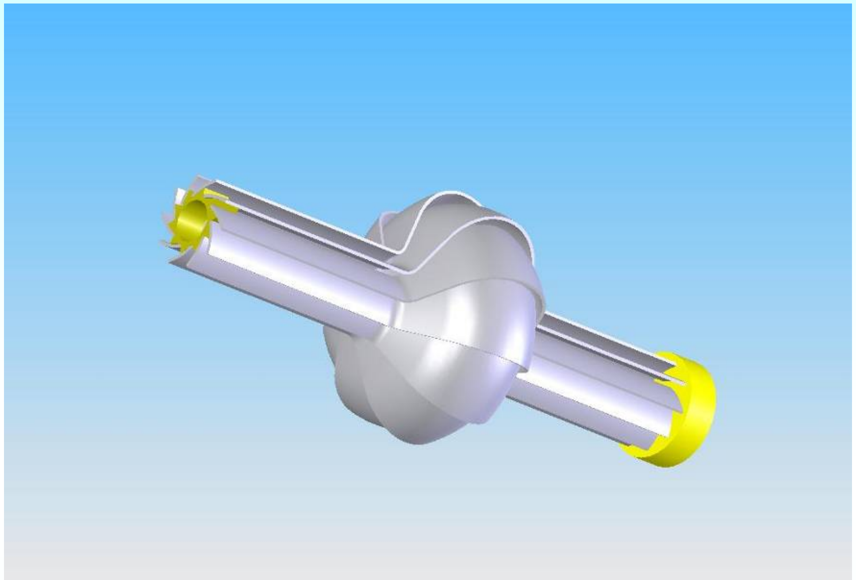
Bias CERN

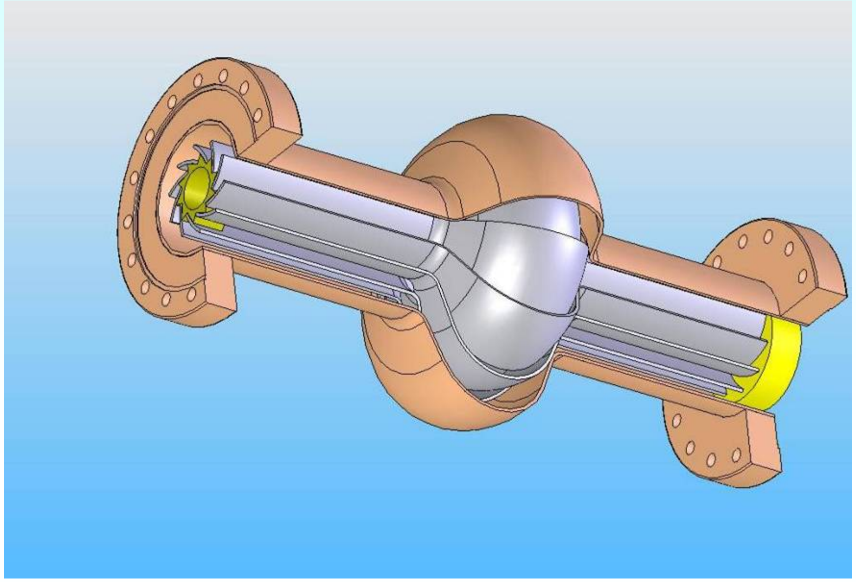
Low ratio cathode/substrate area

Low sputtering rate (1 micron /day)

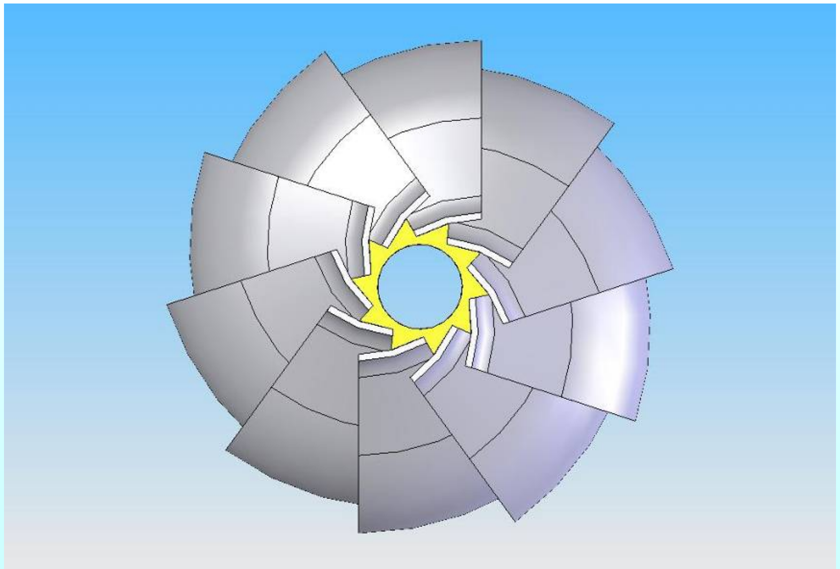


Cavity shaped cathode

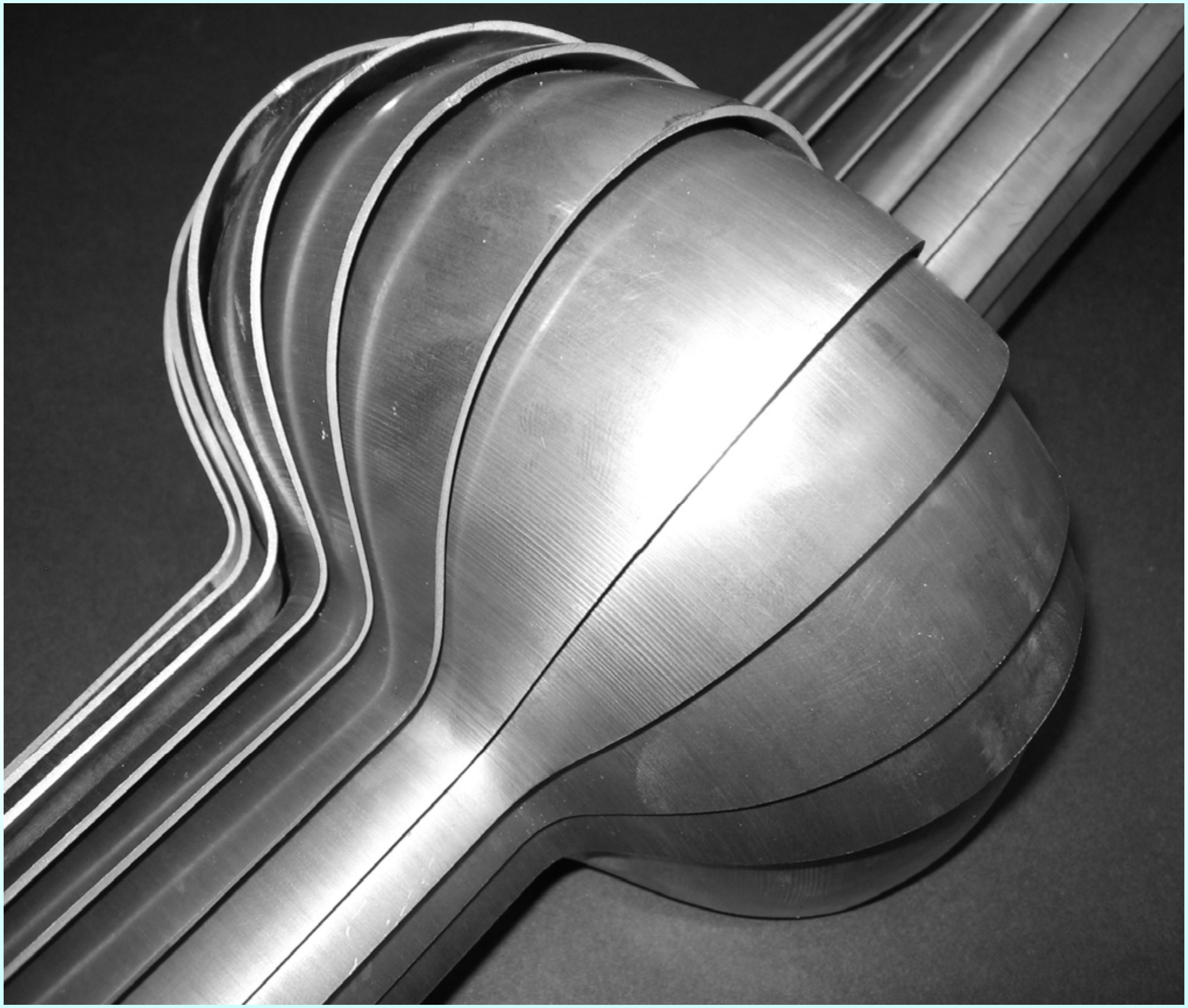




High ratio cathode/substrate area



Cavity shaped cathode



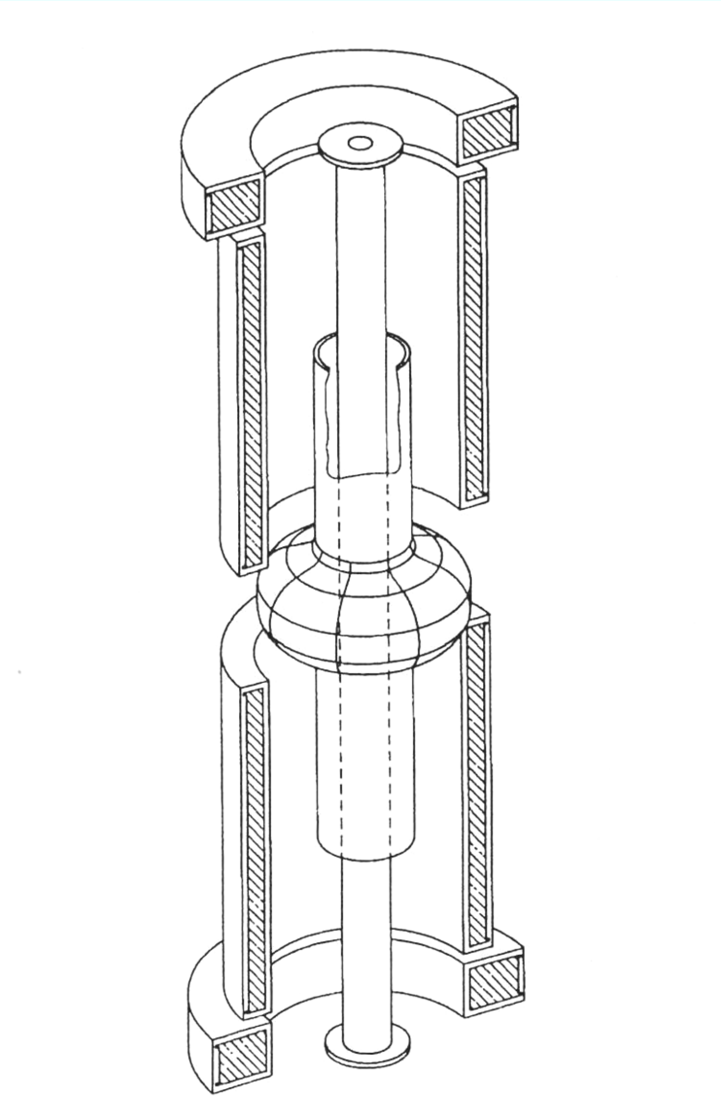
in progress…

Conclusion

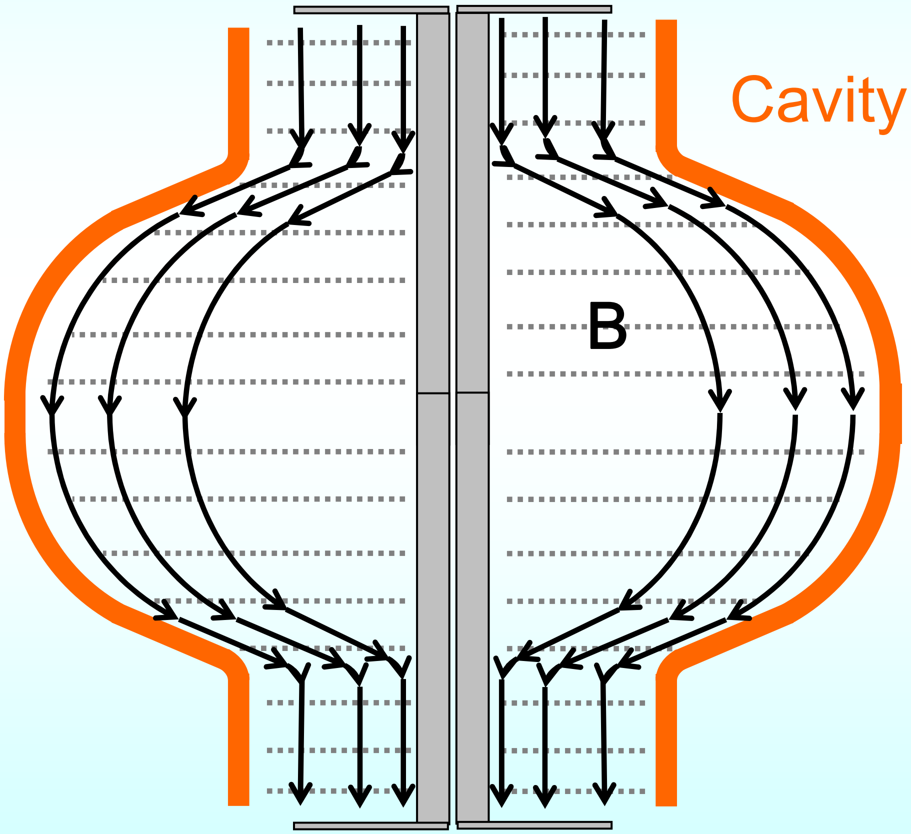
Three new magnetron sputtering configurations are ready!

...soon 20 cavities to measure.

Cylindrical Post-Magnetron



Magnetic field lines follow the cavity shape



Niobium cathode