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Carbon-Based Coatings for Electron Cloud Mitigation in SRF Photocathodes

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Abstract

Multipacting is a common issue in the context of cathode units of superconducting radio-frequency photoinjectors (SRF-guns) utilized in linear accelerators under resonant conditions.

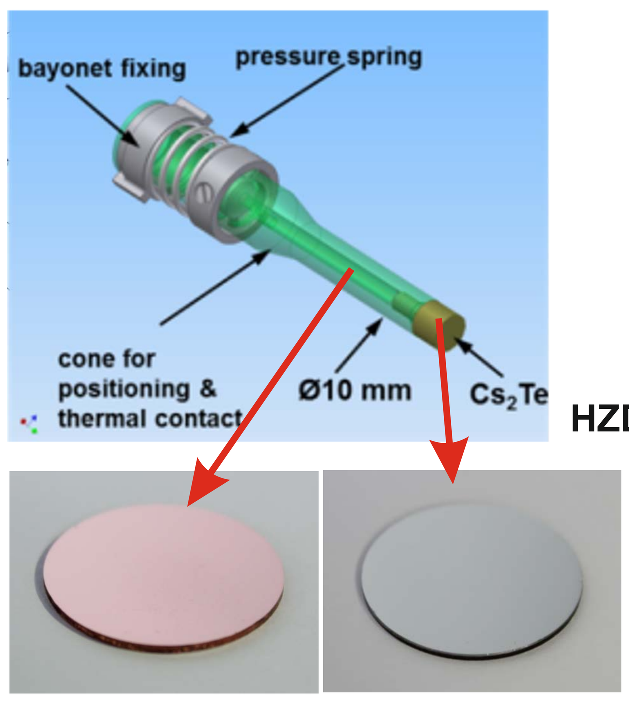
During the past three years, we developed a coating along with a corresponding in-situ characterization process in order to realize SRF-gun surfaces featuring low secondary electron yield (SEY).

Important aspects that have been accounted for are the homogeneity and adhesion of the coatings deposited on the cylindrical SRF-gun mantle. Furthermore, the correlation between SEY and crystallinity, morphology, and contamination was studied in detail.

The SEY maximum can be tuned between 1.5 and less than 0.7 depending on the deposition conditions. In this work, we recap the results and present a general strategy for the effective mitigation of electron cloud multiplication.

Experiment

Photo cathode



HZDR

OFHC Cu Mo

Pretreatment:
- ethanol, dest. water
- polishing
- sandblasting
- wet chem. etching
- plasma etching

Synthesis:
- DCMS
- Ti-interlayer

Characterization:
- SEY (in-situ)
- SEM

FELBE cathode dummy inside the coating substrate holder

Results

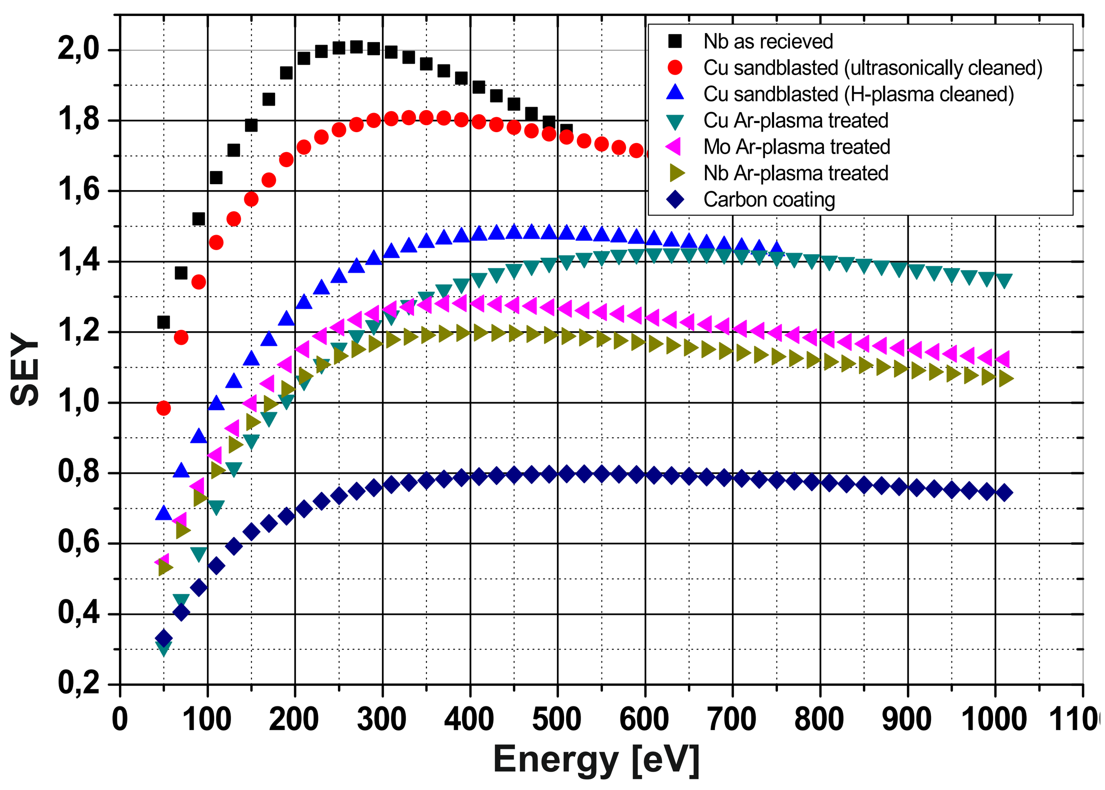


Figure 1: SEY of various materials, different pretreatments.

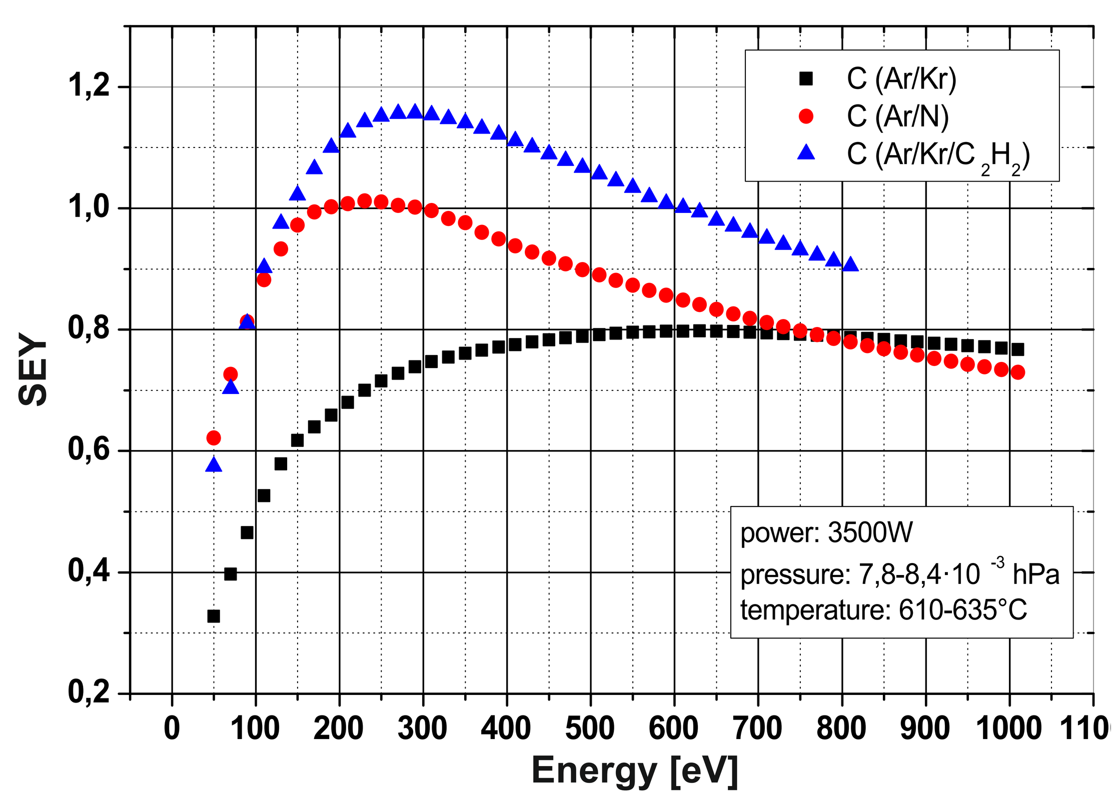


Figure 2: Influence of process gas mixture on SEY.

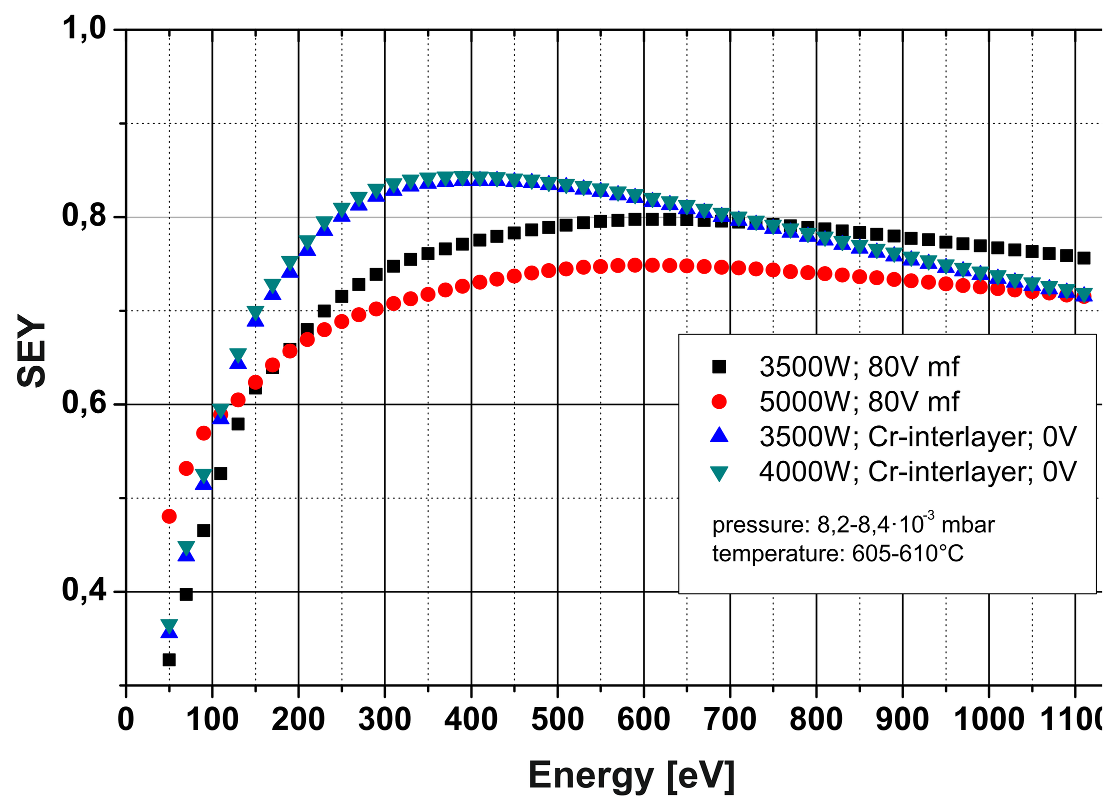


Figure 3: Influence of „sputter power“ and bias voltage on SEY.

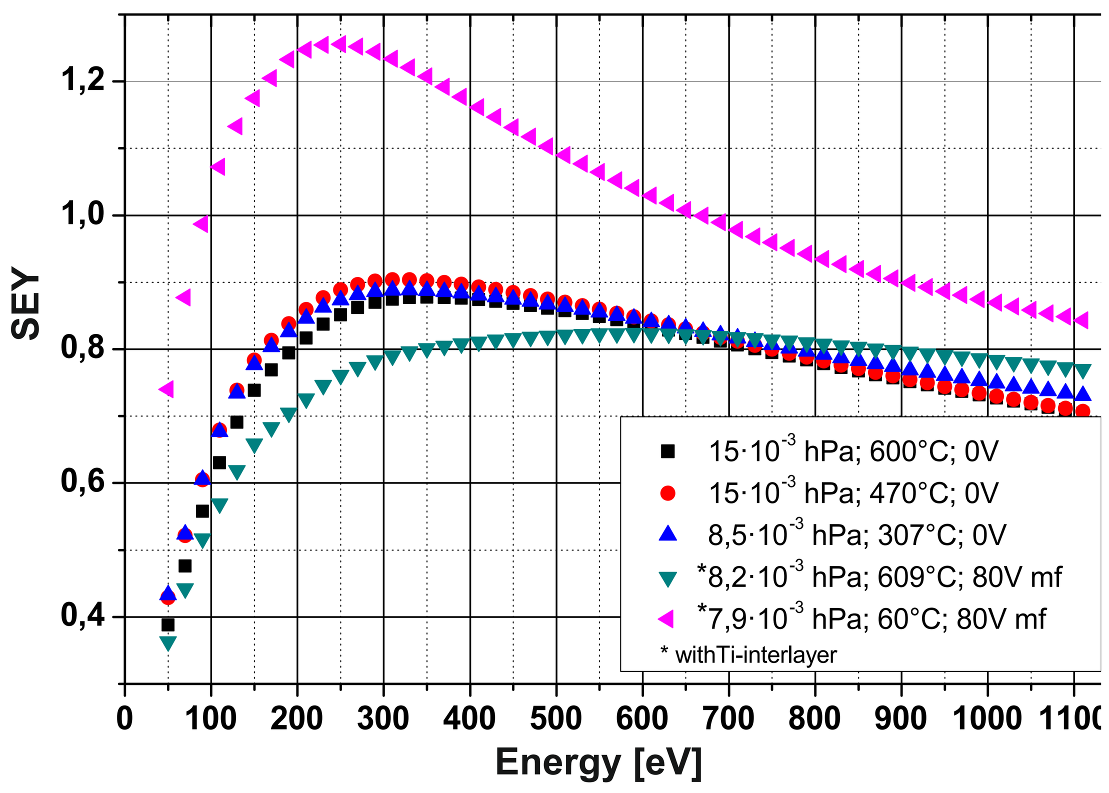


Figure 4: Influence of temperature (pressure and bias) on SEY.

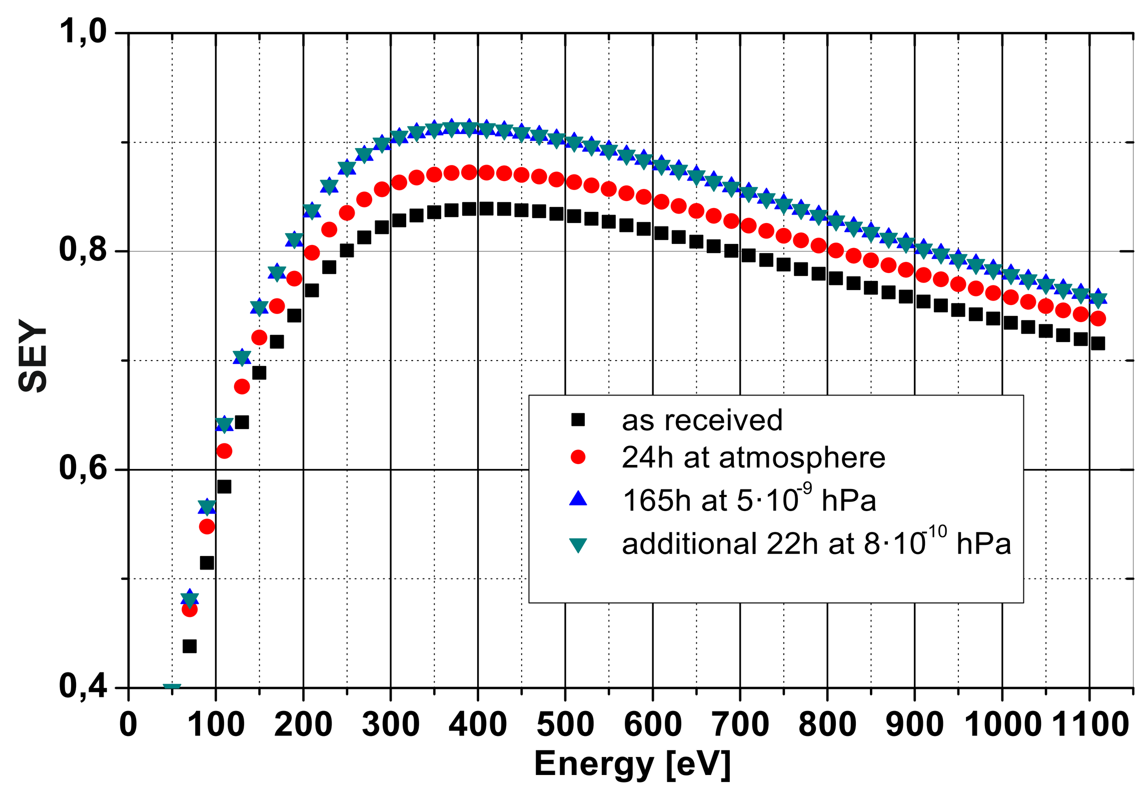


Figure 5: Influence of storage condition on SEY.

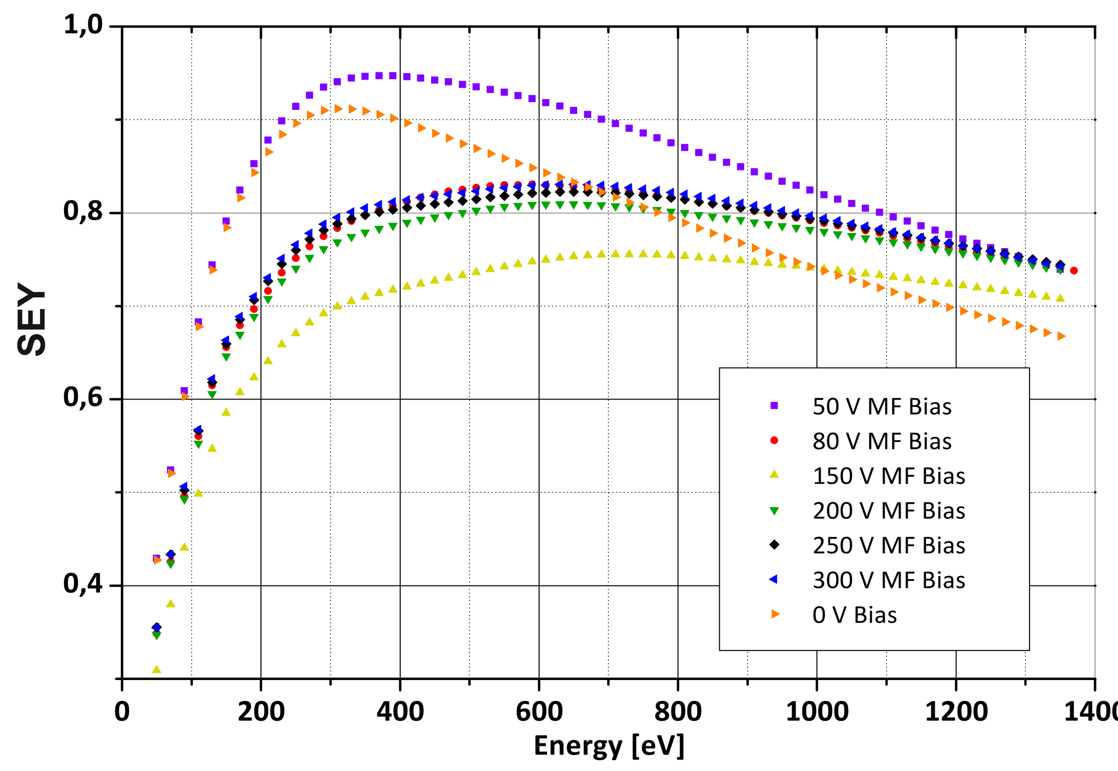
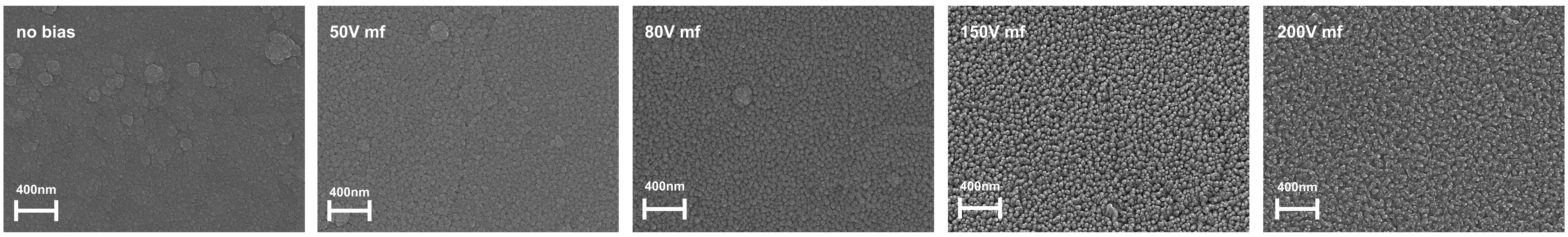
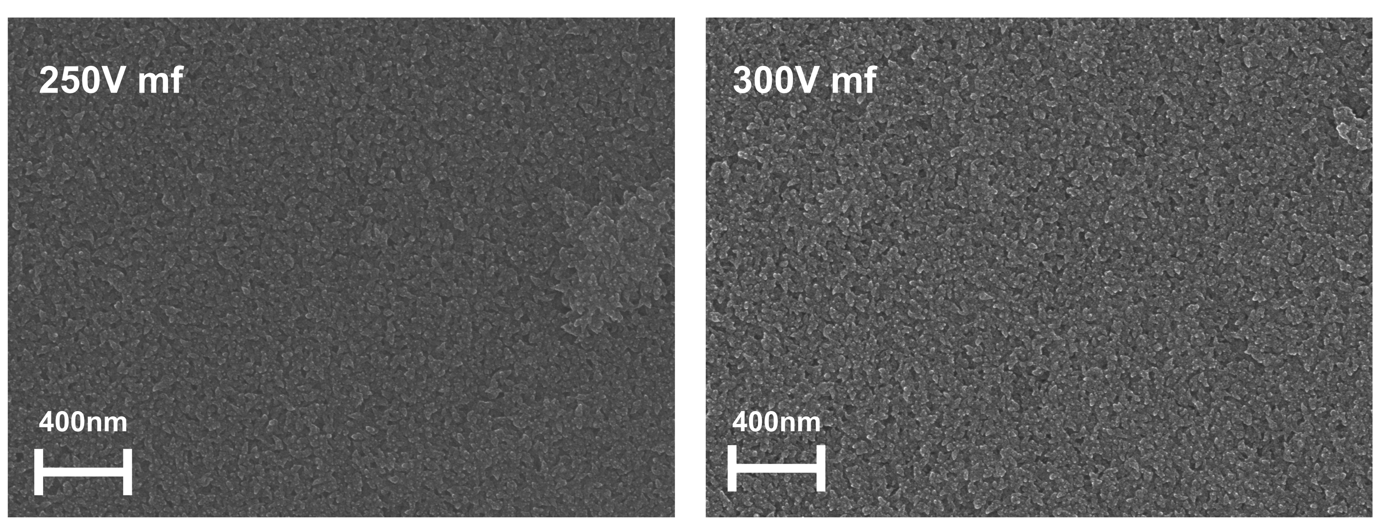


Figure 6: Influence of mf-bias voltage on SEY.

Morphology change as a result of bias voltage change.





Summary

- Carbon coatings can lower the SEY significantly
- By controlling the process parameters the SEY can be tailored between 0.7 and 1.2
- SEY is morphology-dependent (common roughness measurements and values (Ra, Rq,...) show no significant tendency, modelling needed)
- Successful implementation of carbon coatings in 3D srf-gun

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