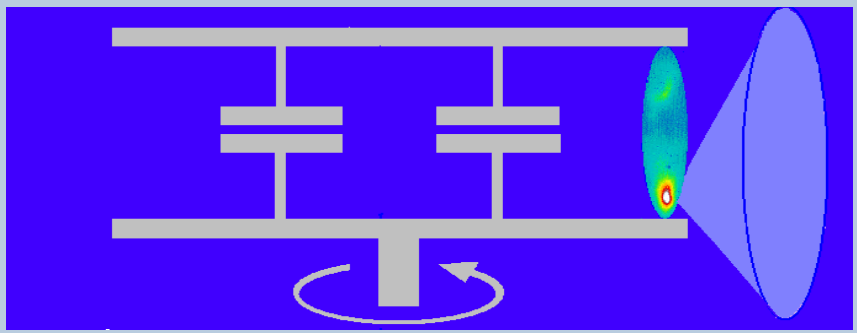
State Research Center of Russian Federation
TROITSK INSTITUTE FOR INNOVATION & FUSION RESEARCH
(SRC RF TRINITI)

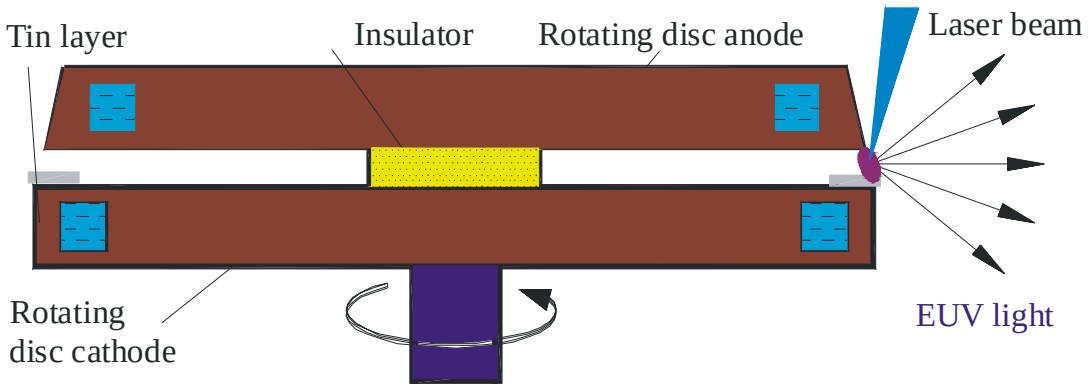
Development of EUV sources with tin fuel and rotating disk electrodes

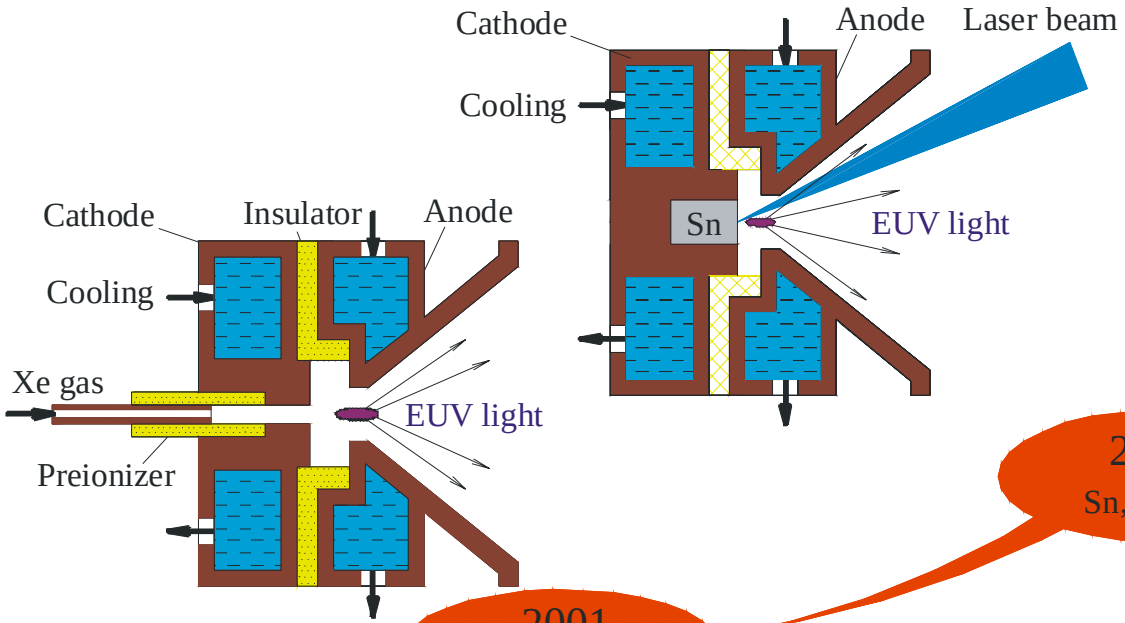
V. Borisov



Evolution of discharge produced plasma source at SRC RF TRINITI

ROTATING DISC ELECTRODES (RDE)



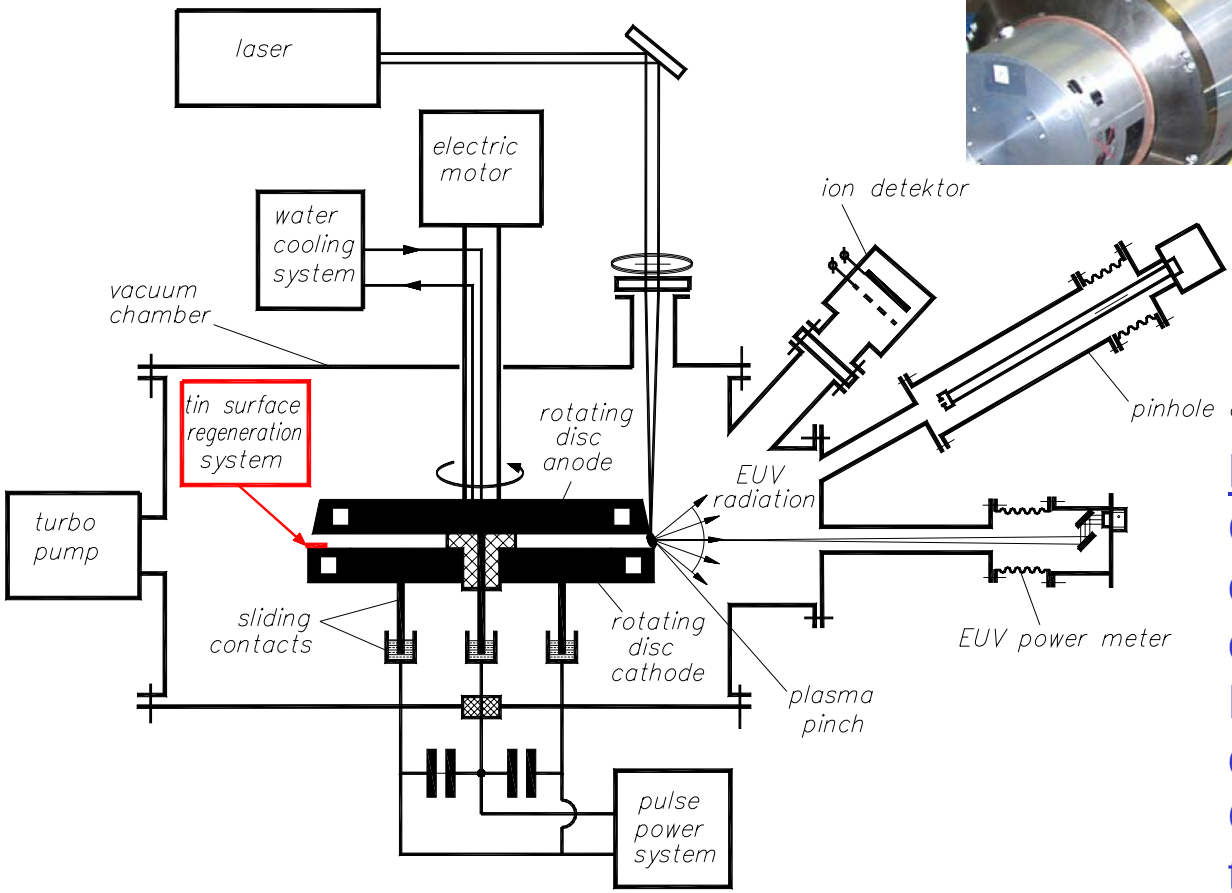


2001
Xe, CE=0.5%

2002
Sn, CE=2%

2003
Sn, CE=2%
& long electrode life time

RDE SOURCE
Design # 1

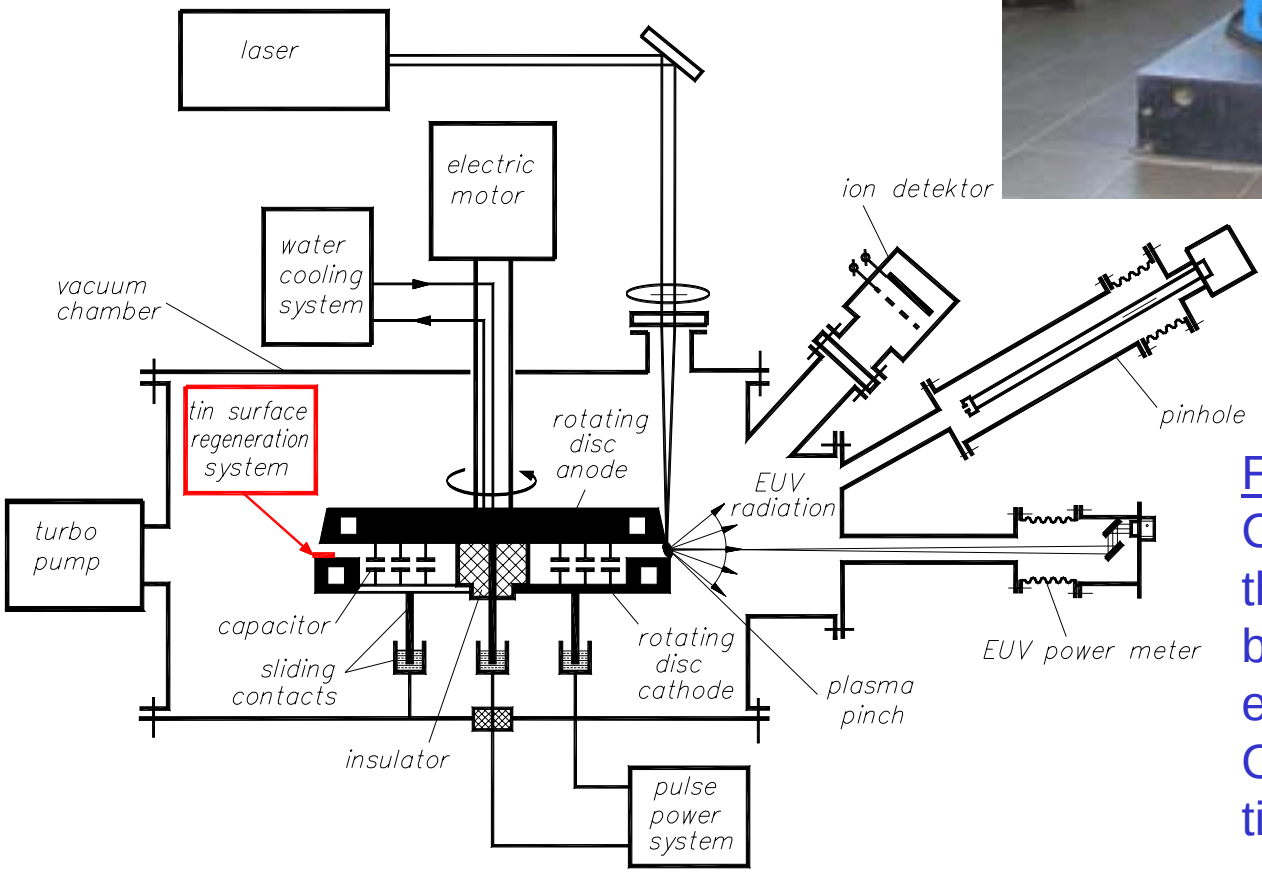


Features.

Capacitors are arranged outside the vacuum chamber and connect with RDE by liquid metal sliding contacts.

Operation with solid or liquid tin is possible.

RDE SOURCE
Design # 2

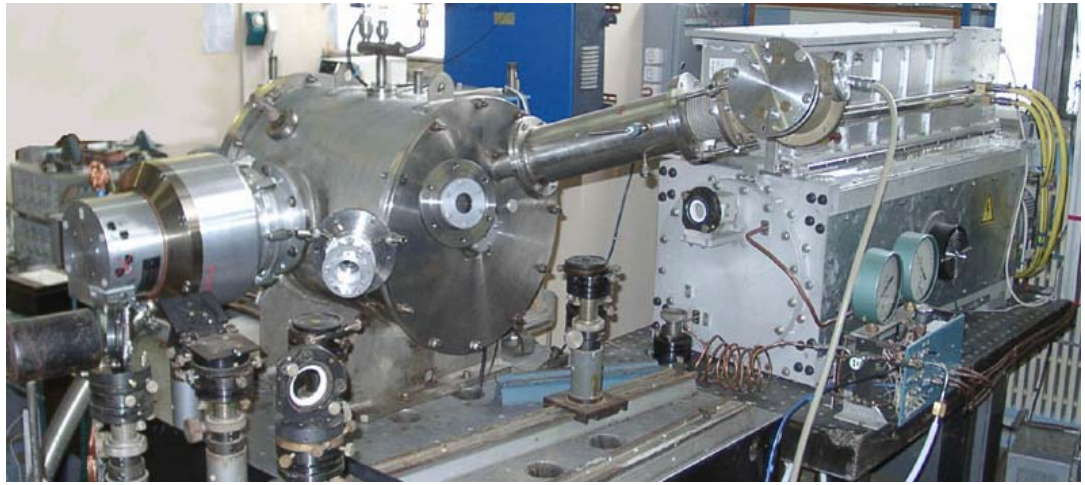


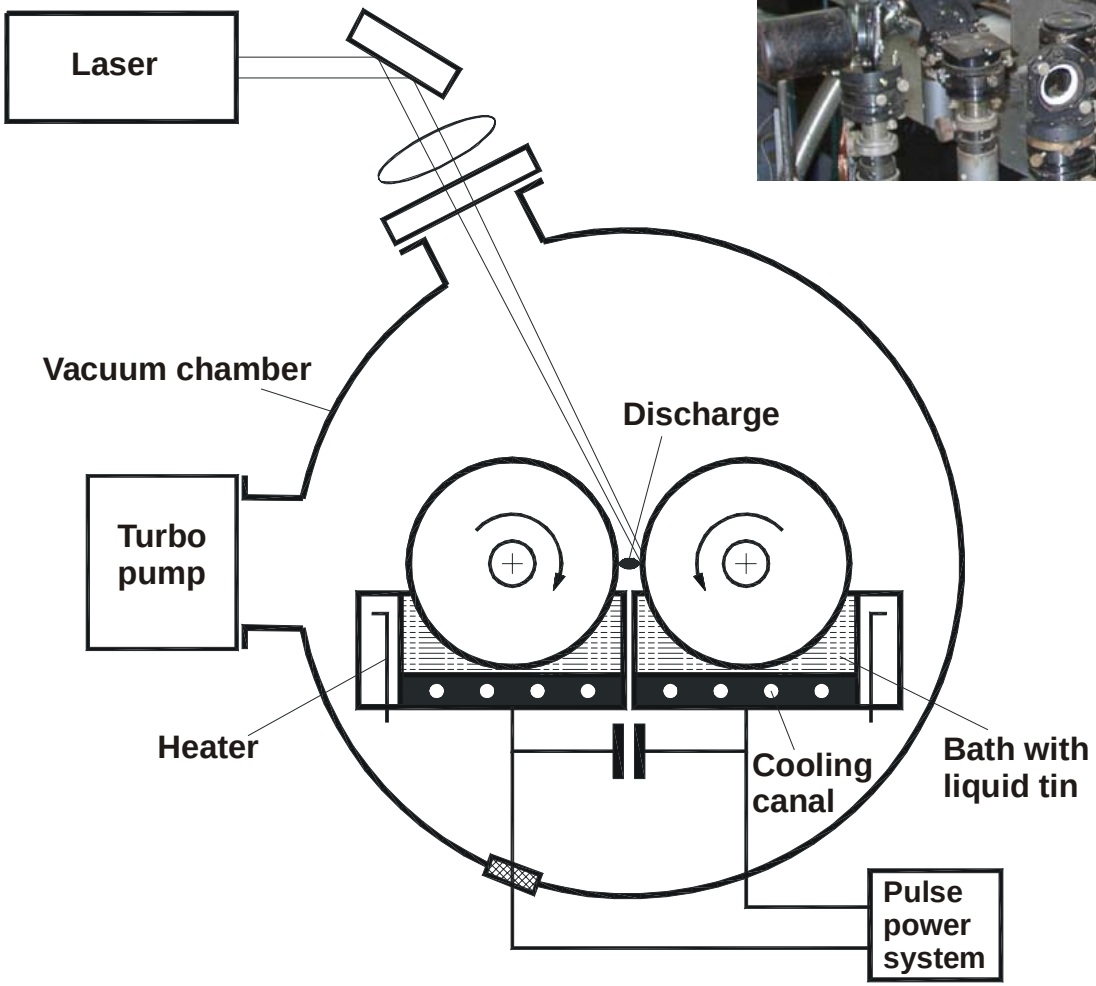
Features.

Capacitors are placed inside the vacuum chamber between the rotating disc electrodes.

Operation with solid or liquid tin is possible.

RDE SOURCE
Design # 3





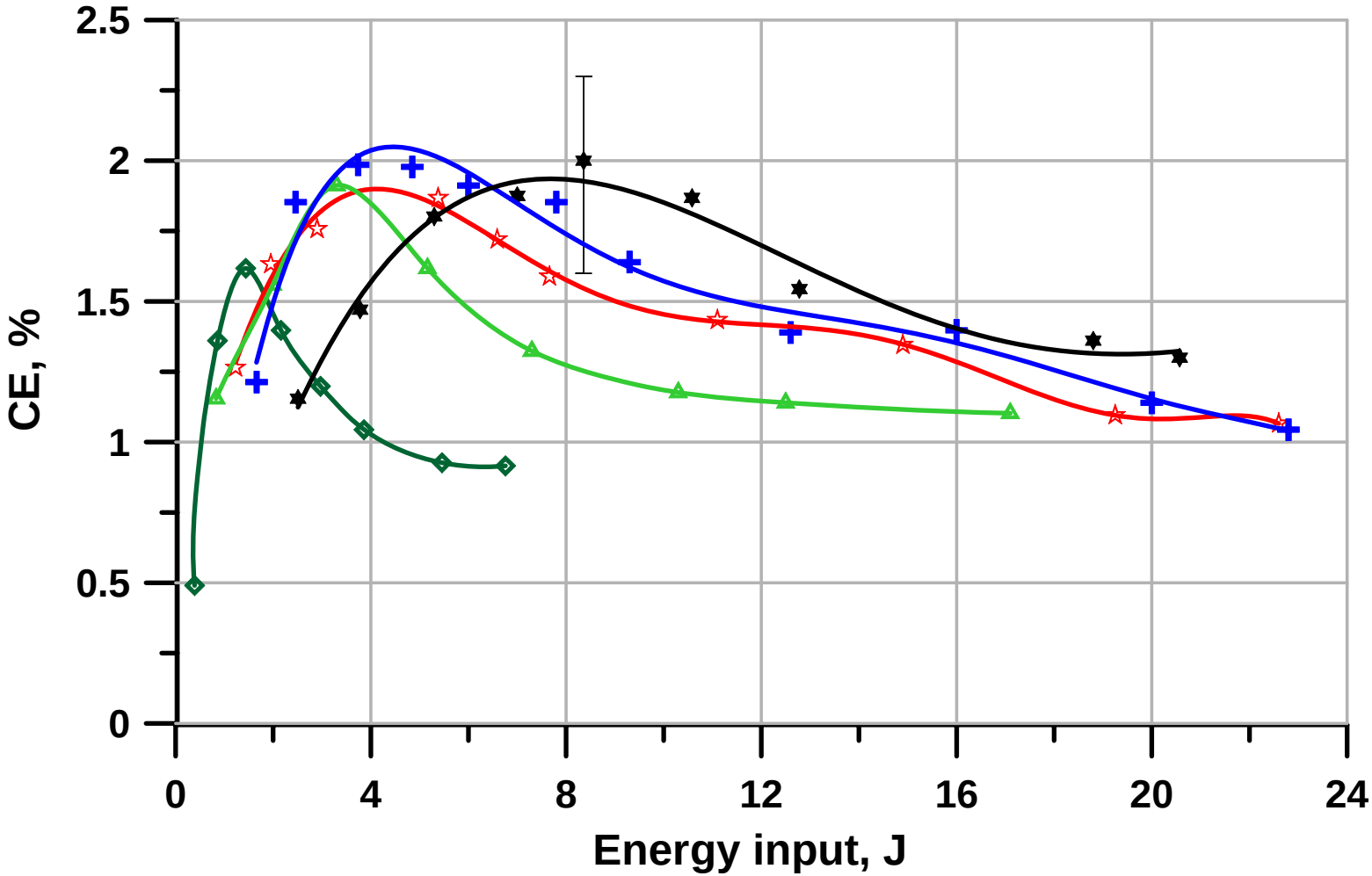
Features.

Tin is delivered by passing the rotating disc electrodes through the baths with liquid tin.

The liquid tin into the baths is used for both heat removal from electrodes and sliding contacts.

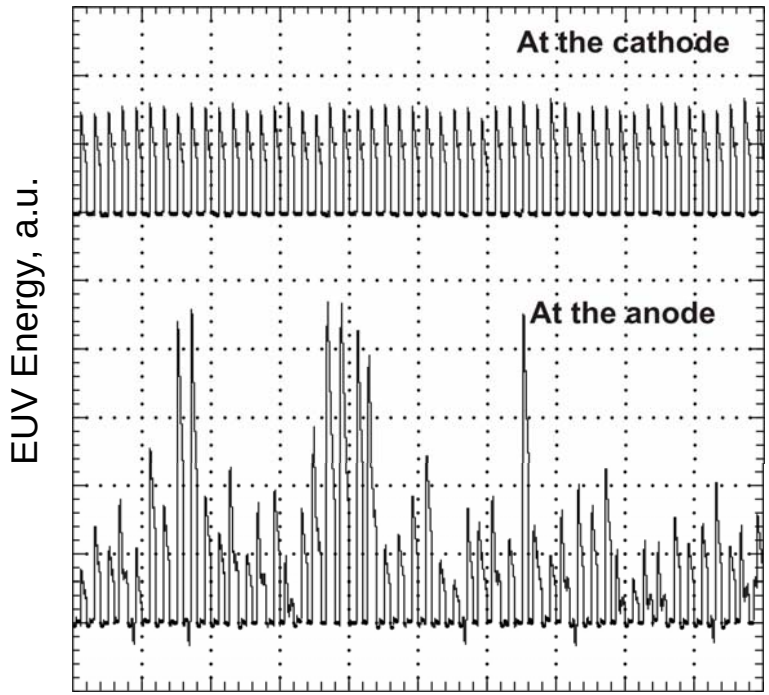
Simple system of tin surface regeneration.

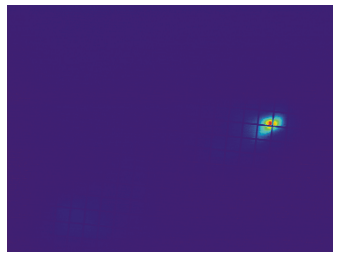
Conversion efficiency as function of input energy

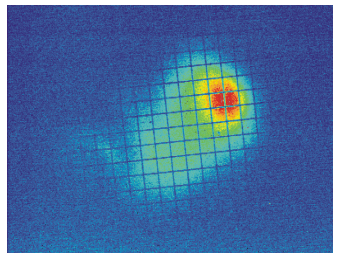


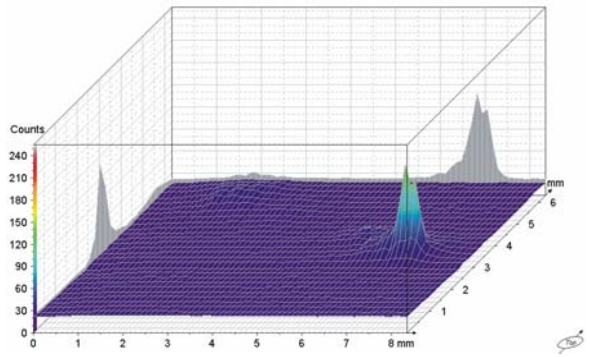
High- effective operation at high input energies (E_{in} ~ 8 J/pulse) gives the possibility to achieve the required EUV source parameters at acceptable repetition rates (7– 10 kHz).

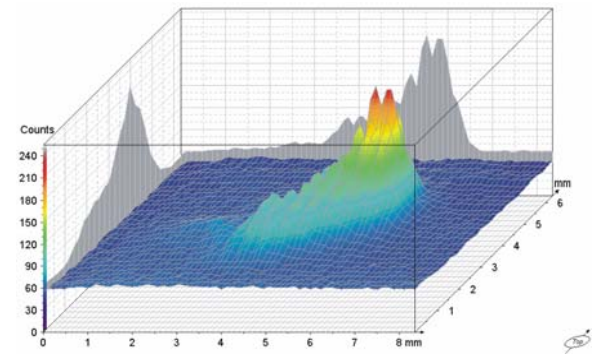
Effects of Sn vapor plum generation at the cathode or at the anode



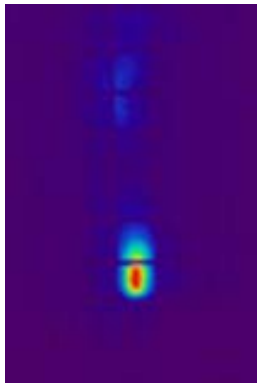


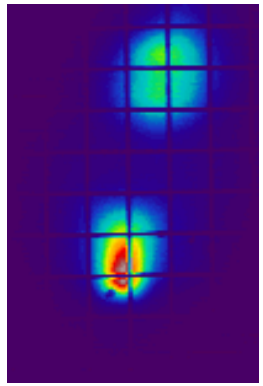


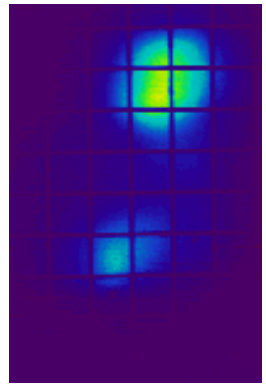


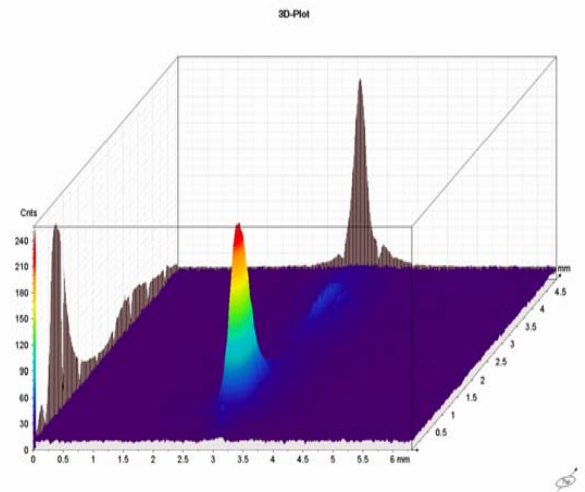


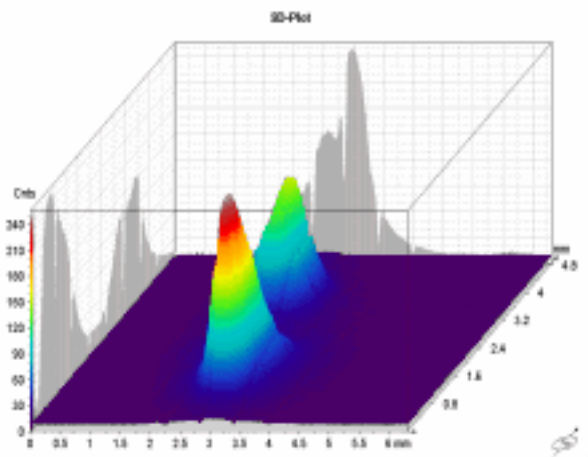
Configuration of EUV emitting region for different discharge conditions

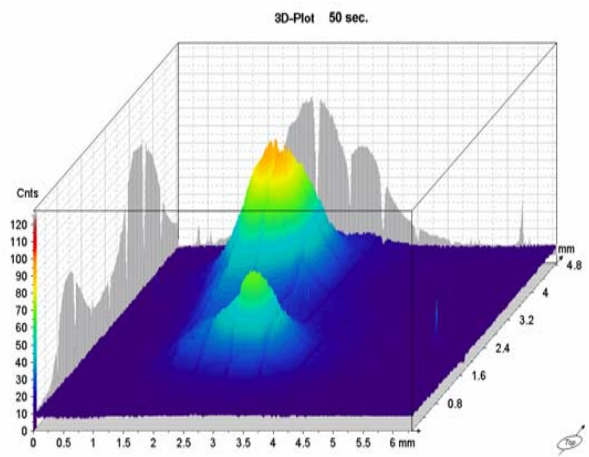












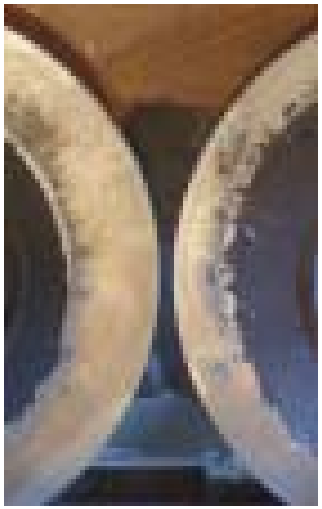
a **b** **c**

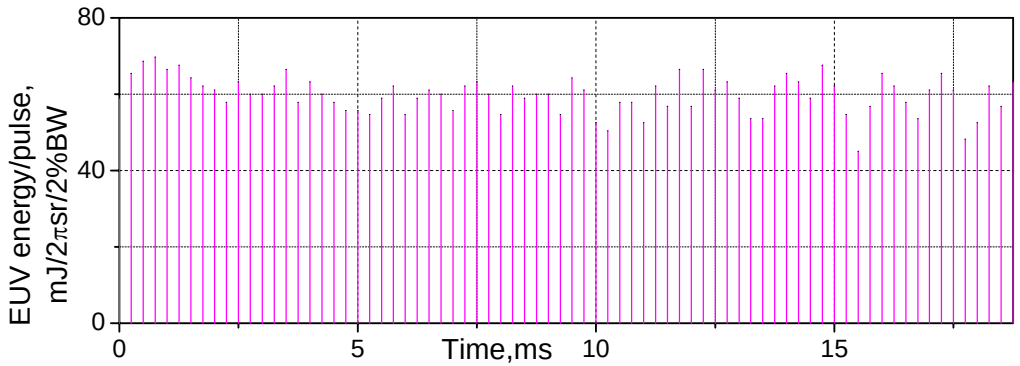
Operation with liquid tin: increase of the tin droplets production

Design # 2

The use of liquid tin provides simple method of tin surface regeneration for rotating disc electrodes, but leads to high level of tin droplets production.

Design #3

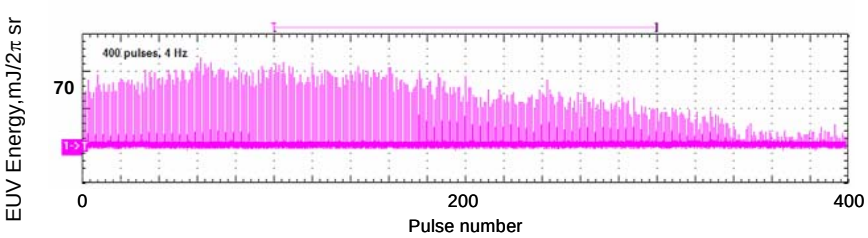




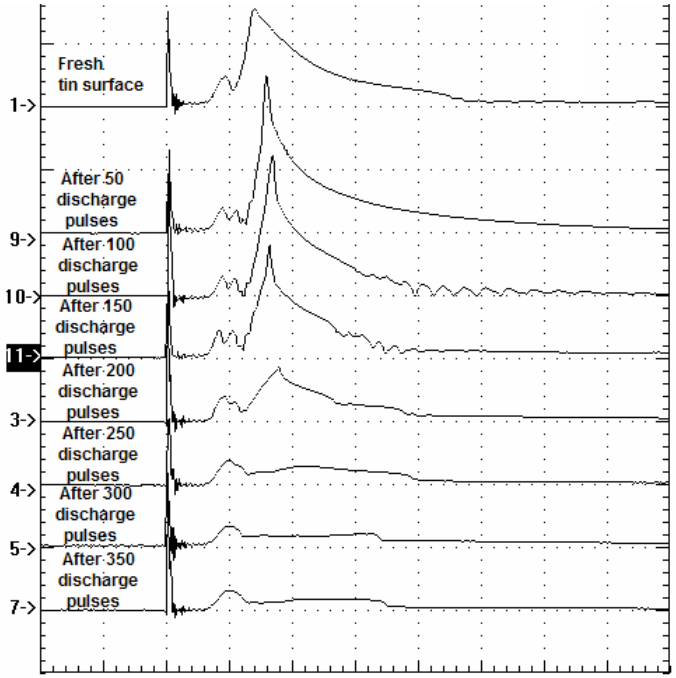
Output power 240 W/2π sr at 4 kHz

Operation with solid tin: small amount of tin droplets production

Non- rotating disc electrodes:

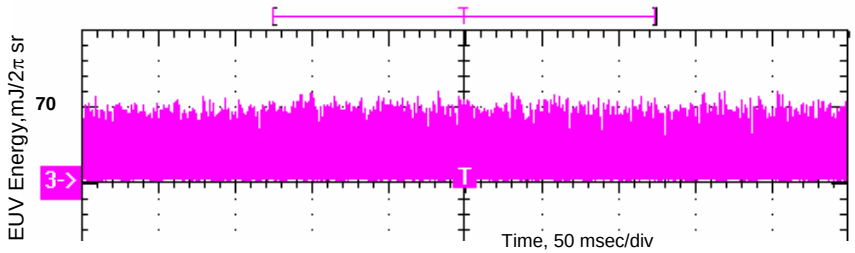


decrease of EUV energy with pulse number

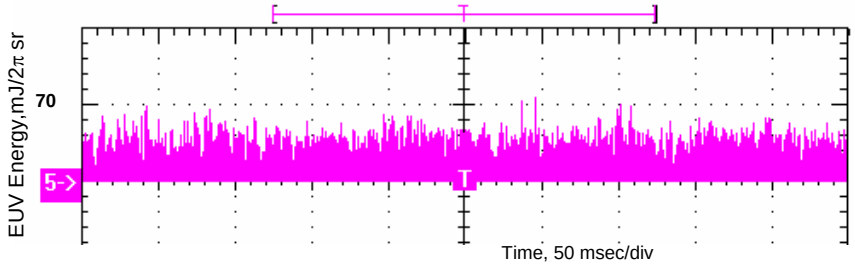


Ion detector signals, provided by laser beam

Rotating disc electrodes



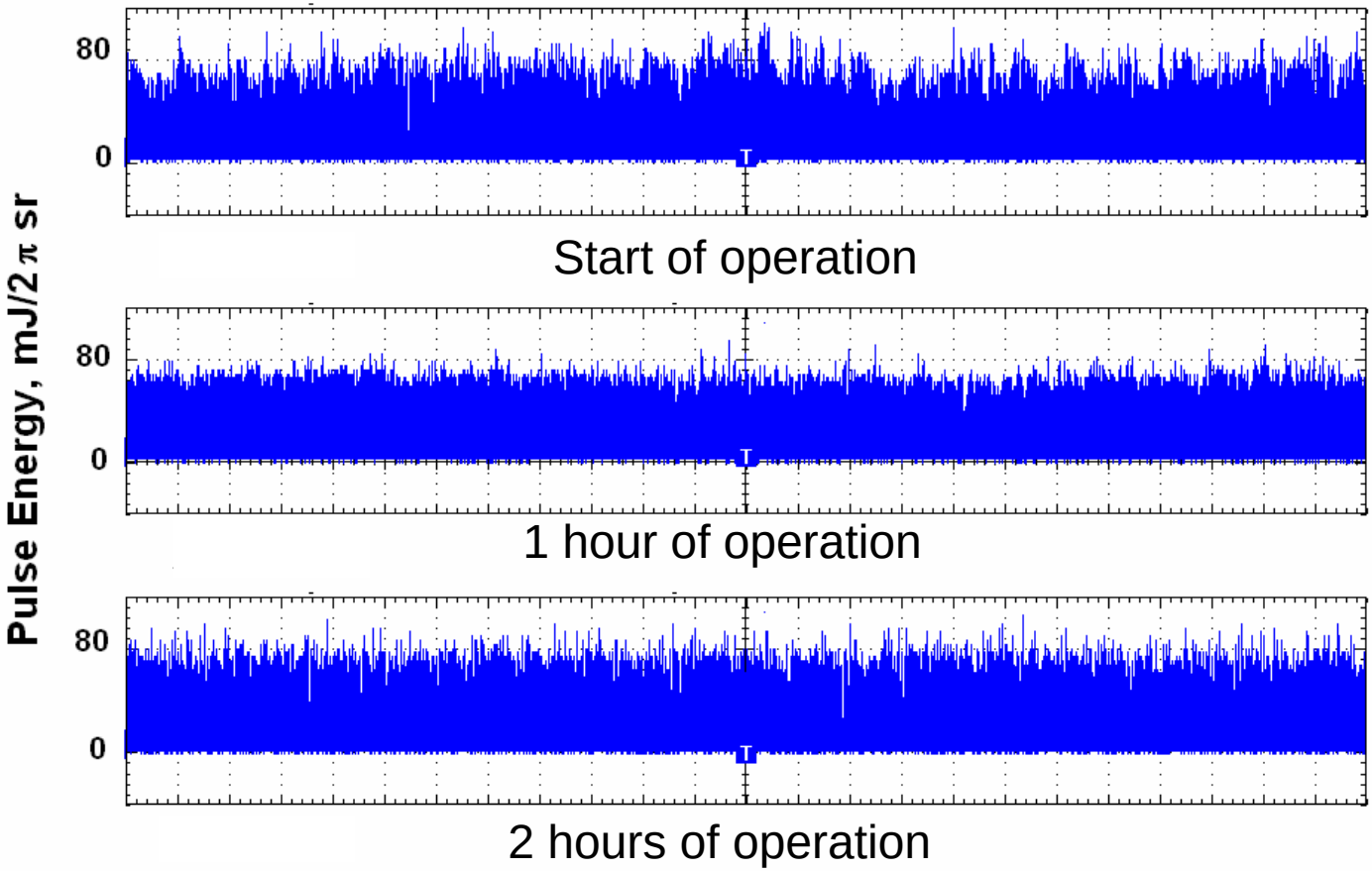
EUV signals with fresh solid tin surface at 3 kHz



EUV signals after 6 millions pulses at 3 kHz if the system of tin surface regeneration is not used

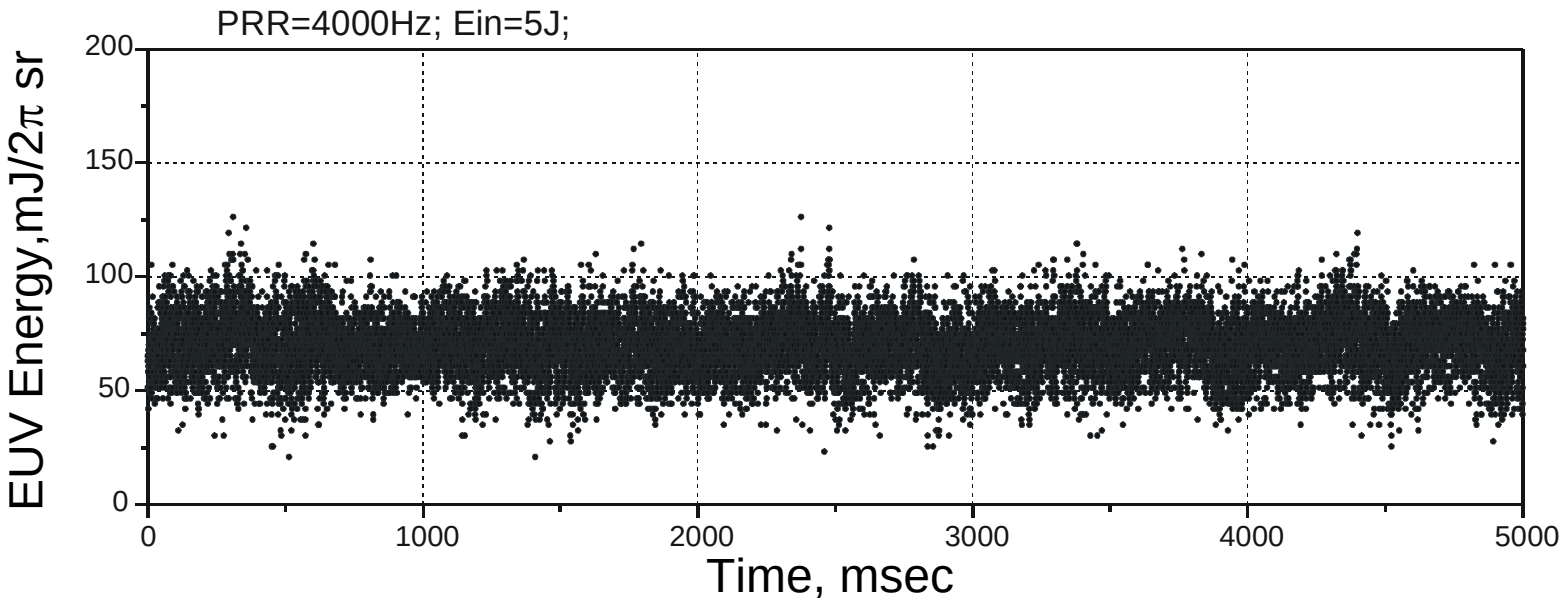
Tin surface after 6 millions pulses if system of tin surface regeneration is not used

Long time operation of EUV source with tin surface regeneration system



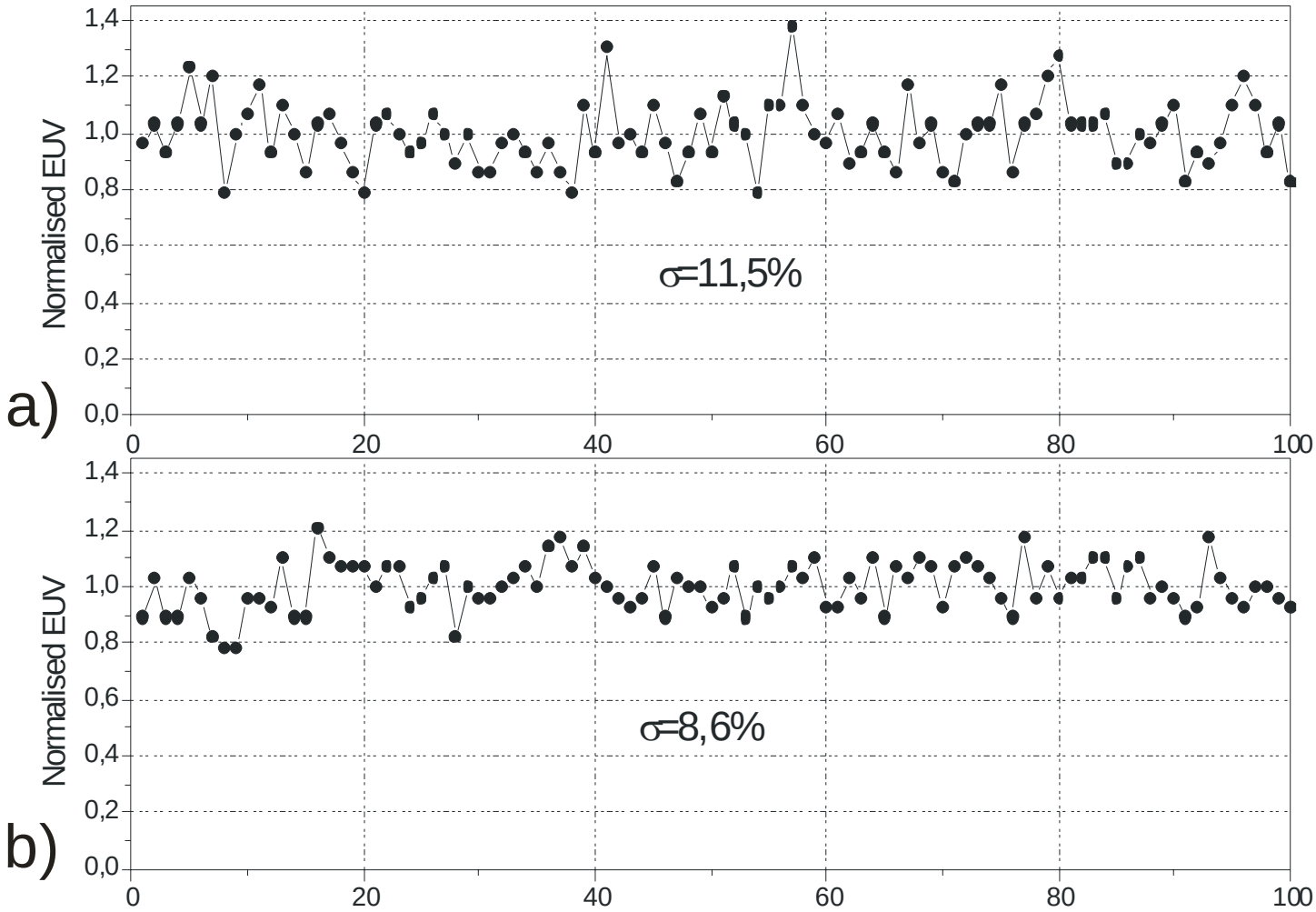
Output power 220 W/2π sr at 3 kHz

EUV source operation at 20 kW input power and 4 kHz



Output power 280 W/2π sr

Pulse-to-pulse stability over 100 shots for solid (a) and for liquid (b) tin



Conclusion

Several designs of RDE source have been investigated at SRC RF TRINITI during the two last years. RDE sources can operate with solid and/or liquid tin at input power up to 20 kW and pulse repetition rate up to 4 kHz. The obtained experimental results do clearer both the main problems to meet HVM requirements and the directions of next efforts.