A pulsed vacuum arc ion source with a pure boron cathode

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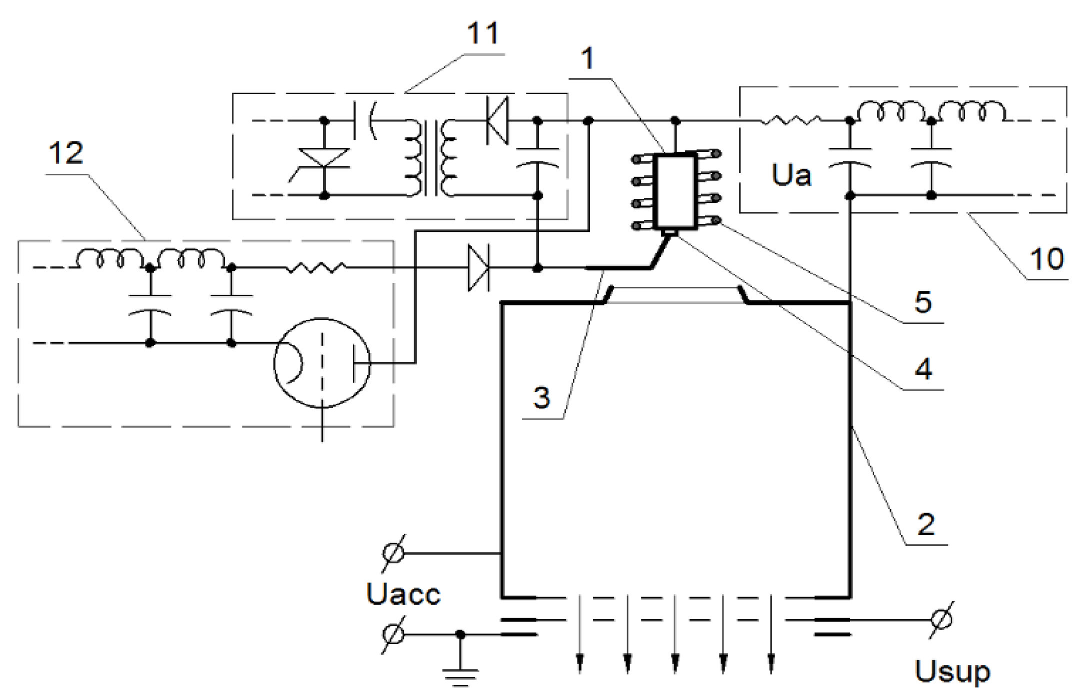
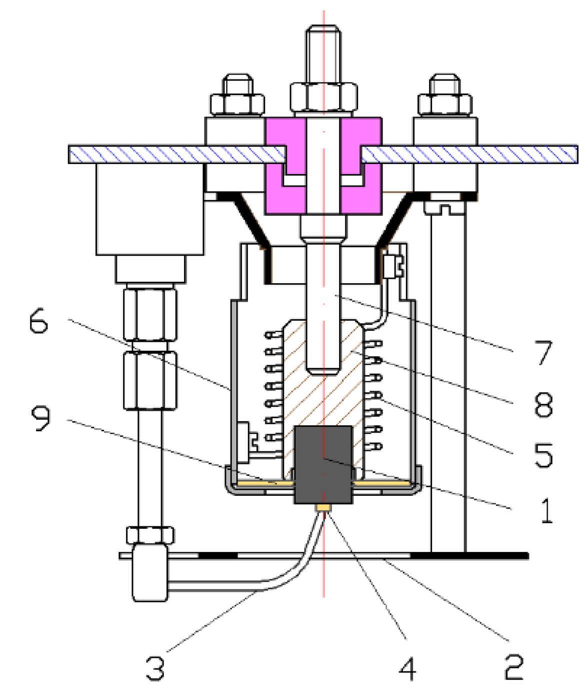
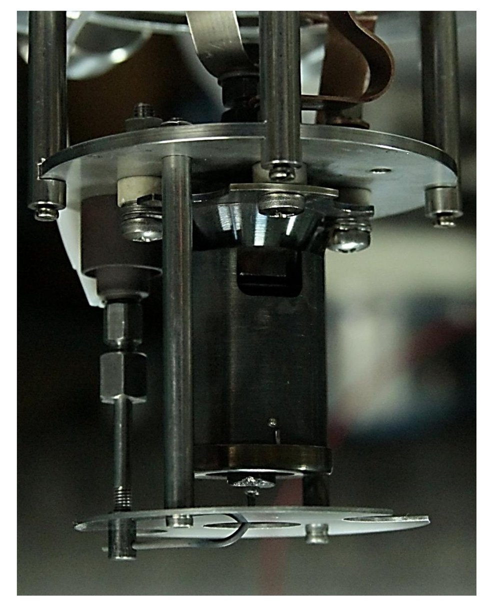
ABSTRACT

The report presents experimental results on a pulsed vacuum arc ion source with an elemental boron cathode. Boron is a semiconductor having a high specific resistance (~ 1.8 MOhm×cm) under normal conditions and is difficult to sputter and evaporate [1]. Therefore, for arc ignition with pure boron, it is required to preheat the cathode up to 1000 °C. We have designed a high-temperature cathodic unit which uses a special arc triggering technique, provides cathodic arc operation with pure boron, and allows one to decrease the cathode temperature down to 600 °C. For an arc current of 100 A with a duration of 100–300 µs, the 450-mA beam consists of boron ions in singly and doubly ionized states.

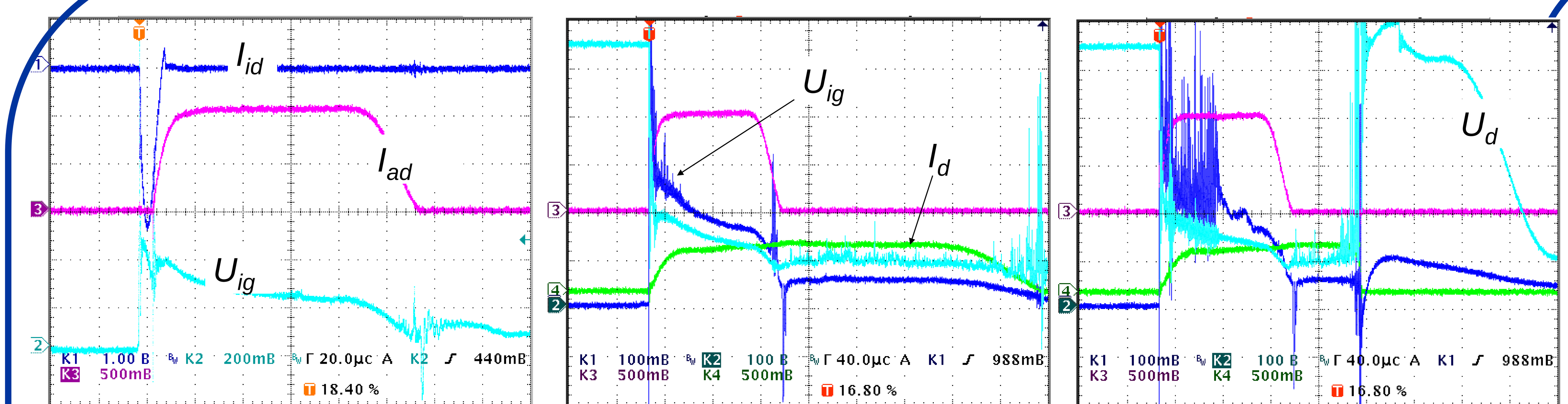


1 – boron cathode,
2 – hollow anode,
3 – igniting electrode,
4 – ceramic pellet (alumina or Nb),
5 – heater spiral,
6 – thermal shield,
7 – current lead,
8 – ceramic disk (alumina),
8 – cathode holder,
9 – insulator,
10, 11, 12 – power supplies.



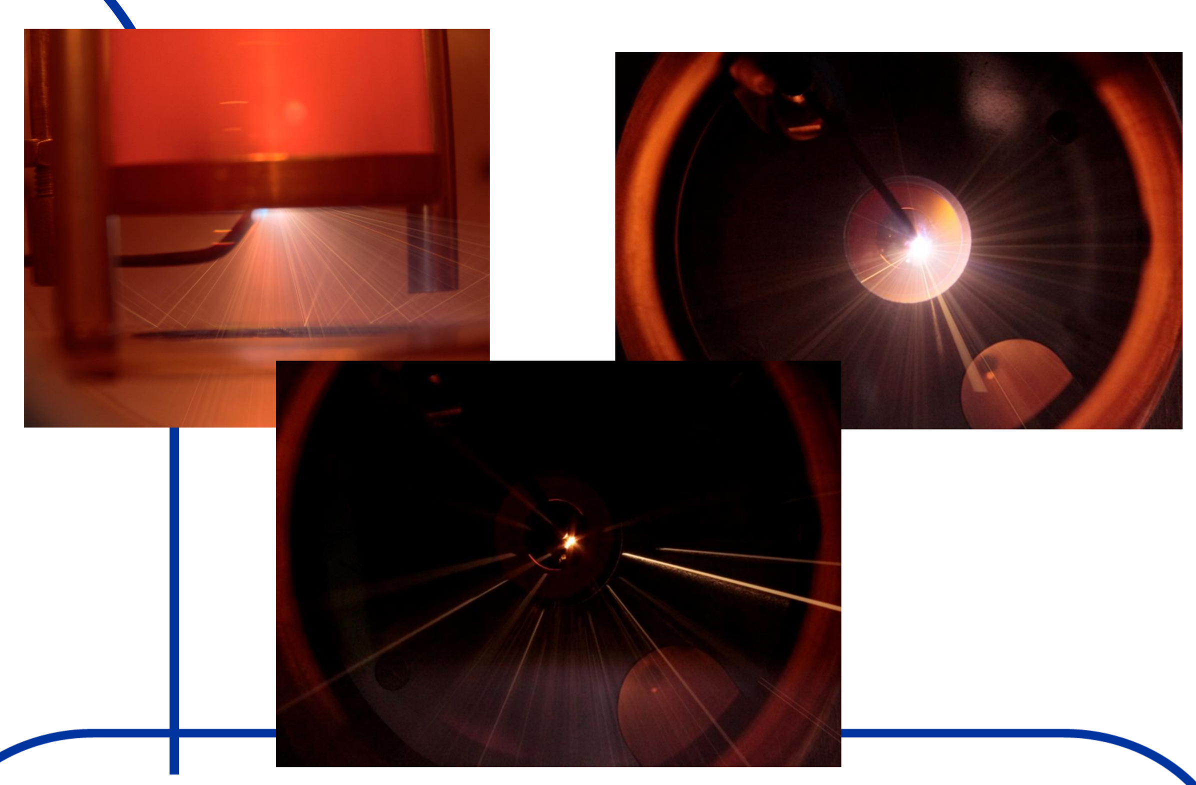


Ion source sketch design and cathode unit (drawing and photography)

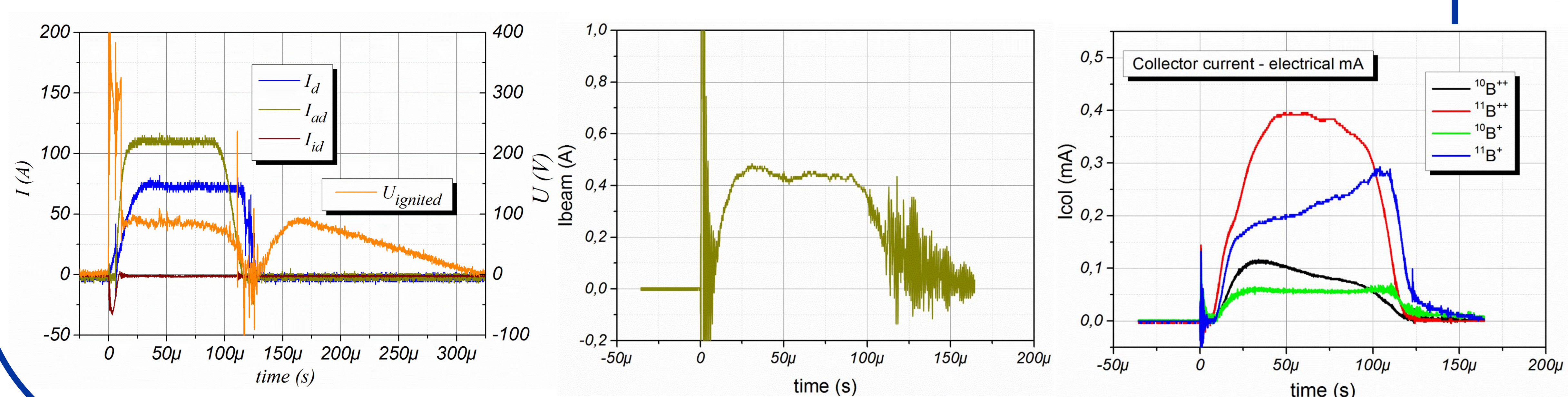


Ignited discharge I_{id}, auxiliary discharge I_{ad} and main discharge I_d currents, discharge voltage U_d for different operational modes.
Ion beam current I_{beam}, separated ion beam I_{col} and ignited voltage $U_{ignited}$.

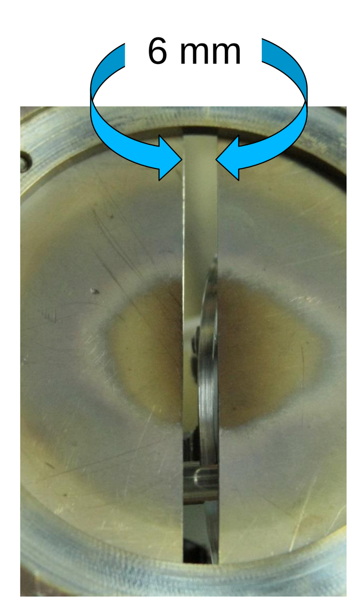
Cathode spot and microdroplet luminescence at different times



A disadvantage of the vacuum arc is the presence in the plasma flow microdroplet fraction.



Ion beam print



Conclusions

The proposed high-temperature cathode unit based on a vacuum arc with pure boron allows one to decrease the cathode temperature for stable arc ignition from 1000 °C [1, 2] to 600–650 °C, which greatly reduces the energy expended in plasma generation. The cathode unit, which is built in the ion source, provides the generation of a 450-mA beam containing only singly and doubly charged boron ions with near-equal current amplitudes (particle mA) at a discharge current pulse duration of 100 µs.

References

1. **F. Richter, S. Peter, V.B. Filippov et al., IEEE Trans. Plasma Sci. 27, 1079-1083 (1999).**
2. **J. M. Williams, C.C. Klepper, D. J. Olivers, R. C. Hazelton and J. H. Freeman, "Operation and Applications of the Boron Cathodic Arc Ion Source," in Ion Implantation Technology-2008, AIP Conference Proceedings 1066, edited by E. G. Seeba et al. (American Institute of Physics, Melville, NY, 2008), pp. 469–472.**

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