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Cryogenic high-gradient discharge system at Uppsala University.

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A cryogenic DC HV system integrated in a stand-alone cryocooler has been constructed at Uppsala University in order to investigate the fundamental mechanisms of field emission and breakdown nucleation. A series of high-field measurements has been carried out with pairs of copper and niobium electrodes at temperatures ranging from ambient down to 4K. We observed a significant increase in the field holding capability of the electrodes when cooled and conditioned at cryogenic temperatures.
A significant reduction of fluctuations and greater stability of the field emitted current from fully conditioned electrodes operated at cryogenic temperatures was also observed, together with an increase of the maximum current enabled by the larger attainable field.

The results show a general agreement of BD characteristics with the proposed theoretical models, where the temperature enters exponentially via e^{1/k_bT} term, and confirm the increase in field holding capability at cryogenic temperatures observed in other studies.
The present work provides experimental data that can be used to refine such models and potentially discriminate between various underlying physical mechanisms, thus eventually improving our understanding of BD phenomena.
Finally, our study provides valuable data for the design of future normal-conducting accelerators at cryogenic temperatures with very high gradient and reduced breakdown rates, with the potential of a reduced cost and optimized performance.

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