ECTON PROCESSES IN A VACUUM ARC

Gennady A. Mesyats
P. N. Lebedev Physics Institute, Russian Academy of Sciences, Moscow, Russia

The paper reviews the state-of-the-art in studying the physical processes that occur in the cathode spots of vacuum arcs. The main relevant experimental data are interpreted in the context of the ecton model of the cathode spot of a vacuum arc. Central to the ecton model is explosive electron emission, the phenomenon discovered by the author and his collaborators in the mid 60th of the last century in studying high-voltage pulsed vacuum breakdown. A description of this phenomenon is given and the physical processes observed in a vacuum arc are analyzed in comparison with those inherent in explosive electron emission.

In the context of the ecton model, the cathode spot of a vacuum arc consists of individual cells which are explosive emission sites each emitting a portion of electrons termed an ecton. An increase in arc current is accompanied by a mere increase in number of simultaneously operating ectons; therefore, as observed in experiments, the parameters of an electric arc weakly depend on current up to the kiloampere level. The cathode spot processes are cyclic in nature due to the finiteness of the ecton lifetime. A statistical model of a vacuum arc is proposed to interpret the effect of spontaneous extinction of an arc. It is shown that the arc plasma is generated due to microexplosions that occur on the cathode surface as a result of Joule heating of cathode microprotrusions by high-density explosive emission current. Predictions of numerical simulations of the ecton processes in the cathode spot of a vacuum arc are analyzed. The physical processes responsible for the charge state of the arc plasma and for the directed motion of ions are discussed. It is shown that the ionization processes occur in a narrow (about a micrometer wide) region near the cathode, and subsequently the ionic composition of the plasma remains unchanged. The ions gain directed velocities of the order of $10^6$ cm/s even at distances of several micrometers from the cathode due to the electron pressure gradient.

The paper is concluded with a brief overview of pulsed electrophysical devices and machines depending for their operation on explosive electron emission that have been developed and built under supervision of the author.