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The role of oxygen and nitrogen metastable states in the electrical breakdown of air JOHN LOWKE, CSIRO Materials Science and Engineering

— For the initial formation of an electrical discharge in air, an electric field of approximately 25 kV/cm is required at a pressure of 1 bar, corresponding to a value of E/N of ~100 Td; E is the electric field strength and N the gas number density. Below 100 Td, rates of electron attachment to form negative ions are greater than for ionization, so that a discharge of electrons is impossible. However, in less than a microsecond, metastable molecules of oxygen and nitrogen are produced, which markedly change the character of the discharge. The singlet delta metastable state of oxygen detaches electrons from negative ions of oxygen. By far the largest collisional process is the production of the metastable vibrational states of nitrogen. Populations of these states become so large that there is a significant increase in electron energy through collisions of these states with low-energy electrons. Solutions have been obtained of the Boltzmann transport equation for various values of E/N to obtain rates of production of the various metastables. It is found that the effect of the metastable states of nitrogen increases the electron energy at low values of E/N by orders of magnitude, ionization still being significant at E/N = 20 Td. An analysis is made of continuity equations of electrons, ions and metastables and it is concluded that sustaining fields during the electrical breakdown process can be as low as 5 kV/cm at 1 bar, or an E/N of 20 Td, which is a reduction of a factor of five from the initial breakdown fields.

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