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Dynamics and pattern formation during microwave breakdown at atmospheric pressure[1]

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A self-organized array of plasma filaments moving towards the source has been recently observed in microwave breakdown experiments in the millimeter range at MIT (Y. Hidaka et al., Phys. Rev. Lett. 100, 035003 (2008)). These filaments are qualitatively different from the well-known filaments observed in laser breakdown, and develop transverse to the propagation direction, along the direction of the electric field polarization. A model coupling Maxwell's equations with a simple description of the plasma dynamics has been developed and has been shown to reproduce very well the experimental observations (J.P. Boeuf et al., Phys. Rev. Lett. 104, 015002 (2010)). The propagation of the plasma toward the source is due to an ionisation-diffusion mechanism and the self-organized filamentary structure is associated with the scattered field pattern. The filaments develop in the direction of the incident field due to field enhancement by polarization at their tip and form an array with a spatial period on the order of one quarter wave length. The physics and dynamics of the filamentary plasma array will be discussed in a first part, on the basis of comparisons between model and experimental results. In a second part other aspects of microwave breakdown at atmospheric pressure will be presented, such as the development of microwave streamers (that can absorb very efficiently the microwave energy under specific, resonant conditions), the formation of complex nets of plasma filaments during breakdown in an under-critical field (breakdown is initiated next to a metallic initiator and propagates, due to thermal instabilities, in a region where the microwave field is below the critical field). The context of applications of this study (plasma aided combustion and flow control, breakdown next to an antenna) will be presented briefly.

[1]This work has be performed in the frame of the RTRA STAE PLASMAX project