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Theory and design of emission-driven microplasmas for plasma-assisted processes: Tiny devices for large outcomes

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With the growing emphasis on nano/microscale systems, sustaining and utilizing plasmas in the microscale has transformed into an exciting and novel research area in the last decade or so with several experimental, theoretical and numerical investigations. While initial efforts in trying to understand microdischarges focused on trying to prevent breakdown in electrostatic microscale devices, recent research has expanded to exploiting these versatile plasmas in several applications. The overarching goal of this talk is to describe the unique characteristics of microplasmas summarizing some of the recent contributions following which we will look at the future of microplasmas, potential applications and challenges. Specifically, microplasmas require emission mechanisms from the cathode other than secondary electron emission which could be provided either by field emission or a combination of thermionic and field emission. The first half of the talk will thus focus on theories for microscale breakdown and their relation to the traditional Townsend criterion, interplay of emission mechanisms and plasma number densities/operating modes of these plasmas. The second half of the talk will discuss proof-of-concept results for potential applications that can benefit from microplasma devices. The discussion will emphasize the potentially superior performance of emission driven microplasmas in comparison to existing alternatives such as dielectric barrier discharges. Finally, current challenges and the future research road map will be laid out.