Guest Editorial
Special Issue on High-Pressure Arcs and High-Frequency Thermal Plasmas

SINCE the publication of the last Special Issue on Arc Plasmas 11 years ago, research into thermal plasma technology has been stimulated by new application areas which are mainly concerned with material processing and by the ever-increasing demand on the existing technology. This applies to arcs as well as high-frequency (RF) thermal plasmas. The understanding, refinement, and optimization of engineering systems using thermal plasmas as the key element require a multidisciplinary approach. The maturity of numerical techniques, the understanding of basic physical and chemical processes occurring in thermal plasmas, and the rapid advancement of computing power at an affordable price in the past decade have made computer modeling and simulation an inseparable tool for the understanding and optimization of thermal plasma systems.

Thermal plasmas usually refers to high-pressure arcs and RF discharges under local thermodynamic equilibrium (LTE) conditions. However, in certain regions of the plasma and under some operational conditions, substantial departures from LTE may occur. The departure from LTE and its influence on the characteristics of the plasma have been active research topics.

The applications of high-pressure arcs and RF discharges are diverse, but the underlying basic physical processes are the same, with differing dominant energy transport processes for different applications. The papers in the Special Issue are conveniently divided, according to the means of producing the plasma, into high-pressure arcs followed by high-frequency thermal plasmas. The current trend of research is well reflected by the majority of the papers in this issue: the application of well-established diagnostics backed up by a realistic computer simulation which aids the understanding of the detailed physical processes responsible for the experimental results.

Research topics covered by this Special Issue include fundamental aspects of arcs and RF discharges, as well as topics specifically related to applications. In the case of thermal arcs, radiation transport, thermodynamic and transport properties, the onset of arc instability, the influence of the Lorentz force, arc–shock interaction, and nonequilibrium chemical and ionization reactions are common fundamental processes investigated. Much attention is also paid to the cathode and anode regions which play a critical role in forming a stable arc and in the life of a thermal plasma engineering system. Intensive interactions between the arc and its surroundings are studied for specific applications. The influence of ablated material vapor from the discharge vessel wall and from the anode, as well as the effects of injected mass for certain material processing, on the characteristics of the arc have been examined in detail.

Computer modeling and simulation based on two-dimensional, time-dependent conservation equations coupled with the relevant Maxwell's equations, and, possibly, the relevant species equations, are now standard tools for assisting the understanding of the basic physical and chemical processes occurring in arc and RF devices, and for optimization studies of the operational parameters of a particular engineering system. Very sophisticated computer simulation is reported in this Special Issue for welding applications, which adopts a unified approach by including the anode and cathode region and phase changes. The magnetohydrodynamic and thermal aspects of the formation of the droplets for gas metal arc welding have been revealed. The Special Issue also reflects another recent trend in computer simulation. That is the adaptation of commercially available computational fluid dynamics packages (CFD) for the modeling of thermal plasma systems.

The Special Issue covers a wide range of applications spanning current interruption, welding, and cutting to more recent application areas, such as waste destruction, synthesis of fine powders, and chemical vapor deposition of diamond films.

It is our hope that the Special Issue gives an overview of the current active research topics concerning thermal plasmas and their applications, and the trend of future research in this area.

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