Diagnostics of thermal plasmas

Citation for published version (APA):

Schram, D. C., Sanden, van de, M. C. M., & Mullen, van der, J. J. A. M. (1991). Diagnostics of thermal plasmas. In U. Ehlemann, H. G. Lergon, & K. Wiesemann (Eds.), *ISPC 1991 : 10th international symposium on plasma chemistry, Bochum, August 4-9, 1991* (Vol. 1, pp. 1.2). [i2] International Union of Pure and Applied Chemistry.

Document status and date:

Published: 01/01/1991

Document Version:

Publisher's PDF, also known as Version of Record (includes final page, issue and volume numbers)

Please check the document version of this publication:

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

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DIAGNOSTICS OF THERMAL PLASMAS

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The overview treats diagnostic methods used to determine important plasma parameters, such as the electron density n_e , the electron and heavy particle temperatures T_e and T_h , and flow velocities. We will restrict ourselves to (sub)atmospheric thermal plasmas, in which the plasma is in (or close to) PLTE, i.e. the excited states are in equilibrium with the continuum. The electron density is in the range of 10^{20}m^{-3} – 10^{23}m^{-3} and the electron and heavy particle temperatures are in the 1 eV range.

Emission and absorption spectroscopy and interferometry will be introduced first for the diagnostics of stationary arcs with axial observation. The high precision obtained in these experiments will permit us to discuss influences of deviations from equilibrium in the PLTE-framework. Also Stark broadening and continuum intensity will be introduced as means to determine plasma parameters (mainly n_e). At the same time these detailed findings can be compared with results of two-dimensional modeling to establish the validity of these models. Then the discussion will be focused on flowing systems. First for the (slowly flowing) Inductively Coupled Plasma (ICP) results on absolute line intensity and $H\beta$ -line broadening will be shown and interpreted in n_e , T_e and deviation from equilibrium. From power interruption experiments the heavy particle temperature will be deduced, as well as observations on the state of non-equilibrium.

The discussion will be continued by reviewing flowing thermal arc plasmas expanding into a low pressure vessel. These plasmas are used as particle source and in plasma deposition. Flow velocities are much higher here. Possibilities are Doppler broadening to determine T_h , $H\beta$ broadening and line continuum ratios to determine n_e . Also examples of the axial dependences of flow velocity, pressure and electric field are given. These findings are compared with results of the above mentioned two-dimensional models.

Expanding thermal arcs are used also for plasma deposition, and knowledge of the physics of the expansion in the low pressure section is essential. Methods to observe phenomena as supersonic expansion and shock with spectroscopy (including molecular transitions) and Thomson and Rayleigh scattering will be reviewed. Three dimensional contours of the shock in n_e , n_h and T_e can be obtained in this way.

The final subject forms the diagnostics of expanding spraying plasmas work as anemometry and determination of the temperature evolution of spray particles.