Characterisation of plasmas produced by the "Torche a injection axiale"

CHARACTERISATION OF PLASMAS PRODUCED BY THE "TORCHE À INJECTION AXIALE"

J. Jonkers, L.J.M. Selen, J.A.M. van der Mullen, E.A.H. Timmermans and D.C. Schram, Department of Applied Physics, Eindhoven University of Technology, P.O. Box 513, 5600 MB Eindhoven, The Netherlands.

The microwave torch named "Torche à Injection Axiale" (TIA), i.e. torch with axial gas injection, was developed by the group of Moisan in 1993 [1]. The TIA can, dependent on the geometry of the nozzle, excite many kinds of gases or mixtures, such as air, CO_2 and noble gases. Therefore, this plasma source is very promising for spectrochemical purposes [2]. Since the TIA was developed, many papers [3,4,5,6,7] have been devoted to the characterisation of this torch. The various reported temperatures of plasmas created by the TIA are compared. Using the particle balance of the plasma [8] it will be shown that the temperatures obtained from passive emission spectroscopy can not be equal to the electron temperature, since they are too low to sustain the plasma.

On the other hand the real electron temperature, as obtained by Thomson scattering, causes a production of free electrons which is much larger then the estimated losses due to recombination, convection and diffusion. One possible explanation is that the diffusion is underestimated. Therefore the radial distribution of the electron density is measured using Thomson scattering. It is found that the n_e profile is hollow, just like in an ICP. The steep outer gradients indeed enhance the losses due to diffusion. However, the real diffusion losses are still not large enough to explain the large discrepancy between production and destruction. Probably some molecular processes are also important. Since the plasma is expanding into the open air, mixing with for instance nitrogen is very likely [9]. The combination of charge transfer $Ar^+ + N_2 \rightarrow Ar + N_2^+$ and dissociative recombination $N_2^+ + e \rightarrow N^* + N$ can lead to an extra destruction channel of charged particles. The presence of this mechanism is supported by the fact that in the plasmas the "First Negative system" of N_2^+ and many atomic nitrogen lines can be observed [3,4,5,6]. The significance of such mechanisms is investigated by controlling the environment in which the plasma expands.

The authors would like to thank AVR-Chemie for their financial support.

[1] Moisan, M., Sauvé, G., Zakrzewski, Z., Hubert, J., *Plasma Sources, Sci. and Technol.*, 1994, **3**, 584.

[2] Timmermans, E.A.H., Letourneur, K., de Groote, F.P.J., Jonkers J., and van der Mullen, J.A.M., "The use of MIP-AES for the quantitative analysis of metals in fly-ashes", a contribution to this conference.

[3] Ricard, A., St-Onge, L., Malvos, H., Gicquel, A., Hubert, J., and Moisan, M., *J. Phys. III France*, 1995, **15**, 1269.

[4] Quintero, M.C., Rodero, A., Gamero, A., and A. Sola, *Europhysics Conference Abstracts 18E ESCAMPIG XII*, 1994, pp. 342.

[5] Rodero, A., Garcia, M.C., Quintero, M.C., Sola, A., and Gamero, A., *J. Phys. D: Appl. Phys*, 1996, **29**, 681.

[6] Jonkers, J., Vos, H.P.C., van der Mullen, J.A.M., and Timmermans, E.A.H., *Spectrochim. Acta B*, 1996, **51**, 457.

[7] Jonkers, J., de Regt, J.M., van der Mullen, J.A.M, Vos, H.P.C., de Groote, F.P.J., and Timmermans, E.A.H., *Spectrochim. Acta B*, 1996, **51**, 1385.

[8] Lieberman, M.A., and Lichtenberg, A.J., *Principles of plasma discharges and materials processing*, John Wiley & Sons, 1994.

[9] de Regt, J.M., de Groote, F.P.J., van der Mullen, J.A.M., and Schram, D.C., "Air entrainment in an inductively coupled plasma measured by Raman and Rayleigh scattering", accepted for publication in *Spectrochimica Acta B*.