

Non equilibrium characterization and spectroscopic analysis of ICP-plasma

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NON EQUILIBRIUM CHARACTERIZATION AND SPECTROSCOPIC ANALYSIS OF ICP-PLASMA

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Inductively coupled plasmas are traditionally characterized by temperature at a specific pressure. In previous work [1,2] it has been demonstrated that the electron density, n_e , is a better measure for the thermodynamic state. Close to LTE, n_e varies over more than two orders magnitude when the electron temperature varies only a factor of two. So, a new description is developed for an isobaric plasma based on electron density and a parameter which describes the non-equilibrium of the plasma. In this description the electron temperature, which is a much less significant parameter, is not needed. Relatively simple partial differential equations result, which can be utilized to model numerically and partly analytically the dynamics of the plasma.

Detailed measurements of electron densities and absolute Ar I line intensities have been performed to verify and underline the above mentioned approach. This is done for the active zone where the power is absorbed and for the analyte zone above the load coil.

From a comparison of model and experiment it is obvious that a description based on electron density is much more discriminate than one based on (electron) temperature. This will be illustrated by giving the results also in terms of the temperature, T_e . These T_e are then compared with temperatures T_e^{LTE} from n_e and p assuming LTE. It is clear that a very high precision would be required in the determination of T_e (better 3% precision) to resolve the non-equilibrium character of the plasma, whereas the accuracy required in n_e is only 20-30%.

The above described "close enough to LTE concept" has also been extended to describe the analyte excitation and ionization. It can be shown that deviations from a LTE distribution are significant (typically a factor 5), but much smaller than the erroneous values up to 1000 reported in the literature.

The resent scheme opens the possibility to model matrix effects and to optimize ICP-performance.

- [1] I.J.M.M. Raaymakers, P.W.J.M. Bouwmans, B. van der Sijde and D.C. Schram, spectrochim. Acta 38B, 697 (1983)
- [2] B.L. Caughlin and M.W. Blades, Spectrochim. Acta 39B, 1583 (1984).