

Spectroscopy – a powerful diagnostic tool in source development

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One of the main tasks in the development of negative ion sources for neutral beam systems is the optimisation of negative ion formation in the plasma. The complex plasma chemistry requires an insight in the underlying processes determined by the plasma parameters. At the present time, the surface process plays the dominant role in the production of negative ions, whereas the destruction is governed by volume processes. The surface process is based on the interaction of atoms or ions with materials of low work function currently achieved by evaporation of cesium. Since the survival length of negative ions is in the range of a few cm, the plasma region close to the extraction area is of particular interest. Thus, diagnostic methods are essential which can provide a correlation of measured plasma quantities with extracted current densities.

Emission spectroscopy represents a passive, and therefore non-invasive, diagnostic tool with a simple and robust set-up. Spectra are recorded easily with sufficient temporal resolution whereas several lines of sight provide spatial resolution. An absolute calibration of the optical system offers the possibility to obtain a variety of different plasma parameters: electron density and electron temperature, gas temperature, atomic and molecular hydrogen densities as well as cesium densities (atoms and ions). In particular, monitoring of cesium emission reflects the cesium distribution inside the source by cesium evaporation and redistribution by the plasma itself, i.e. sputtering during the pulse. Furthermore, this diagnostics is also capable to deduce the most interesting parameter namely the negative ion density. In addition, beam emission spectroscopy is applied which allows a quantification of the stripping losses.

The diagnostic tool is routinely used at the RF sources of the IPP (BATMAN and MANITU). Correlations of line intensities with extracted current densities of negative ions and electrons will be presented and discussed. Improvements have been made in the understanding of the cesium behaviour and the consequences on extraction of negative ions. Since the half-size ITER source RADI will operate without extraction spectroscopic diagnostics will be the basis for extrapolations to expected current densities. The diagnostic tool was also applied to the KAMABOKO arc source on the MANTIS testbed in Cadarache. This offers the possibility to compare sources on the basis of the same diagnostic method for the first time.