Impurity Fluxes

On the collector samples the following metal impurities were permanently detected: Fe, Cr, Cu and Mo. Their origin seems to be clear. Fe and Cr are the main components of the wall material (stainless steel). Cu was eroded from the probe head, and Mo was released from the limiters.

Moreover, on some samples traces of other elements as Ti, Cd and Pb were found. The doubtless identification of the latter two elements was possible by AES- and SIMS-measurements of limiter pieces after their removal from the tokamak on which these elements were also present. Ti is a constituent of stainless steel whereas the origin of Pb and Cd is not known.

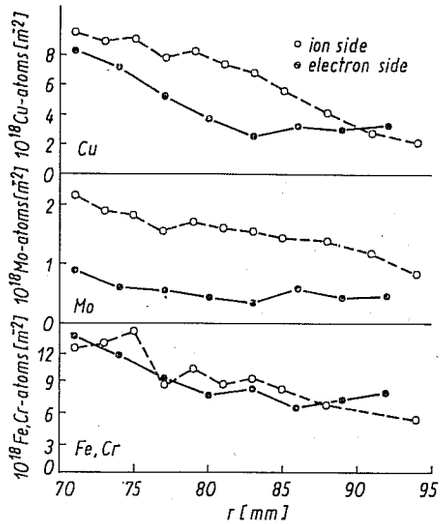

Fig. 7. Dependence of collected impurity fluxes in both toroidal directions on the minor radius
(plasma current 13 kA)

The deposited amount of the impurities is a measure of the impinging impurity flux if erosion processes can be neglected or can be taken into account. In the present experiment, visible erosion traces on collector samples and probe head were not observed. However, the occurrence of Cu on the Si-samples reveals an erosion of the collector probe head. Furthermore, traces of silicon were also found on the molybdenum limiter by AES after some hundred discharges with the collector probe inside the plasma. The above determined energies of the plasma ions hitting the probe head are large enough to induce its erosion by sputtering.

The sputtering yield of protons strongly depends on the surface binding energy which is not exactly known for the deposit. Using a mean value of 10^{-3} sputtered atoms/proton for the impurity species [5] and the above estimated hydrogen flux, an erosion rate of about 4×10^{17} atoms/m^2 per discharge is obtained. A similar value is necessary to explain the amount of Cu eroded from the probe head and redeposited on the Si-samples. Fig. 7 demonstrates that the erosion of the probe head and the Cu-redeposition on the Si-samples is larger on the ion side than on the electron side which can be explained by the higher proton impact energy on that side in near plasma regions.

However, the qualitative behaviour of the impurity deposition on the Si-samples seems to be not strongly affected by erosion and redeposition effects. Thus the deposited amount of the limiter material is higher on the ion side than on the electron side and all impurity fluxes increase continuously with decreasing minor radius (Fig. 7).

On the other hand, it cannot be ruled out that the observed radial dependences of the deposited impurity amount are somewhat influenced by erosion and redeposition processes on the collector surface. Taking this into consideration the observed decay length of about 20—30 mm is an upper limit valid for the decay length of the impurity fluxes.

Looking at the absolute values of the intrinsic impurities Fe and Cr (wall material) and Mo (limiter material) it can be established that the ratio of iron and chromium corresponds to the bulk ratio of the wall material (in Fig. 7 the sum of the Fe- and Cr-amount is presented) and that much more wall material than limiter material has contaminated the plasma. This is a consequence of the relatively small limiter-wall separation. Surface analysis of the limiter surface showed that the surface concentration of Fe and Cr on the limiter is less than 5% and hence the limiter is not a significant source of wall material during high power discharges. On the other hand, the low surface concentration of the limiter material on the wall in the vicinity of the collector probe [6] is an indication that Mo was mainly released from the limiter itself.

Comparing both toroidal directions the intrinsic impurities show a different behaviour. Whereas the wall material shows a nearly symmetric flow to the probe, the flow of Mo is distinctly asymmetric with a preferred transport in codirection of the plasma current. This different behaviour can be explained by the different location of the sources. The source of Mo, the limiter, is 140° toroidally away from the probe ion side. Thus Mo-ions must be transported a longer distance through the plasma.

A possible explanation of the preferred deposition on the probe ion side could be the shorter distance between the source and collector probes in codirection of the plasma current than in counterdirection. However, in experiments with impurity injection it was found that there is also a preferred deposition on the probe ion side even if the distance between source and collector probe is equal in both toroidal directions [7]. Hence the results may be interpreted as a preferred transport of impurities in codirection of the plasma current. Thus, the transport of the impurities seems to be correlated to the asymmetric plasma flow in the boundary layer, as stated above.

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