ion temperatures of 300 eV and 100 eV are obtained with plasma densities up to $3 \cdot 10^{19}$ m^{-3}. The plasma edge is defined by an aperture limiter on $r = 85$ mm and a sector limiter on $r = 75$ mm, both made of molybdenum. For investigating the boundary layer Langmuir and collector probes have been applied. As collectors silicon single crystals ⟨1, 1, 1⟩ have been used. Using a sample transfer system, the Si-samples mounted on a probe head of Cu were exposed to the edge plasma in order to determine properties of fluxes of plasma particles and impurity atoms in co- and counterdirection of the plasma current. The experimental configuration is shown in Fig. 1. Both the sector limiter which spanned a poloidal angle of 50° and the collector probe were on the torus top side. The Langmuir probe was located on the bottom side of the torus.

After exposure the collector samples and also parts of the sector limiter were analyzed by surface analysis techniques. In the case of the Si-samples, mainly RBS with 1,7 MeV ^{4}He$^+$-ions was applied. These measurements were done in channeling geometry to increase the sensitivity for impurity detection and to determine the Si-lattice damage. The damage investigations can give information on plasma fluxes. For hydrogen such investigations are more accurate than trapping measurements because in the latter case the results are strongly affected by adsorption layers at the surface.

In order to correlate the amount of the lattice damage to energy and fluence of the protons, calibration measurements were carried out, similar to earlier investigations with deuterons [2].

Results

Damage Calibration Measurements

Fig. 2 shows the dependence of the damage amount in Si ⟨1, 1, 1⟩ on the incident fluence of hydrogen and for comparison of deuterium at different bombarding energies. As can be seen from Fig. 2 the damage behaviour is similar for both isotopes. However, at a given energy and fluence the values are somewhat lower for hydrogen than for deuterium which can be due to the fact that protons loose more kinetic energy by inelastic processes. As a consequence, also the range of hydrogen in silicon is somewhat shorter than that of deuterium at these low energies [3]. Saturation values of the damage (taken at fluences larger than 10^{21} atoms/m^2) are shown in Fig. 3 in dependence on the incident energy.

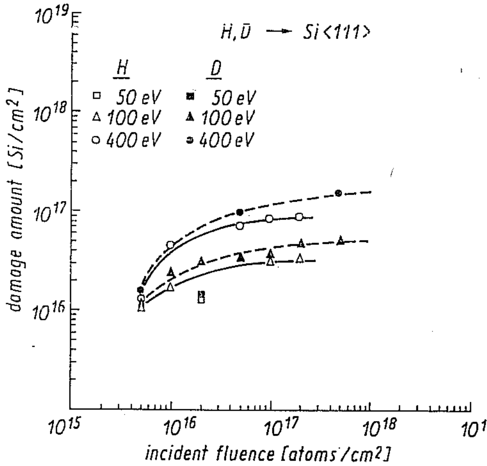

Fig. 2. Dependence of the damage amount in Si ⟨1, 1, 1⟩ on the incident fluence of hydrogen and deuterium

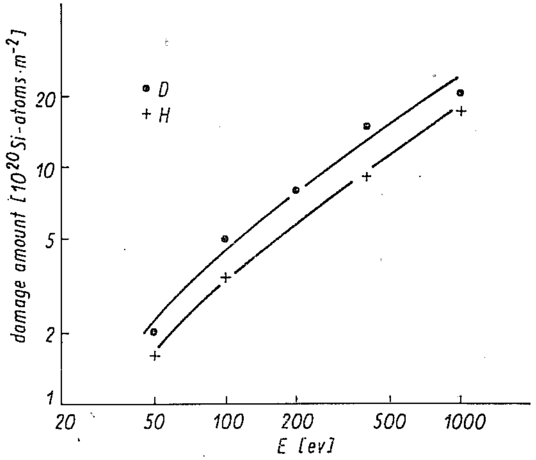

Fig. 3. Saturation values of the damage in Si ⟨1, 1, 1⟩ in dependence on the incident energy of protons and deuterons

Boundary Plasma Measurements

The amount of the plasma induced damage of Si-samples which faced the co- and counterdirection of the plasma current is presented in Fig. 4a and b in dependence on the minor radius. Generally, the damage on the probe ion side (codirection) is larger than on the electron side (counterdirection) in the boundary layer for minor radii up to about 80 mm, while the opposite case is true in the scrape-off plasma. Fig. 4b shows that a strong plasma decay occurs at minor radii between 90 and 95 mm. A similar decay of impurity fluxes was also found in this region.

The dependence of the damage amount on the number of discharges (incident fluence) is shown in Fig. 5. Because the masured damage amount does not depend on the number of discharges we can conclude that saturation is obtained and that the energy distribution is not far from the monoenergetic one. The latter result is due to the fact that the ions are accelerated in front of the probe by the sheath potential.

The mean kinetic energy E transported through the sheath to a floating probe by protons is given by simple models as

$$E \approx 3kT_e + 2kT_i$$

where T_e and T_i are the electron and ion temperature, respectively. Assuming $T_e = T_i$ and taking into account that the damage amount at saturation is not significantly influenced by the transversal energy of the gyromotion of the ions one obtains that the measured damage amount is related to an ion energy of about $4kT_e$. Proton impact energies derived from the observed damage amount using the calibration measurements and deduced values of the electron temperature are presented in Tab. 1 for two regimes with different plasma current.

The different values of the ion impact energies on the ion and electron side of the probe can be explained by the asymmetric plasma flow induced by the toroidal electrical field. Through the action of this field there is a preferred motion of electrons to the electron side and of ions to the ion side of the probe. As a consequence the sheath potential in