Nitrogen transport, inventory evolution and ammonia formation in N_2-seeded discharges on ASDEX Upgrade and JET

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To prevent damage to the divertor target plates, impurity seeding will be unavoidable in ITER. Among the tested impurities, nitrogen (N) is the most likely candidate impurity. Besides promoting the radiation in the plasma edge, nitrogen seeding also provides improved confinement in existing tokamaks. The drawback of using N is the related ammonia formation which could act as a mechanism of in-vessel tritium retention during the active phase of ITER operation.

Ammonia formation was studied both in dedicated experiments with stable discharge conditions and as piggy back data analysis with significantly larger variation of discharge parameters. Formation of ammonia was observed through measuring its concentration in the neutral gas and the emission of the ND radical. Both diagnostics showed same global trends as well as a consistent spatial distribution which showed that the dominant contribution to ammonia formation comes from surface reactions on plasma-shaded surfaces surrounding the divertor.

Amount of detected ammonia was proportional to the N density in the core, as detected with charge exchange spectroscopy, and this relation dominated over the impact of any other discharge parameter. The N density itself strongly was impacted by recycling, governed by the nitrogen wall inventory, which is related to the implementation of N into W and Be. As a consequence, variations of factor of 2 were detected in the N density in the core and edge at the same N_2 seeding rates. In both datasets, the N was injected into the divertor area, which resulted in a very low seeding efficiency.

The seeding efficiency was vastly improved with alternative injection locations (top and midplane), and the impact of the wall inventory was reduced, while keeping the same beneficial effects on the plasma. In discharges where N_2 seeding was replaced with BN powder injections neither N_2 nor ammonia was detected in the neutral gas, while the core N concentration was relatively high. However, the radiation pattern also diverged from the desired distribution around the X-point. Nevertheless, these results demonstrate that the N distribution in the plasma, and the resulting ammonia formation can be strongly affected with the choice of N source.