

Contents

| | |
|---|-------------|
| Preface | viii |
| Acknowledgements | ix |
| Author biographies | x |
| 1 Introduction | 1-1 |
| 1.1 High-Z impurity accumulation | 1-1 |
| 1.2 Carbonization and boronization | 1-4 |
| 1.3 Impurity transport | 1-8 |
| References | 1-9 |
| 2 Transport model | 2-1 |
| 2.1 Atomic processes | 2-1 |
| 2.2 Neoclassical and turbulent transport in the closed-flux surface (core) region | 2-5 |
| 2.2.1 Inward pinch and temperature screening | 2-5 |
| 2.2.2 Ripple transport | 2-7 |
| 2.2.3 Poloidal variation of electrostatic potential | 2-9 |
| 2.2.4 Fluctuation-driven flux | 2-11 |
| 2.3 Transport in the open-flux surface region | 2-13 |
| References | 2-17 |
| 3 Diagnostics | 3-1 |
| 3.1 Introduction | 3-1 |
| 3.2 Passive spectroscopy | 3-3 |
| 3.2.1 UV-visible-NIR spectroscopy | 3-3 |
| 3.2.2 VUV and EUV spectroscopy | 3-11 |
| 3.2.3 Soft X-ray diagnostics | 3-20 |
| 3.2.4 Bolometers | 3-30 |
| 3.3 Active spectroscopy | 3-32 |
| 3.3.1 Principle of charge-exchange spectroscopy | 3-32 |
| 3.3.2 Background line emission | 3-35 |
| 3.3.3 Fine structure | 3-36 |
| 3.3.4 Cross-section effect | 3-38 |
| 3.3.5 Application to diagnostics | 3-40 |
| References | 3-43 |

| | | | | | |
|----------|---|------------|----------|--|------------|
| 4 | Approaches to the study of impurity transport | 4-1 | 7 | Effect of magnetic topology on impurity transport | 7-1 |
| 4.1 | Approaches with an intrinsic impurity redistribution | 4-1 | 7.1 | Magnetic island | 7-1 |
| 4.1.1 | Impurity transport analysis using sawtooth oscillation | 4-2 | 7.2 | Edge stochastic magnetic field region | 7-6 |
| 4.1.2 | Impurity transport analysis using edge-localized modes | 4-5 | 7.2.1 | Ergodic divertor in tokamak plasma | 7-6 |
| 4.1.3 | Impurity transport analysis using the transition from a low-confinement mode to an internal transport barrier | 4-8 | 7.2.2 | Intrinsic stochastic magnetic field in helical plasma | 7-8 |
| 4.2 | Approaches with a non-intrinsic impurity injection | 4-9 | 7.3 | Last closed-flux surface | 7-10 |
| 4.2.1 | Impurity transport analysis with a gas puff | 4-11 | 7.3.1 | Structure of radial electric field at last closed-flux surface | 7-10 |
| 4.2.2 | Impurity transport analysis with a laser blow-off | 4-16 | 7.3.2 | Transport model | 7-14 |
| 4.2.3 | Impurity transport analysis with an impurity pellet | 4-18 | 7.3.3 | Experimental results | 7-16 |
| | References | 4-23 | | References | 7-17 |
| 5 | Impurity transport across magnetic flux surfaces | 5-1 | 8 | Control of impurity accumulation | 8-1 |
| 5.1 | Effect of radial electric field on impurity transport | 5-1 | 8.1 | Impact of electron cyclotron resonance heating | 8-2 |
| 5.2 | Impurity accumulation | 5-5 | 8.2 | Impact of ion cyclotron resonance heating | 8-9 |
| 5.2.1 | Impurity accumulation in tokamak plasmas | 5-6 | 8.3 | Other effects on impurity accumulation | 8-13 |
| 5.2.2 | Impurity accumulation in helical plasmas | 5-8 | | References | 8-16 |
| 5.3 | Poloidal asymmetry of impurity density | 5-9 | | | |
| 5.3.1 | In-Out/Out-In asymmetry of impurity density | 5-9 | | | |
| 5.3.2 | Up-Down/Down-Up asymmetry of impurity density | 5-15 | | | |
| 5.4 | Impurity holes | 5-17 | | | |
| 5.4.1 | Discovery of the impurity hole | 5-17 | | | |
| 5.4.2 | Comparison of impurity transport between tokamak and helical internal transport barriers | 5-19 | | | |
| 5.4.3 | Sign flip of convection velocity | 5-20 | | | |
| | References | 5-22 | | | |
| 6 | Impurity transport in the edge/scrape-off layer region | 6-1 | | | |
| 6.1 | Impurity sources in plasma-facing components | 6-1 | | | |
| 6.1.1 | Physical sputtering | 6-1 | | | |
| 6.1.2 | Chodura sheath | 6-3 | | | |
| 6.1.3 | Tungsten erosion induced by edge-localized modes | 6-5 | | | |
| 6.2 | Impurity transport parallel to the magnetic field line | 6-8 | | | |
| 6.2.1 | Bulk ion flow in the scrape-off layer | 6-8 | | | |
| 6.2.2 | Impurity shielding by friction force | 6-11 | | | |
| 6.2.3 | Impurity parallel flow: measurement and simulation | 6-13 | | | |
| 6.2.4 | Thermal force in the low-collisional scrape-off layer | 6-15 | | | |
| | References | 6-17 | | | |