First $H$-mode with lower-hybrid current drive and lithium-wall coatings on the EAST superconducting tokamak


aInstitute of Plasma Physics, Chinese Academy of Sciences, Hefei 230031, China
bDepartment of Modern Physics, University of Science and Technology of China, Hefei 230026, China
cPrinceton Plasma Physics Laboratory, Princeton University, Princeton, New Jersey 08543, United States
dGeneral Atomics, San Diego, California 92186-5608, United States

In the recent experimental campaign of the Experimental Advanced Superconducting Tokamak (EAST) the first $H$-mode with type-III edge localized modes (ELMs) at an $H$ factor of $H_{\text{ITER98-9}} \sim 1.7$ was produced by lower-hybrid wave (LHW) as only additional power source with strongly off-axis power deposition as required in Advanced Tokamak scenarios at a power level close to the threshold power ($\sim 1$ MW) predicted by the international tokamak scaling. To access $H$-mode at this power level intensive lithium-wall coating was used. Before the application of lithium (Li) the $H$-mode was inaccessible. The threshold power for $H$-mode access follows the international tokamak scaling and a threshold in electron density was identified. This is good news for ITER since ITER will operate at very marginal power level at the beginning of its operation. EAST $H$-mode results demonstrated that the LHW is a promising inexpensive heating alternative for $H$-mode access at low threshold power, provided with steady state capability and compatible with Advanced Tokamak scenarios.

Strong accumulating effects of Li deposition on the $H$-mode access and performance have been observed. With increasing accumulating Li deposition the $H$-mode duration was gradually extended up to 6.4 s corresponding to 60 confinement times, limited only by the possible discharge duration at present. Finally, it was observed that the neutral density near the lower X-point was progressively reduced by a factor of 4 with increasing Li accumulated amount, which was considered as the main mechanism for the $H$-mode power threshold reduction by the Li-wall coatings. The application of lithium could therefore provide a relatively inexpensive way to enhance the performance of tokamak $H$-mode discharges or facilitate the $H$-mode access including ITER.