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Development of Long Pulse Fully Non-inductive High-confinement Plasma with Full Tungsten Limiter/Divertor on EAST

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The major goal of EAST is to demonstrate long-pulse high-performance regime with tungsten wall for scientific understanding in support of future fusion device. Recently, one hundred-seconds steady-state plasmas adapted to reactor-relevant parameters have been achieved in high poloidal beta scenario: (1) a fully non-inductive plasma with high density (ne/nGW ~0.82) and high bootstrap current (fBS~56%) at high βp ~3.0; (2) excellent energy confinement quality (H98y2 ~1.5/βN ~1.8) by electron dominant heating with zero torque injection; (3) key issues of particle and heat balance tackled with actively cooling tungsten divertor; (4) small ELMs throughout the discharge compatible with detachment divertor sustained high core confinement. We enhanced H&CD efficiency at high density by applying high frequency low hybrid current drive (LHCD) system, together with low recycling wall and the synergy effect by adding electron cyclotron heating (ECH) system. The high energy confinement accompanying internal transport barrier is sustained by electron dominant heating, the broaden current profile with high-qmin and negative or weak shear was optimized by early heating and RF power deposition, the analysis also points to the strong effect of Shafranov shift on turbulence. In addition, key issues of particle and heat balance for long pulse operation are addressed with actively cooling tungsten divertor and real-time wall-conditioning. ELMs are kept at low amplitude level at high density to facilitate efficient RF power coupling and reduce divertor sputtering/erosion. Furthermore, long pulse H-modes up to 100s also have been successfully achieved under both boronized and uncoating wall conditions with type II ELMs at q95 ~ 6 similar to ITER SSO scheme. Energy confinement can be kept high (H98y2 >1.1) with and is independent of the tungsten source from the main limiter and heating mixed. On the contrary type-I ELMy H-modes in similar q95 ~ 6 conditions is hard to be maintained for high tungsten impurity sources, and decreased energy confinement illustrating the need for optimum ELM control with full tungsten wall. Solutions in these areas are vital and can offer unique contributions to the critical issues relevant for the next-step fusion such as ITER and CFETR.

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