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FTP/P1-31: Plasma Jets for Runaway Electron Beam Suppression

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Multi-MA relativistic (˜10-20 MeV) runaway electrons (REs), likely to be produced during disruptions in ITER, are a major threat. Dissipation of the REs energy through collisions requires reaching the Rosenbluth critical electron density (4.2×10ˆ22 m-3) by impurity injection, which is extremely challenging. Sufficient impurity mass, very short reaction and delivery time, deep penetration to RE beam location, and efficient ablation and assimilation into the post-current quench plasma are key parameters, whose values are very difficult to be achieved simultaneously on the required time scale for ITER safe and fast shutdown (˜1.2 ms). Complex plasma jets with nanoparticles are an attractive candidate for a REs suppression technique with real-time capability because: (a) they carry a large mass as compared to common gases; (b) can be accelerated to several km/s as a plasma slug in a plasma gun; (c) the resulting plasma jet has a sufficiently high ram pressure to overcome the magnetic field pressure; (d) ablation and assimilation are much enhanced due to their very large surface-to-volume ratio; (e) expanding plasma jet facilitates achieving toroidal uniformity of electron density. FAR-TECH has been developing a coaxial plasma gun prototype with a solid state TiH_2/C_60 pulsed power injector, capable of producing a hyper-velocity (>4 km/s), high-density (>10ˆ17 cm-3), C_60¬ nanoparticle plasma jet in ˜0.5 ms, with an overall reaction-to-delivery time of ˜1-2 ms. We present a comprehensive characterization of the TiH_2/C_60 cartridge, which produced ˜180 mg of C_60 molecular gas by explosive sublimation of C_60 powder, and the first results for a coaxial plasma gun producing a hyper-velocity C_60 plasma jet. In the next step, the prototype system is proposed for a small scale proof-of-principle REs suppression experiment on DIII-D, which has carbon tiles, can produce and control RE beams, and has a broad range of diagnostics. As injection time is ˜1 ms, the nanoparticle plasma jet can be used during the thermal quench to remove RE 'seeds', the current quench to stop the REs 'avalanche', or the RE current plateau, to dissipate the REs energy.

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