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Proof-of-Principle Microwave Plasma Cathode Source toward Negative Ion Production

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The technology for the continuous operation of neutral beam injectors (NBI) for thermonuclear fusion with high-power output based on negative ion sources has not yet been realized. One of the major challenges is the development of, long-pulse, high-power ion sources with limited maintenance requirements.
To meet the diverse requirements of next-generation fusion reactors, plasma sources with high scalability and high controllability for uniform plasma production are needed.
At TAE Technologies, a project has been launched to develop negative ion sources for applications in next-generation field-reversed configuration (FRC) fusion devices [1] and boron neutron capture therapy (BNCT) [2].
As one candidate for such plasma sources, the use of a microwave plasma cathode (MPC) [3] instead of conventional filaments has been proposed. The MPC aims to provide sufficient fast electron density to achieve the scalability and plasma uniformity of arc-driven plasma sources, while requiring less maintenance.
In this paper, initial results from a proof-of-principle experiment are presented, in which a commercially available electron cyclotron resonance (ECR) antenna [4] was biased to modify the electron energy distribution function of the ECR plasma. The influence of the applied bias on plasma parameters is discussed.

[1] T. Roche et al., Nature Commun. 16, 3487 (2025).
[2] A. Dunaevsky et al., UCANS11, Vancouver, Canada (2025).
[3] Y. Matsubara et al., Rev. Sci. Instrum. 63, 2595 (1992).
[4] F. Zoubian et al., Plasma Res. Express 3, 025010 (2021).

Primary author: SHIMABUKURO, Yuji (University of California Irvine, TAE Technologies)

Presenter: SHIMABUKURO, Yuji (University of California Irvine, TAE Technologies)

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