**Development of GaAs and GaN passive millimeter-wave imaging diagnostics on the DIII-D tokamak**

Ying Chen1, Yilun Zhu1, Xianzi Liu1, Guanying Yu1, Yu Ye1, Jo-Han Yu1, Gerrit Kramer2, Neville Luhmann Jr.1

*1 University of California, Davis, Davis, United States*

*2 Princeton Plasma Physics Laboratory, Princeton, United States*

Millimeter-wave imaging diagnostics provide 2D/3D fluctuation structures of density and temperature in tokamak, which are essential for dangerous disruption prediction and better plasma physics understanding. The passive visualization radiometer, Electron Cyclotron Emission Imaging (ECEI), has been developed and applied on tokamaks throughout the world since 1995. Based on the rigors to which fusion plasma diagnostics are subjected, the innovative system-on-chip generation diagnostics have been developed and demonstrated epoch-marking breakthroughs, including over 400x signal level gain, over 85% electronics noise suppression, and extremely high integration level. The W-band (75-110 GHz) gallium arsenide (GaAs) receiver chip (size 3 x 3 mm2) has been developed and applied to the DIII-D ECEI system since 2017. It provides both 2D equilibrium temperature profiles and temperature fluctuations. While facing several orders of magnitude stronger neutron radiation on burning plasma reactor, radiation tolerance is the most urgent requirement to all diagnostics. The employment of wide bandgap semiconductors provides one promising solution for millimeter-wave measurement by virtue of its wider bandgap, which allows the sensitive detector to operate at higher voltages, temperatures, and frequencies. In 2022, a W-band gallium nitride (GaN) passive receiver chip (5 x 3 mm2) has been developed by the University of California at Davis, for further improvement against the radiation (auxiliary heating, neutron, X-ray) harsh environment. The system-on-chip millimeter-wave detectors are developed as general modules for amplitude and phase measurements, which could be widely applied to radiometers, reflectometers, interferometers, scattering, and polarimeters for present and future diagnostics.

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