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Space Propulsion Powered by Millimeter-Wave Discharge

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This paper presents a beamed energy propulsion[1] thruster, "Microwave Rocket" which obtains propulsive energy by a millimeter-wave beam transferred from the ground as illustrated in Fig. 1. A megawatt-output oscillator, Gyrotron,[2,3] which is exclusively developed as a heating device for a nuclear fusion application, is a promising beam source device for rocket propulsion.

Figure 1 Schematic image of the BEP rocket, artist image.

The millimeter-wave beam is received through a tapered beam-concentrator and guided into a cylindrical thruster body. Then, millimeter-wave discharge is induced in the thruster: An ionization front propagates at a supersonic speed by absorbing the beam energy and drives a millimeter-wave supported detonation (MSD) wave: Atmospheric air inside of the thruster is shock-compressed, resulting in impulsive thrust.

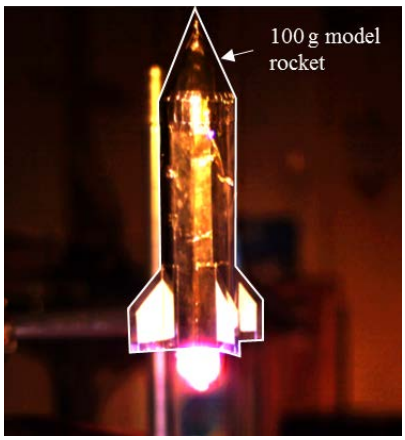

Figure 2 100 g model rocket launch in a multi-pulse operation.

We have demonstrated thrust generation in single pulse and repetitive pulse operation modes[4,5] and launched a 126 g thruster model up to 2 m altitude as shown in Fig. 2 using a 1-MW class gyrotron developed by Japan Atomic Energy Agency.

Physics of millimeter-wave discharge[6-8] has not been fully understood and propagation speed of the detonation wave is unpredictable. Figure 3 shows the measured and computed millimeter-wave discharge.

Father studies in both experiment and calculations are necessary for the optimization of the thruster design and operation.

(a) (b)

Figure 3 Millimeter-wave discharge in atmospheric air. The power beam frequency is 170 GHz and its intensity is over 10MW/cm^2. (a) observed[5] and (b) computed.[9]

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