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Experimental studies on electromagnetic radiation intensification in GHz band by sub-wavelength plasma structures

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The technology of radio frequency (RF) radiation intensification based on modulation effects of sub-wavelength plasma structures is developed and reported [1-3]. It exhibits important scientific significance and promising potential of broad applications in various areas, such as wireless information network and microwave communication and control technology, etc. A novel achievement based on sub-wavelength plasma modulation of emission and reception enhancement of radio frequency (RF) radiation is carried out in experiments and corresponding numerical simulation analyses. An inductively coupled plasma (ICP) is applied to provide appropriate sub-wavelength structures aiming at enhancing the electromagnetic radiation of an omnidirectional ellipse dipole antenna, as shown in Fig. 1.

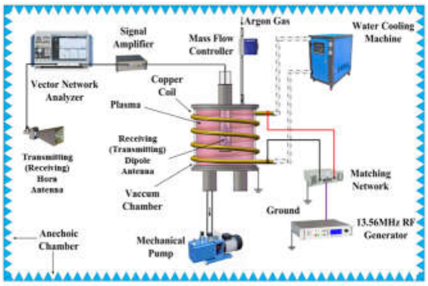

Fig. 1. The schematic diagram of experimental setup

As shown in Fig. 2, the considerable intensification on receiving signal gain up to ~10 dB than that without the plasma modulation is observed in the experiment for the first time of ~1 GHz band. Meanwhile, electromagnetic signals transmitted by the plasma added antenna still maintain good quality for communication. Particularly, differing from the traditional RF electromagnetic radiation enhancement method characterized by focusing the radiation field of antenna in a specific direction, the sub-wavelength plasma-added intensification presents an omnidirectional enhancement.

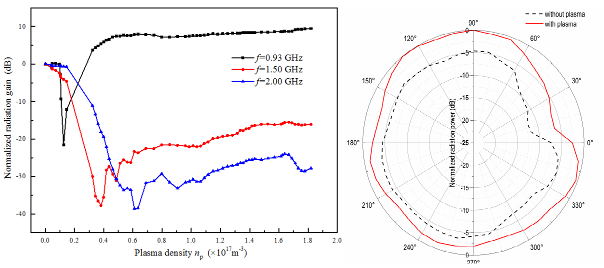

Fig. 2. The normalized radiation gain varied with the plasma density for different frequencies and the normalized H plane radiation pattern at 0.97 GHz with or without plasma

The plasma parameter dependence of the optimal modulation technology is further investigated by numerical simulations, as shown in Fig. 3. And the modulation role of the antenna radiation with sub-wavelength plasma layer located at different positions was studied, and the inhomogeneous plasma layer with multiple electron density distribution profiles were employed to explore the effect of plasma density distribution on the antenna radiation, as shown in Fig. 4. The relevant results have exhibited important scientific significance and application potential of sub-wavelength plasma modulation on communication technology.

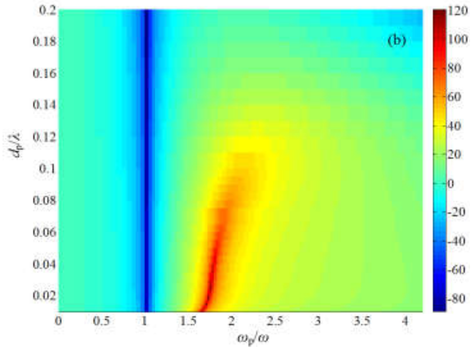

Fig. 3. 2-D contour maps of the cooperative effect of the relative plasma thickness (d_p/λ) and relative plasma frequency (ω_p/ω) on radiated power

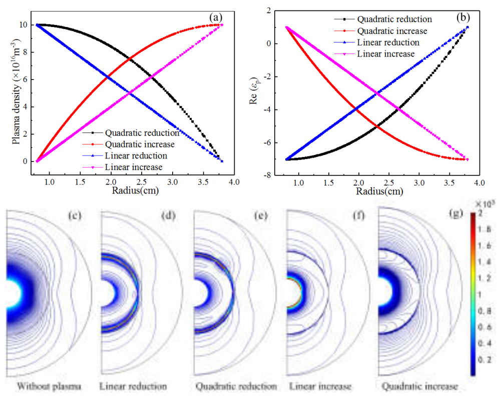

Fig. 4. a) Different density distribution; b) Variation of real part of plasma relative permittivity for different density distribution; c) - g) The contour of electric field intensity

References

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[3] Fanrong Kong, Peiqi Chen, Qiuyue Nie*, et al. Research on radiation characteristics of dipole antenna modulation by subwavelength inhomogeneous plasma layer. AIP Advances, 2018, 8(2): 025014.