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Design of a metamaterial slow wave structure for an O-type high power microwave generator

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We describe a new O-type high power microwave oscillator that uses a metamaterial slow wave structure (MSWS) supporting waves with negative dispersion. The MSWS comprises periodically alternating, oppositely oriented split ring resonators (SRRs) connected to a metal tube where the distance between the rings is much less than a wavelength of the radiation generated. The SRRs provide negative permeability $\boldsymbol{\mu}$. The diameter of the metal tube is such that the generated oscillations are below cutoff for a regular waveguide with the same dimension, thus providing negative permittivity $\boldsymbol{\varepsilon}$. A tubular electron beam propagates coaxially through this structure. The interaction space is coupled with the outer coaxial channel through gaps between the SRRs. Radiation is extracted in an endfire manner at the end of the outer channel via a conical horn section. Using particle-in-cell (PIC) simulations, it was found that the electron beam in the interaction space forms a sequence of trapped electron bunches by the synchronous operating wave. The output parameters of this oscillator for an applied voltage U = 400 kV, electron beam current I = 4.5 kA, and guide axial magnetic field B = 2 T are radiation power P = 260 MW, radiation frequency f = 1.4 GHz, and electronic efficiency $\eta = 15\%$ when the total SWS length L consisting of 12 split rings is 34.5 cm. The output radiation pattern corresponds to a TE_{21}-like hybrid mode. This article presents details on the simulations of this novel structure and computational and experimental cold tests of a prototype structure in preparation for experimental hot tests. *Published by AIP Publishing.*
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