TWO-DIMENSIONAL PERIODIC LATTICE CHERENKOV MASER: SCALABILITY FROM 37.5GHz TO 350GHz

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Masers capable of producing high-power output radiation in the spectral range from 100's of GHz to low-THz, to address a range of user needs will be presented. Future applications include remote sensing and biological/medical imaging (to reduce the exposure time during large area mapping). Compact masers that are capable of producing the required output power at these frequencies presently are not widely available. Many current techniques require high-voltage (sometimes up to 500kV) high-current electron beams giving multi-MW output powers. However at low-THz (0.3THz – 1THz) frequencies many applications require an output power of 1kW-10kW but need compact transportable sources of coherent radiation that use a relatively low voltage (from 50kV-100kV) and low current (up to 100A) electron beam.

In this paper the scaling of a periodic 2D lattice to form a Cherenkov maser interaction region compatible with an electron beam of energy 50keV (as opposed to a 300keV electron beam [1,2]) is presented. We discuss the results of numerical studies of a Cherenkov maser based on a 2D lattice and demonstrate the scalability of such devices from the mid-GHz to low-THz frequency range. The results of the experimental studies of a Ka band 2D periodic lattice of cylindrical geometry are shown and compared with theoretical predictions. The influence of the periodic structure parameters on the maser performance is discussed and the possibility to tune such masers using electron beam voltage is demonstrated. We show that in all cases the Fresnel number of the maser based on such a cavity formed by a 2D periodic lattice is larger than 1 while still being able to maintain the coherence of the radiation due to the two-dimensional distributed feedback mechanism [3]. The large interaction region formed by the periodic lattice allows a moderate power density inside the beam-wave interaction space whilst simultaneously avoiding the formation of electron beam instabilities associated with a high beam charge density. We demonstrate that the structure also provides effective mode selection over the azimuthal and radial wave numbers for all frequency ranges studied.

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3. A. W. Cross, I. V. Konoplev , A. D. R. Phelps, K. Ronald, J. Appl. Phys., 93, p.2208, (2003).