PIC SIMULATION OF MM AND SUB-MM RADIATION SOURCE BASED ON TWO-STREAM INSTABILITY

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Although there has been much interest in the THz region since as early as the 1920s, this part of the spectrum still remains one of the least used[1]. The interest in terahertz is driven by various fields such as biology, medicine, homeland security, and environmental monitoring, just to name a few[2]. THz radiation combines the penetrating power of lower-frequency waves and imaging capabilities of higher-energy infrared radiation. Conventional electronic sources of THz radiation either require very small structures or are bulky and expensive to operate. Optical sources necessitate cryogenic cooling and are presently capable of producing milliwatt levels of power at terahertz frequencies.

We propose a millimeter and sub-millimeter wave source based on a well-known phenomenon called the “two-stream instability.” The source is compact, simple in design, and requires low-energy and low-current electron beams for operation. In the proposed source the gain is obtained through the interaction of electron beams provided the velocity difference exceeds a threshold value. As a result, the presence of resonators and other circuits is not required and this fact frees the source from problems associated with complex machining, precise alignment, expensive parts, and catastrophic failures. The proposed device promises to be a reliable and inexpensive source of millimeter and sub-millimeter wave radiation and has the potential to generate watts of power at THz frequencies.

The threshold velocity difference and velocity difference for maximum gain are calculated and derived for two electron beams in a beam pipe via a small-signal or perturbation theory. Gain (dB/mm) as a function of total beam current and frequency (obtained through 2-D PIC simulations up to 100 GHz) are, to first order, in excellent agreement with the theory. More 2-D PIC simulations are under way (to be followed by 3-D simulations) in order to further test and validate the proposed configuration and underlying theory at frequencies up to and exceeding 1 THz.

1. P. Siegel, “Terahertz Technology”, IEEE Trans. Microwave Theory Tech., March 2002, vol. 50, pp. 910-928.
2. M. Tonouchi, “Prospect of Terahertz Technology”, 19th International Conference on Applied Electromagnetics and Communications, September 2007, pp. 1-4.