Effective Surface Plasmon Mediated Sub-millimeter Smith-Purcell FEL

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***Abstract*—A metallic slab with a 1D array of rectangular holes together with two counter-streaming electron beams is considered as a sub-millimeter Smith-Purcell FEL. The interaction between electron beams and the effective surface plasmon on the structure is investigated using numerical simulation tools. A scanning electron microscope-based experiment is being prepared for the verification of the interaction of effective surface plasmon and an electron beam.**

I. Introduction And Background

DUE to its simple radiation mechanism and broad spectrum, Smith-Purcell radiation (SPR) [1] has been adopted for the generation of radiation covering wide range of electromagnetic spectrum. Moreover, the lack of compact tunable sources in the terahertz frequency regime, 0.3-3 THz, is attracting more attention to SPR. In addition to various attempts to improve the weak intensity of spontaneous SPR [2]-[5], we've introduced another way which uses counter streaming electron beams and 1D slit array.[6]-[7] A 0.5THz experiment is underway. The sheet electron beam is prepared and in the process of testing. Also single beam experiment with SEM is underway.

II. Results

As depicted in Fig. 1, the Smith-Purcell device under consideration consists of two counter-streaming electron beams and a 1D array of rectangular holes between them. This 1D array has two roles in the radiation mechanism. One is to support surface-confined modes which are responsible for the bunching of the electron beam. The other is to provide momentum shift to the evanescent wave of the electron beam which results in the well-known Smith-Purcell radiation.

To generate 0.5THz using 12kV electron beam, geometrical parameters such as period and slit length were chosen to be 128um and 600um, respectively. [6]-[7] With this set of parameters, the electron beam interacts with the pi-mode. Though the surface-confined mode doesn't directly couple to radiation mode, optimizing the interaction between the electron beam and this surface-confined mode can enhance the output power due to its effect on the bunch formation. The geometrical parameters such as width and thickness of the holes were further optimized using FDTD and PIC simulations.

Before the real experiment adopting two counter-streaming electron beams, a Scanning Electron Microscope (SEM), Fig. 2, is being utilized to investigate the 1D array of rectangular holes as a diffracting element for SPR. Samples with various width, a, and thickness, L, are being fabricated using Deep Etch X-ray Lithography and will be placed in the SEM machine to interact with the electron beam. The details will be presented.

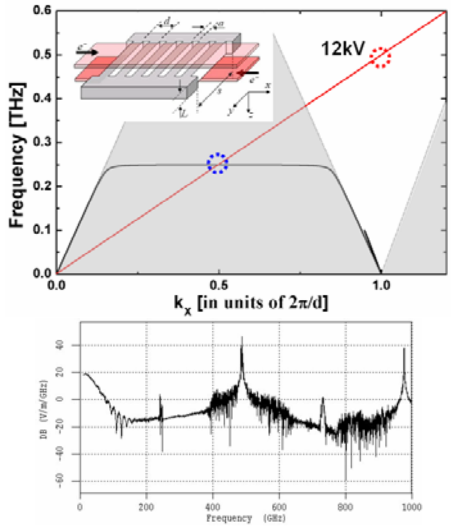

Figure 1. 0.5THz SPR PIC simulation

Figure 2. Single beam experiment using SEM

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