Study of a high-frequency modulated electron beam produced by a ferroelectric cathode

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We present a detailed study of the recently discovered modulation at frequencies of hundreds of MHz of an electron beam produced by a plasma cathode. The plasma cathode consists of a ferroelectric disk sample [$BaTiO_3$ or $Pb(Zr,Ti)O_3$] that is placed in a cylindrical metal box having an output window covered by a grid. The plasma is prepared by a noncomplete discharge which is ignited by a few kV driving pulse applied between a front electrode made of strips and a solid rear electrode. Experiments were carried out at accelerating voltages of $\leq$ 45 kV and pulse duration of $\leq$ 40 μs. It is found that the current modulation (depth of modulation 60% - 80%) appears only when the driving pulse is applied to the front electrode of the ferroelectric sample and the rear electrode is grounded. The modulation spectrum is quite narrow ($\leq$ 3%), with harmonics at frequencies up to a few GHz. The basic frequency of modulation is found to depend on the length of the feed cable to the sample, the amplitude of accelerating voltage, and the anode-cathode gap. Active control of the frequency of the electron beam modulation in the range of 200 MHz - 420 MHz is demonstrated. Investigation of the plasma and the beam modulation properties and their dependence on the experimental parameters is presented. The results indicate the formation of a plasma at the vicinity of the front electrode of the ferroelectric sample during the modulation. In addition, we studied the potential distribution inside the cathode box between the front surface of the ferroelectric sample and the output cathode grid. The results are discussed within the framework of electrons oscillating in the potential well created by the positively charged plasma having feedback coupling with the input cable.