DEVELOPMENT OF PHOTOINJECTOR IN IAP RAS*

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Short dense electron bunches with a charge of 100 pC, duration up to 10 ps and a small spread of particle parameters obtained with a photocathode and accelerated up to MeV average energies can be used in such promising applications as generation of high-power short terahertz pulses of undulator or cyclotron radiation, Compton scattering of laser pulses, as well as injection into more energetic accelerators. A photoinjection complex is being created at the IAP RAS [1], in which a step-by-step acceleration of electrons up to energies of the order of 20 MeV should be realized while maintaining the normalized transverse emittance of bunches at a level of 1 mm mrad. The report describes the design of the accelerating and focusing systems of the accelerator and the development of new versions of the photocathode based on diamond films.

The first section of the accelerator is a classic version of a photoinjector with one-and-half-cell accelerating structure based on the symmetric TM π-mode. Powering the cavity from a 5 MW klystron at a frequency of 2.45 GHz provides an amplitude of the accelerating field at the cathode of about 70 MV/m and particle acceleration to an average energy of ∼3.6 MeV. The design of the magnetic electron-optical system of the photoinjector includes a focusing system of the accelerating section consisting of a main solenoid with a field of about 0.25 T and a counter-cathode coil providing a zero magnetic field on the cathode surface. Such a system provides a regime of compensation for the space charge-related emittance [2] and focusing of the electron beam over a length of about 1 m.

For the second stage, a system of accelerating sections and focusing solenoids has been designed. Each accelerating section is a sequence of 6 coupled cells powered by a single microwave signal source at a frequency of 2.45 GHz. This frequency coincides with the operating frequency of the first stage of the photoinjector, which makes it possible to synchronize all final microwave amplifiers in both stages, feeding them through controlled phase shifters from one stable low-power continuous microwave signal source. The operating TM mode of the accelerating structure is a π-mode with antiphase field oscillations in neighboring cells. With a power supply signal of 5 MW, the amplitude of the accelerating field in the cavities is about 35 MV/m, which, according to calculations, provides an increase in the energy of relativistic particles of about 6.5 MeV over a length of one section of about 40 cm. The sequential arrangement of three such sections makes it possible to achieve an acceleration of 3.5 MeV photoinjection electron bunch up to an average energy of more than 20 MeV.

In parallel with the design of the accelerator, a study of photocathodes based on CVD diamond films is under way. Such cathodes can combine high quantum efficiency and insensitivity to vacuum quality [3, 4]. Investigations are carried out using a specially designed vacuum chamber, which makes it possible to register the electric charge emitted from the cathode surface under the action of laser radiation. According to preliminary results, the quantum efficiency of even a thin (several nm) diamond layer can exceed the quantum efficiency of a copper photocathode by several times, depending on the characteristics of the doping of the diamond.

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