MULTI-BEAM PULSED ELECTRON ACCELERATOR FOR RADIATION PROCESSING

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Abstract

This report describes a design of a multi-beam electron accelerator for beam processing. A wide range of feasible electron beam parameters allows to use these accelerators for various applications (from the environment protection to the treatment of medical and infectious waste). Such accelerators can provide the electron beams with parameters: electron energy 0.1 - 1 MeV, average beam power up to ~500 kW and very large cross section of the electron beam. The accelerator design is based on an use of coaxial spiral-line resonator as high voltage supply and multi-cathode, multi-window electron optical system. Electron pulses are produced by the cold cathodes with a threshold emission characteristic.

1 INTRODUCTION

Electron Beam Processing is widely used in a variety applications. At present the basic form of energy in the chemical industries (a heat, various chemical reactions and low-voltage electricity) starts to be replaced step by step with plasma-chemical initiation of many industrial processes [1-4]. Very good and simple illustration of large difference between traditional and plasma-chemical forms of a process as applied to the light sources can serve the difference in efficiency among the usual lamp, fluorescence lamp and laser where the light fluxes are large in many orders of magnitude as compared with the usual lamp.

The high power beams of the fast electrons is one of the most promising tools for initiation and conducting various physical and chemical processing in the future industry. The efficiency of the radiation technology can be over and over increased by means of an usage a secondary electrons to excite molecules in an irradiation vessel. One fast electron produces a lot of secondary electrons and to increase the energy of these secondary electrons up to the molecule excitation energy an usage of RF and pulsed electric field is suggested [5]. The multi-beam high repetition rate accelerator allows one to use the very cheap DC electric field to accelerate the secondary electrons.

2 ACCELERATOR DESIGN

The design of very compact electron accelerator is based on the usage of a mosaic cold cathodes with threshold emission characteristic which permit to employ a sinusoidal voltage for forming short pulses of the electron beam current. The electron emission of such cathodes starts when the sinusoidal voltage exceeds the threshold value of this voltage and a very cheap and reliable resonance transformer excited by transistor modules can be used as high voltage source. The dispersion of the electron energy can be very low when amplitude of sinusoidal voltage is about the threshold magnitude.

The cathode is constructed as a mosaic of a large number of small cathodes. The electrons emitted by each small cathode are directed to each own output window. The diameter of each window is rather small (20-40mm) which allows to install titanium or metal-polymer foil of 10μm thickness. As a result, beam losses are reduced significantly with respect to a standard design (one beam, one window).

It is important to notice that such a design allows one to increase the number of windows in a simple way. Choosing suitable form and area of the cathode and anode one can provide vary high total beam current. Actually the total electron beam power is limited by the power of transistor modules which is used to convert a DC voltage to a high frequency rectangular voltage. Modern transistor modules allow to construct the 100kHz, 500kW voltage converters.

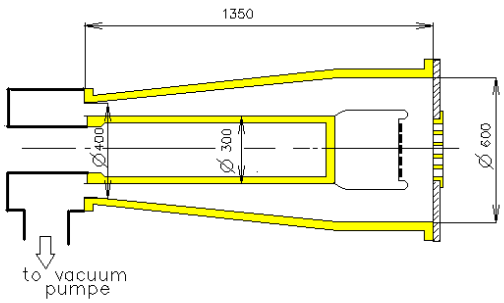

Figure 1: Scheme of the multi-beam high repetition rate (100kHz) electron accelerator

The high voltage resonance transformer is based on λ/4 coaxial resonator. The coaxial line of the resonator is designed as a spiral delay-line. The spiral coaxial resonator is excited by a magnetic flux of a primary

winding located outside the accelerator. Using of the vacuum insulation allows one to enhance significantly the resonator quality (up to 100-1000) and to reach high conversion efficiency of the electric net power to the electron beam power. The experimental verification of 200 keV, 20 kW model of the multi-beam pulsed electron accelerator is shown high conversion efficiency (95-98%) and high reliability during six years of operation.

A scheme of the multi-beam accelerator is shown in Fig.1. Dimensions of the accelerator correspond to an accelerating voltage equal to 300 keV. At this voltage the strength of the electric field is equal to ~30kV/cm which ensure the high reliability of the high voltage system at a moderate quality of electrode surfaces.

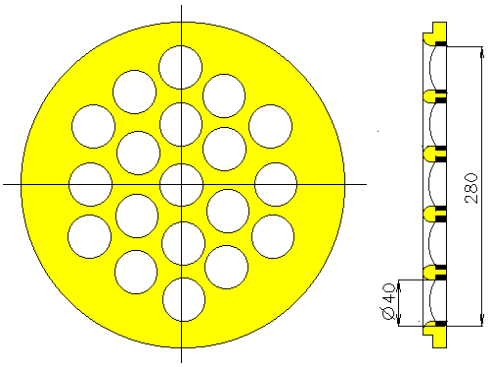

Figure 2: Multi-windows extraction system of the 300 keV, 10 kW electron accelerator

The set of extraction windows of the 300 keV, 10 kW accelerator is sown in Fig 2. At 30 keV/cm electric field strength the dimensions of the 1000 keV accelerator can be increased to ~3 times. The dimensions of the accelerator can be significantly decreased when electrical polish or modification of the electrode surface is curried out.

The 500-700 keV, 30 kW accelerator have been now constructing at JINR (Dubna, Russia).

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