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Optical Bragg accelerators

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It is demonstrated that a Bragg waveguide consisting of a series of dielectric layers may form an excellent optical acceleration structure. Confinement of the accelerating fields is achieved, for both planar and cylindrical configurations by adjusting the first dielectric layer width. A typical structure made of silica and zirconia may support gradients of the order of 1 GV/m with an interaction impedance of a few hundreds of ohms and with an energy velocity of less than 0.5c. An interaction impedance of about 1000 Ω may be obtained by replacing the Zirconia with a (fictitious) material of $\varepsilon=25$. Special attention is paid to the wake field developing in such a structure. In the case of a relatively small number of layers, it is shown that the total electromagnetic power emitted is proportional to the square of the number of electrons in the macrobunch and inversely proportional to the number of microbunches; this power is also inversely proportional to the square of the internal radius of the structure for a cylindrical structure, and to the width of the vacuum core in a planar structure. Quantitative results are given for a higher number of dielectric layers, showing that in comparison to a structure bounded by metallic walls, the emitted power is significantly smaller due to propagation bands allowing electromagnetic energy to escape.

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