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MeV-scale simulations and fabrication tests of silicon slot and woodpile-based waveguides for Dielectric Laser Accelerators

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Hollow-core dielectric Electromagnetic Band Gap (EBG) microstructures powered by lasers represent a new and promising area of accelerator research thanks to the dielectric higher damage threshold and greater accelerating gradients with respect to the metallic counterparts. In this paper, we present MeV-scale 3D beam-dynamics simulations and fabrication results relative to a silicon, woodpile-based travelling-wave structure operating at the frequency of 60 THz (wavelength λ = 5 μm). The simulated CST and HFSS electric field has been employed as input for the Astra simulation package, in order to perform beam-dynamics calculations considering beam injection and extraction into the structure and effects on the main beam parameters, aiming at improving the beam brightness. In order to mitigate space charge effect without reducing the beam current, CW operation is desirable: therefore, the temperature distribution and heat flow under a CW laser power for accelerating gradients ≥ 250 MV/m are analysed.
Finally, we show the first Si prototypes of the woodpile structure obtained by Two Photon Polymerization fabrication process. This technique allows to reach resolutions down to hundreds of nanometers, offering the possibility to print Si-rich structures, or woodpile skeletons to be infiltrated with Si by CVD technique.

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