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Generation of 510 MW of power at X-Band using a metamaterial structure at the Argonne Wakefield Accelerator Facility

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We present recent experimental results generating 510 MW of power at 11.7 GHz using a metallic metamaterial-based power extractor for use in structure-based wakefield acceleration (SWFA). SWFA is a novel acceleration scheme in which high-charge electron bunches are passed through a power extractor structure to produce a high-intensity wakefield. The resulting wakefield can either be used to accelerate a witness bunch in the same beamline or passed through a waveguide to a secondary acceleration beamline. Our approach uses a specifically-tailored metamaterial for the power extractor structure. The properties of the metamaterial, including an all-metal construction and simultaneously high group velocity and shunt impedance, allow us to overcome some of the difficulties encountered by other SWFA techniques.

Here we present the Stage 3 experimental design and results. The Stage 3 experiment builds on the success of the earlier Stage 1 and Stage 2 experiments, which generated 80 MW and 380 MW RF pulses, respectively, with several-nanosecond duration using the 65 MeV electron beam at the Argonne Wakefield Accelerator facility. The Stage 3 experiment implemented significant design improvements, including an all-copper structure, a fully-symmetric output coupler design, and treatment to reduce breakdown risk. These improvements led to the successful generation of 510 MW at 11.7 GHz, which is currently the highest power generated by an extractor for SWFA. This talk will discuss the background of the metamaterial-based design, the advancements that enabled our Stage 3 results, and the potential for increased power generation in the future.

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