220 GHZ MICROFABRICATED SHEET BEAM AMPLIFIER GRATINGS

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The NRL Microfabricated 220 GHz Vacuum Electronic Amplifiers project is aimed toward demonstrating a 50 watt CW output power slow-wave amplifier at 220 GHz based on a sheet electron beam [1]. Slow-wave amplifiers are very compact owing to their intrinsically small electromagnetic circuit features. These small features, however, pose challenges for high power generation because of the high power densities required. As a material, copper has desirable properties for mmW vacuum electronics: Low mmW resistive loss, high thermal conductivity, ease of fabrication, and vacuum compatibility. A suite of microfabrication techniques is being developed in-house for accurately fabricating mmW structures from OFHC copper for high power density.

The present grating design consists of a period of 0.150 mm, half of which is the 0.075 mm slot size, and a grating width of 2.2 mm to accommodate the sheet beam. The depth of the slots required is 0.315 mm for interaction at 220 GHz with a 19 kV, 0.5 A sheet beam. From linear theory, we estimate a peak unsaturated growth rate of 33 dB/cm with a 0.5 GHz bandwidth. The sheet beam has an aspect ratio of 11.

An input coupler design is underway to provide low insertion loss, wide bandwidth in a compact space, and a strong electric field E_z in the direction of the beam, yet prevent backward waves from being launched toward the electron gun. The Ansoft HFSS simulation achieves 2 dB insertion loss, 2 GHz bandwidth and 24 dB directivity.

The amplifier circuits are fabricated by ultraviolet lithography (UV-LIGA) using the SU-8 photoresist for thick layering. An in-house copper electroforming system is used to deposit copper, and a sequence of steps is used to remove the SU-8 [2] involving softening, swelling, burning and plasma removal. Deep Reactive Ion Etching (DRIE) was used as an alternative for making cold test circuits and could be used to make silicon molds for electroforming copper circuits.

1. J. P. Calame, "High heat flux thermal management of microfabricated upper millimeter-wave vacuum electronic devices," *IEEE Int'l Vac. Elec. Conf.*, pp.50-51, April 2008.
2. P. M. Dentinger, W. M. Clift, S. H. Goods, "Removal of SU-8 photoresist for thick film applications," Microelectronic Engineering, Vol. 61-62, 2002, pp. 993-1000.

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