First Results of a Low-THz Helical Groove-Guide TWT

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ABSTRACT: *The paper presents the basic design of a low-THz TWT consisting of a helically arranged groove-guide driven by a hollow beam. The beam interacts with the wave in a periodic sequence of gaps. The small signal gain was estimated as 0.6 to 0.9dB per winding. First simulations prove the validity of the idea and confirm the estimated gain.*

Introduction: As an alternative to high power sheet-beam TWT's [1] a hollow-beam TWT is proposed, where the beam passes through a helically wound groove-guide, Fig. 1.left. While in typical TWT's an RF-structure slows down the wave propagation, here the interaction is similar to the one in a folded waveguide. An azimuthal fraction of the beam sees a periodic sequence of gaps, and synchronism is obtained when the wave travels a full helical winding while an electron passes from one gap to the next. An analytical estimate indicated a small signal gain between 0.6 and 0.9dB [2] and encouraged further investigations.

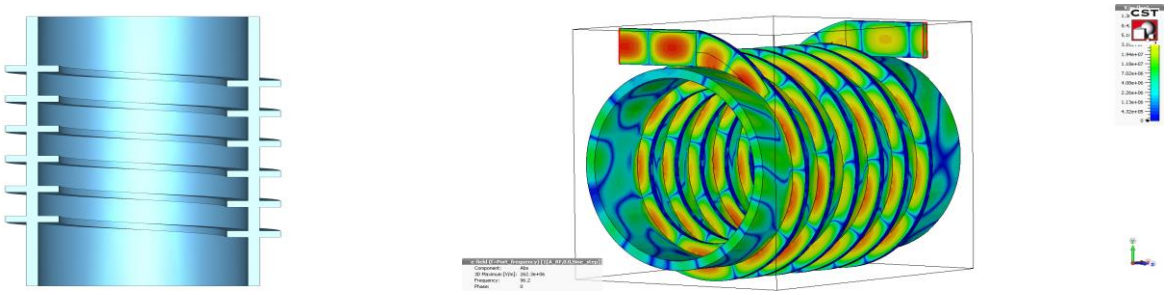

Figure 1: Left: Cross-section of the RF structure. Right: Field intensity plot

First simulations were done with CST Studio. Eigen-modes in the RF structure had to be investigated, Fig. 1.right, and TEM-waves in the beam channel were suppressed by longitudinal fins. After finding a coupler geometry with reasonably small reflection, good simulation results have been obtained. Due to the fins in the beam channel the hollow-beam was split into azimuthally distributed beamlets for PIC simulations. Synchronizing the beam with the RF wave at 95GHz resulted in a good bunching of the beam, Fig.2, and a gain of 7dB with 12 windings could be achieved.

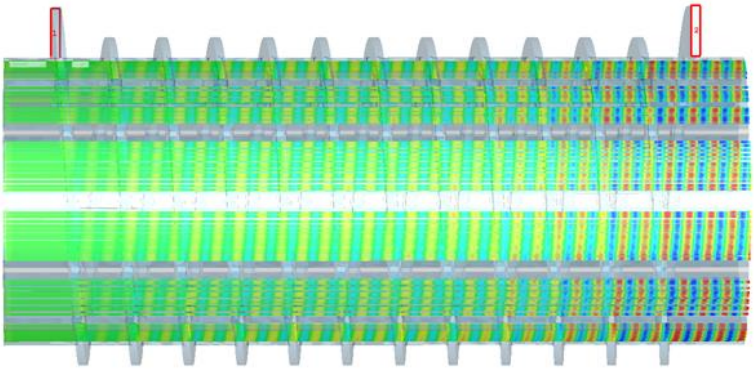

Figure 2: Modulated beam

References

1. B. E. Carlsten et al., “Technology development for a mm-wave sheet-beam traveling-wave tube”, IEEE Transactions on Plasma Science, Vol. 33, No. 1, February 2005, pp. 85-93
2. H. Henke, "Small signal treatment of a 94-GHz helical waveguide TWT", IEEE Trans. on Electron Devices, Vol. 63, No. 3, March 2016