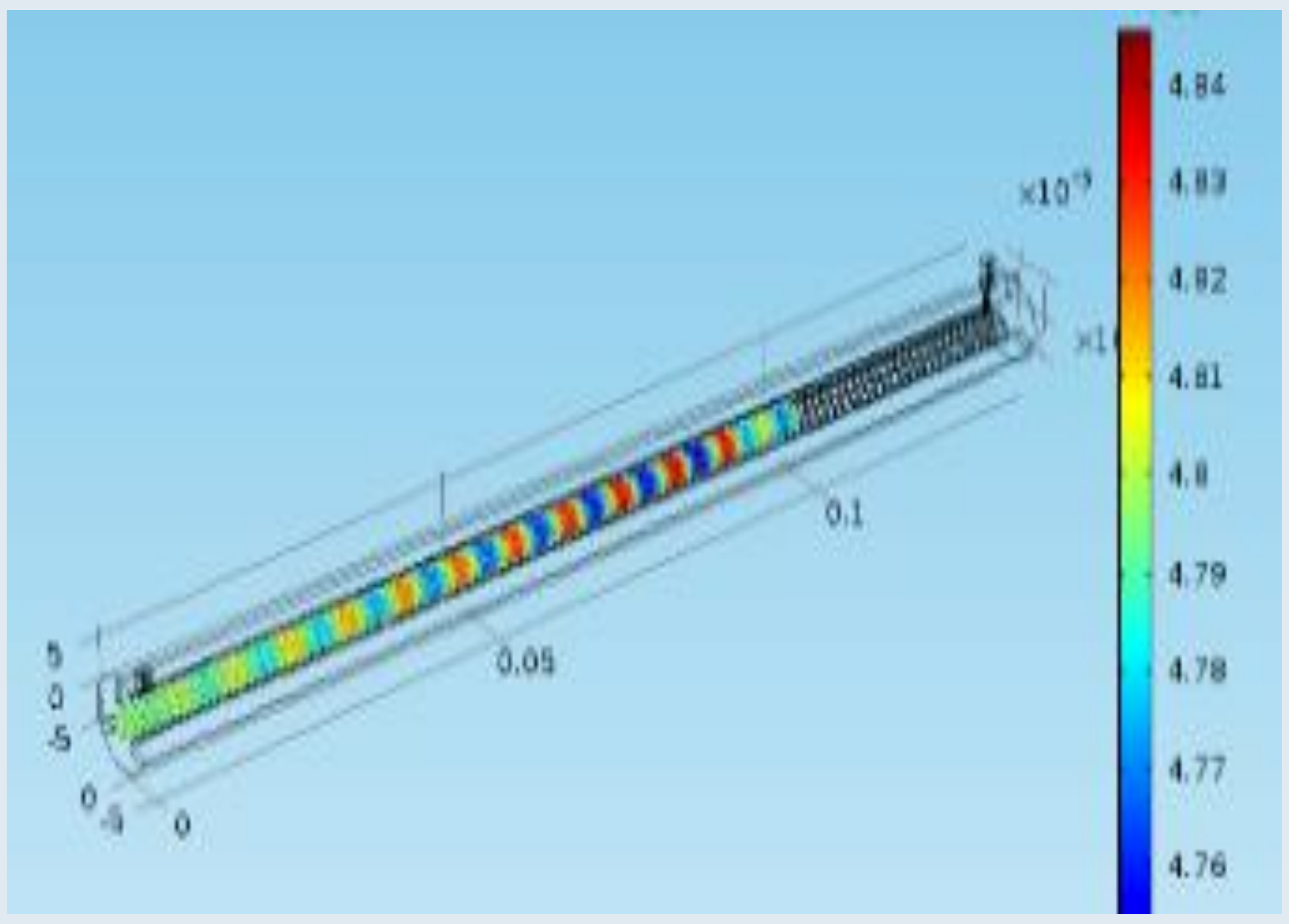

Electron Particle Trajectories of the beam at time step of 2.1ns from input to output of TWT – COMSOL computed [1]

Nonlinear Analysis of Beam-Wave Interaction for High-Power THz TWT Amplifier with Sheet Electron Beam

Interaction of the sheet electron beam with the RF wave from input to output of a TWT is carried out to determine complete performance of the RF wave and the beam for a planar THz TWT amplifier.

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Abstract

High power THz TWTs of frequencies between 0.1THz to 0.3THz are being investigated for their use as amplifiers in ultra broad-band 6G wireless communication systems, because of their high gain, high efficiency, wide bandwidth and high linearity. They have many other new emerging applications in medical imaging and sensing, spectroscopy, high resolution radar, etc. In-house developed SUNRAY-SSM and SUNRAY-LSM codes are used for linear and nonlinear beam-wave interaction analysis of a planar THz TWT with sheet beam. The RF performance like power and gain over the frequency band is found comparable with COMSOL-3D/CST-3D simulation codes. The results on cold circuit parameters like dispersion & impedance characteristics as well as hot parameters like output power and gain as simulated by COMSOL-3D code were reported comparable with the CST-3D simulated results over the THz frequency band for different THz TWTs [1-2].

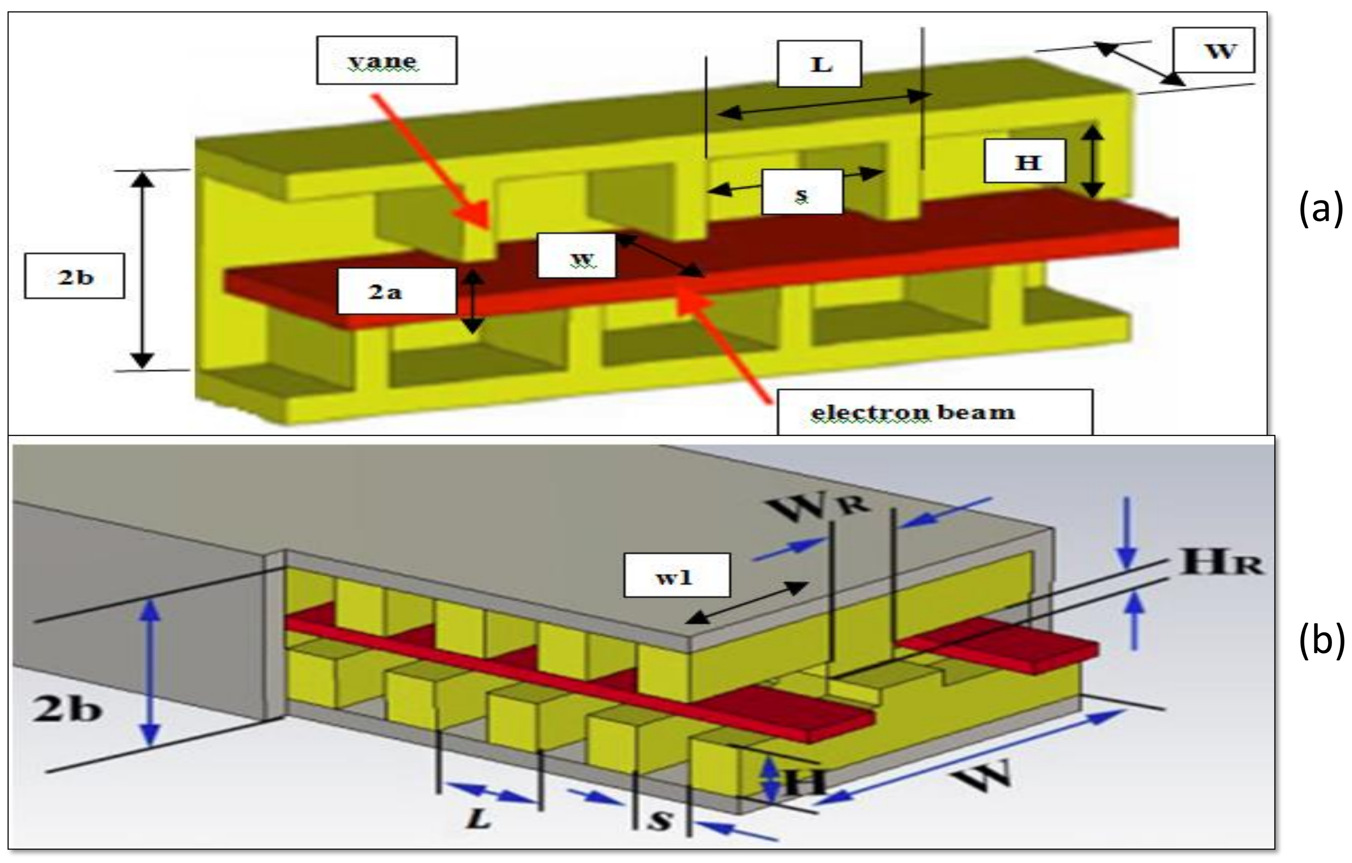

Fig.1: Staggered Double-Vane Slow-Wave Structure (SWS): (a) with single sheet beam and (b) with double sheet beams.

Methodology

For beam-wave interaction analysis, the electron beam is tracked along the RF-SWS in presence of the RF circuit field, ac space charge field and the magnetic focussing field. The propagation constant (β) and the circuit impedance as simulated by CST & COMSOL 3D codes are used. COMSOL-3D results on cold and hot RF performance of a TWT are reported comparable with CST-3D results [1-2]. In-house developed SUNRAY codes [3-4] are used to determine the RF output power and gain of a planar 0.22-THz, 100W, 30dB gain TWT with sheet beam. SUNRAY-SSM code is used for small-signal (linear) beam-wave interaction analysis and SUNRAY-LSM code is used for large signal (nonlinear) beam-wave interaction analysis.

Results

The small-signal gain versus frequency as simulated by SUNRAY-SSM code, and the RF output power versus frequency for 0.5W drive power as simulated by SUNRAY-LSM code for a 100W, 30dB gain THz TWT are shown in Fig.2(a) and (b). Fig.2(c) shows power profile for a 150W THz TWT. Table below shows results for a 25W THz TWT. All the simulated results using SUNRAY codes are comparable with the published simulated results using CST-3D/COMSOL-3D, as shown in the figure and table below.

Frequency (THz)	Propagation const. (rad./m) (CST/COMSOL)	Impedance (Ohms) (CST/COMSOL)	Output power for 0.47mW drive power SUNRAY-1D	Output power (W) for 0.47mW drive CST-3D
0.220	19537	5.8	27.6	25
0.230	20640	4.6	40.8	40
0.240	21800	3.6	35.2	35

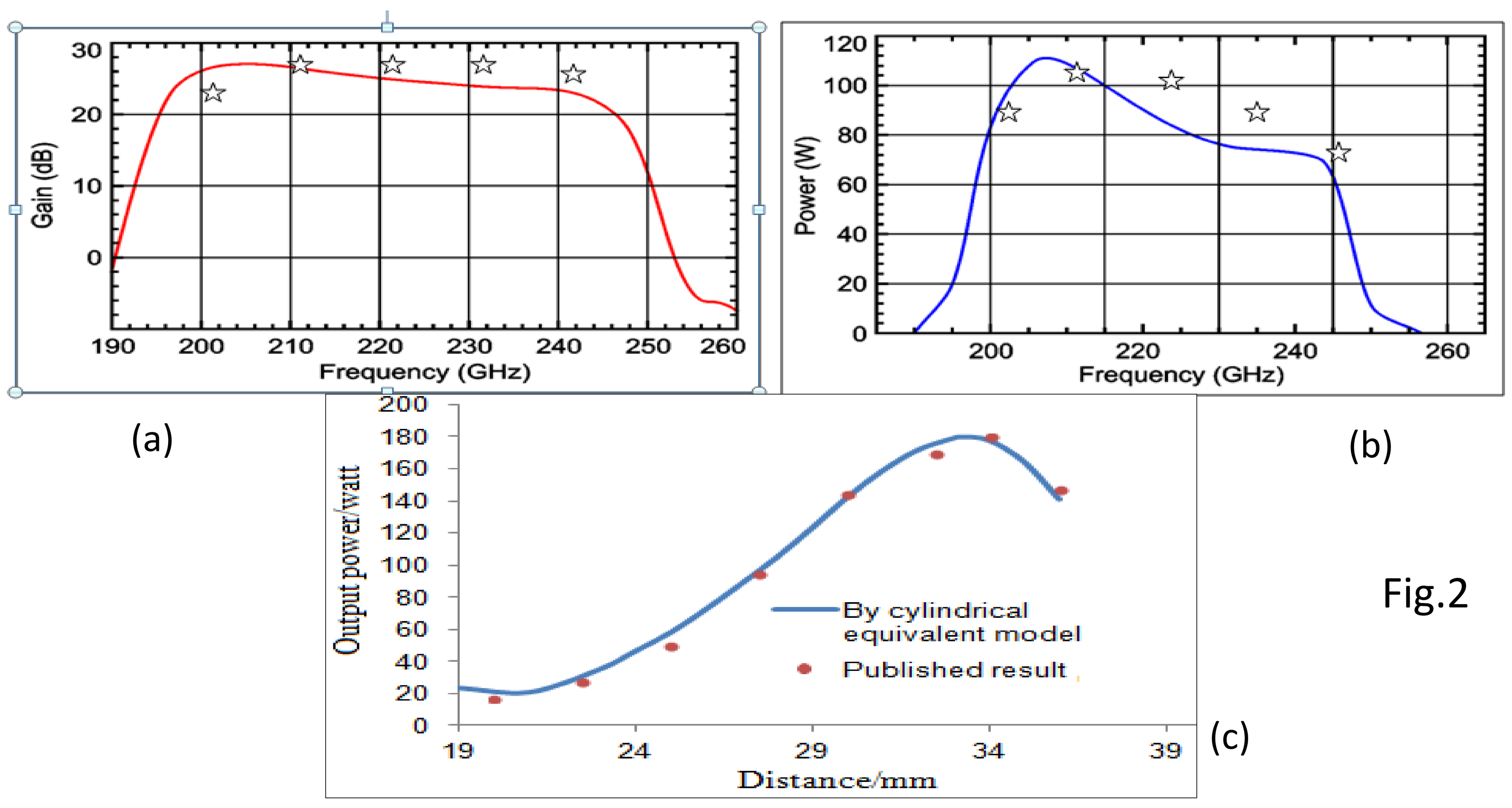

Fig.2

(a) Small-Signal Gain v/s Freq. –red by CST/COMSOL, star marked by SUNRAY-SSM
(b) RF o/p power v/s Freq. for 0.5W drive power –blue by CST/COMSOL, star by SUNRAY-LSM
(c) RF power profile along distance. –blue by CST/COMSOL, dot marked by SUNRAY-LSM

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