HIGH FREQUENCY SINGLE MODE TRAVELING WAVE STRUCTURE FOR PARTICLE ACCELERATION

V. Tsakanov, V. Danielyan, B. Grigoryan, A. Grigoryan, M. Ivanyan, A. Tsakanian, A. Vardanyan, S. Zakaryan

CANDLE SRI, 31 Acharyan, 0040 Yerevan, Armenia

Abstract

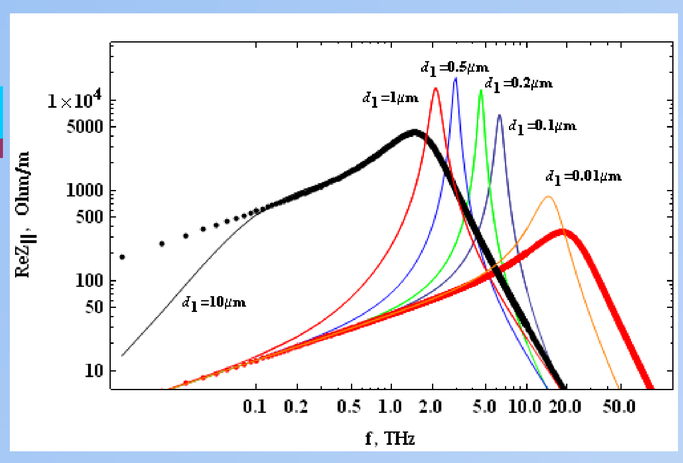
The new high frequency travelling wave with single TE01 slow mode is studied. The structure is composed of a metallic tube with an internally coated low conductive thin layer. It is shown that the impedance of the internally coated metallic tube (ICMT) has a narrow-band single resonance at a high frequency. The resonant frequency corresponds to synchronous TM01 mode excited by the relativistic charge. The dispersion properties of the fundamental and and high order modes of ICMT structure are analysed. Proof-of-principle experimental set-up at AREAL facility is given. The potential of the new structure for the particle acceleration and generation of monochromatic radiation in THz region are discussed.

Narrow band Resonance of two layer Tube

$\sigma_2 = 58\cdot 10^6\ \Omega^{-1}m^{-1}$

q

$\sigma_1 = 3\cdot 10^4\ \Omega^{-1}m^{-1}$



Field Matching for Two-Layer Tube

Q_n– Field Transf. Matrix of 1 layer

$T=(E_z,E_\theta, B_z,B_\theta)$ - vector of tang. Comp.

$T_{in}=Q_1\cdot T_2=Q_1\cdot Q_2\cdots Q_N T_{out}$

$Q=Q_1\cdot Q_2\cdots Q_N$

T_{in} –vector of tangential E&M fields in inner surface

T_{out}- vector of tangential E&M fields in outer surface

Q (4x4)– Field Transformation Matrix of Laminated Tube

Eigenvalue equation for TM modes

High Freguency region
Thin inner layer

$$\frac{1}{\xi_{0n}}\frac{J_1(\xi_{0n})}{J_0(\xi_{0n})}=\frac{1}{k^2 ad}$$

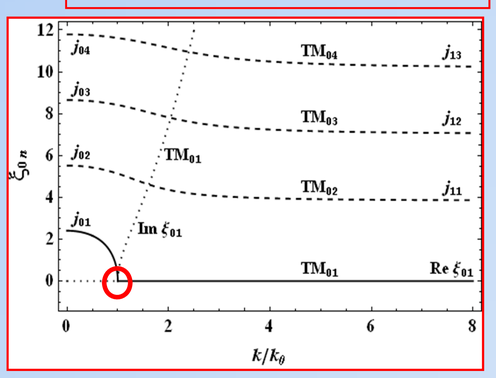


Fig. 2. Real (solid) and imaginary (dotted) parts of TM_{01}, and purely real TM_{0n}, (dashed) transverse eigen-values versus frequency.

$$k_0=\sqrt{2/ad}$$

In a frequency range $k > k_0$

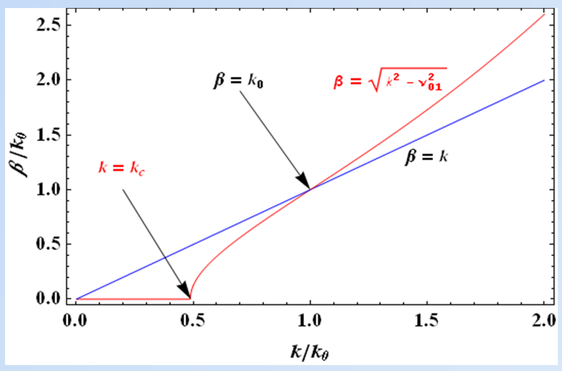
Transverse eigenvalue -purely imaginary $v_{ph} < c$

In a frequency range $0 < k < k_0$

Transverse eigenvalue -purely real $v_{ph} > c$

At synchronous frequency $k = k_0 \Rightarrow v_{ph} = c$

Dispersion Curve for TM_{01}



Longitudinal Monopole Impedance:

$$Z_{||}^0(\omega)=\frac{R}{1+jQ\left(\frac{\omega_0}{\omega}-\frac{\omega}{\omega_0}\right)}$$

$$a^{-1} << |\chi| << d^{-1}$$

$$\chi=\sqrt{-j\sigma_1\mu_0\omega}$$

$\omega_0 = ck_0$ - resonance frequency

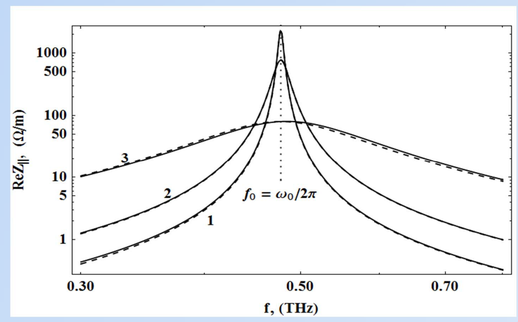


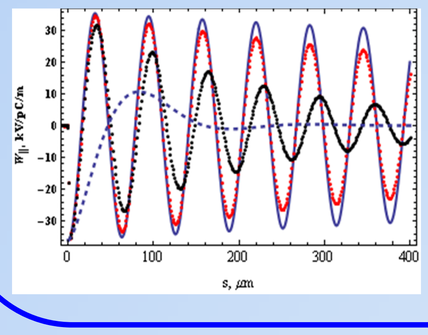
Fig. 4. *The exact (solid) and analytic (dashed) solutions for the real part of impedance for various conductivities of the inner layer:* $\sigma_1 = 3\cdot 10^3, 3\cdot 10^4, 3\cdot 10^5$

Wake function

$$W_{||}^0(s)=-\frac{Z_0 c}{\pi a^2}e^{-\alpha s}\left[\cos(k_\alpha s)-\frac{\alpha}{k_\alpha}\sin(k_\alpha s)\right]$$

d=200nm

$\sigma_2 = \infty$



Two-layer $\sigma_1 = 3\cdot 10^4 \Omega^{-1}m^{-1}$

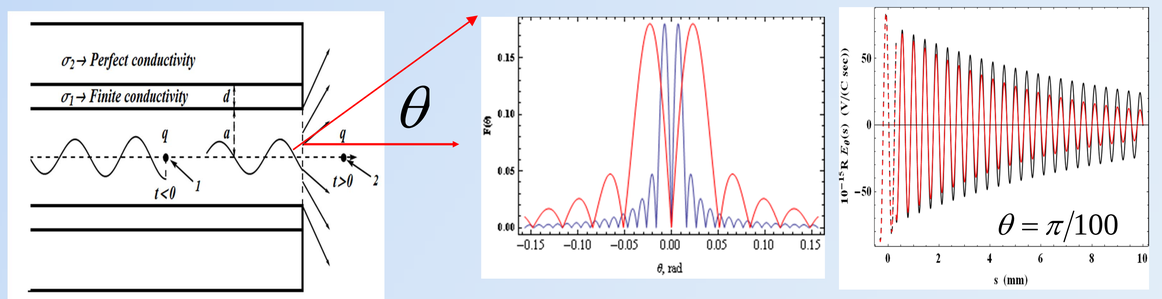
Two-layer $\sigma_1 = 3\cdot 10^5 \Omega^{-1}m^{-1}$

single-layer $\sigma_1 = 3\cdot 10^4 \Omega^{-1}m^{-1}$

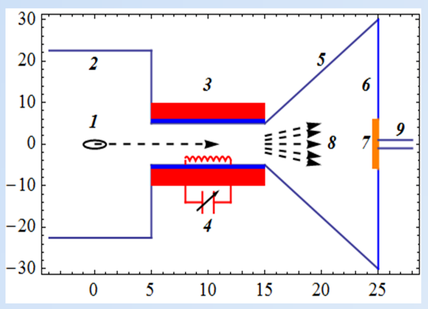
$a_1 = 1mm$ $a_2 = 2mm$

Open-end radiation

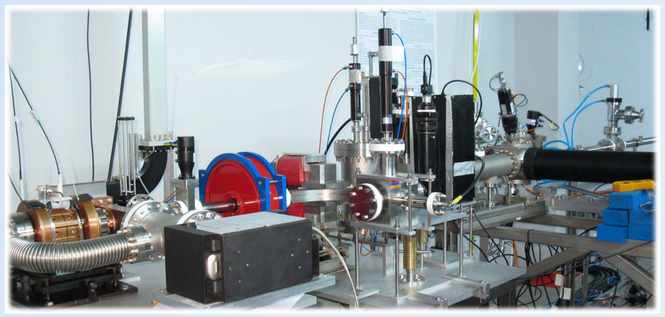
$d_1 = 0.2\mu m$ — $a_1 = 1mm$ f=4.7 THz — $a_1 = 1cm$ f=1.5 THz



Experimental Set-up



1- Electron Beam, 2- AREAL Beam pipe, 3- two-layer waveguide, 4- Network analyser, 5-conical screen, 6- plane metallic screen, 7- photoplate, 8-radiation from the open, 9- e-beam extraction



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#tsakanov@asls.candle.am