State Committee
of Science RA

Wake Fields in a Three-Layer Cylindrical Waveguide

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Ultrafast Beams and Applications

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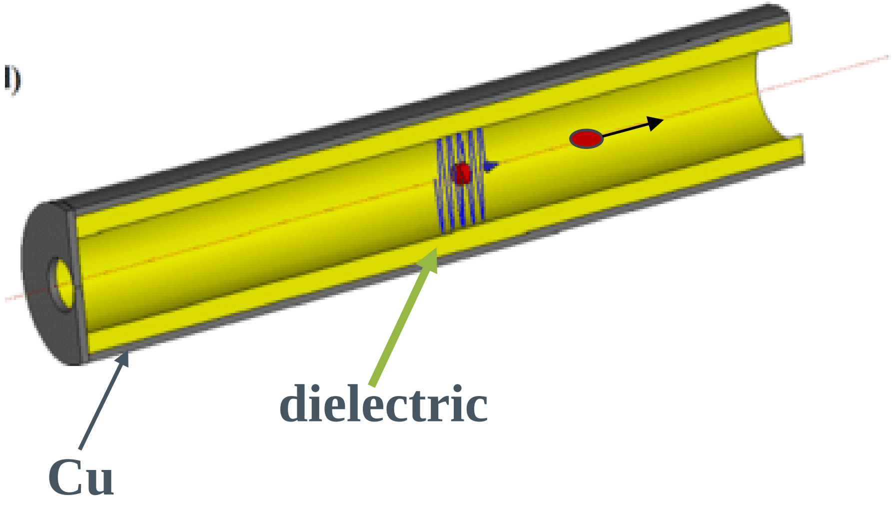
ABBREVIATION



Multilayer structure purposes

- Wakefield acceleration
- Two-beam acceleration
- Source of monochromatic radiation

TITLE AND CONTENT LAYOUT LIST

INTRODUCTION

1. What is NEG(non-evaporable getter)?

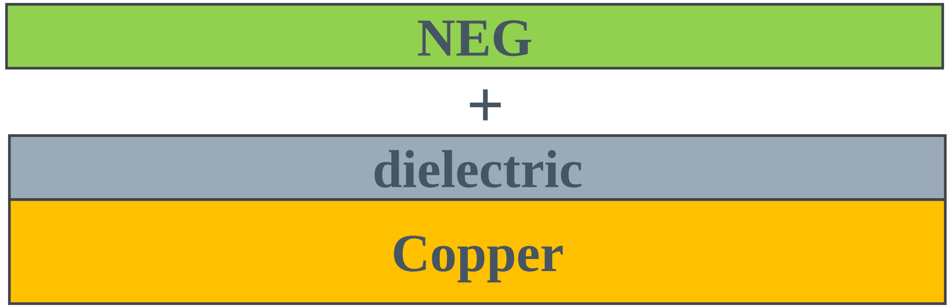
   Alloy of titanium-zirconium-vanadium.

2. For what it used?

   Maintain a high vacuum in beam pipes and assemblies of accelerating devices.

   Prevent the accumulation of a static charge on the dielectric surface

   Prevent overheating of the dielectric and its burnout when directly exposed to radiation.



NEG

+

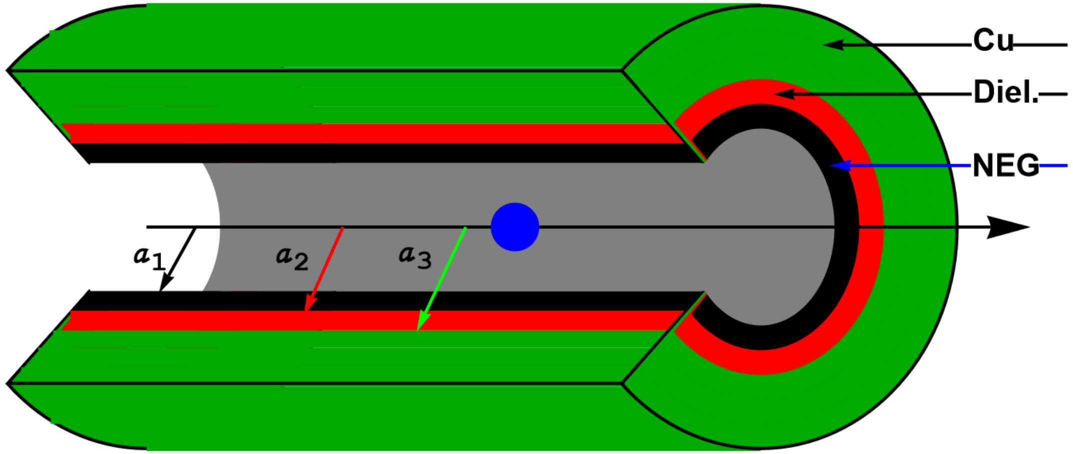
dielectric

Copper

- Studied impedances, wake functions, and distributions of dispersion curves of tree-layer structure.
- Considered various combinations of geometric and electromagnetic parameters of the structure.
- Estimated the distorting effect of the inner metal coating on the resonant characteristics of the wake fields of two layer structure.

Minimize the destructive effect of the NEG layer by optimizing its parameters.

GEOMETRY & STATEMENT OF THE PROBLEM



Cylindrical waveguide with a three-layer wall: fixed parameters.

$a_1 = 1cm$ is the inner radius of the waveguide;

$d_{diel} = a_3 - a_2 = 1\mu m$ is the thickness of the dielectric coating.

$\varepsilon_{diel} = 10$ relative permittivity of dielectric

$\sigma_{Cu} = 58 \cdot 10^6 \Omega^{-1} m^{-1}$ conductivity of Cupper

RESEARCH METHOD

DIELECTRIC LAYER

Thin layer, no losses ,

NEG LAYER

Two different cunductivities of same alloy:

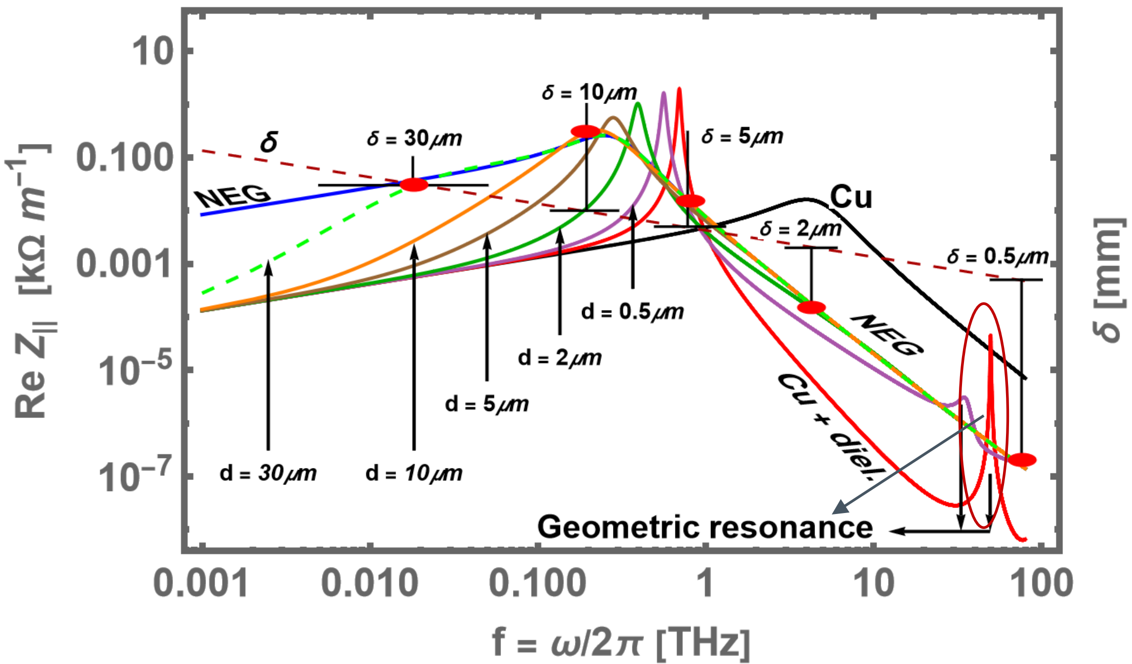
$\sigma_1 = 1.4 \cdot 10^4 \Omega^{-1} m^{-1}$ and $\sigma_2 = 8 \cdot 10^5 \Omega^{-1} m^{-1}$

Layer thickness: it should not be so thin otherwise will lose of its absorbing properties and create additional difficulties during deposition

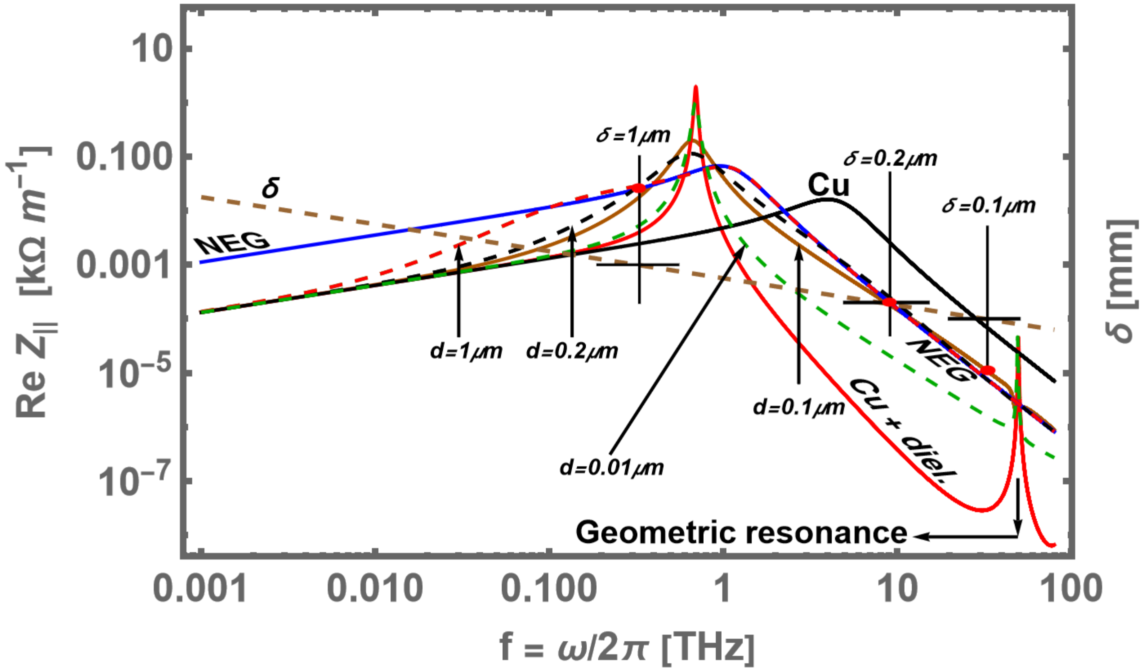
LONGITUDINAL MONOPOLE IMPEDANCE

NARROW-BAND SINGLE RESONANCES FOR DIFFERENT NEG LAYER THICKNESSES

$\sigma_1 = 1.4 \cdot 10^4 \Omega^{-1} m^{-1}$

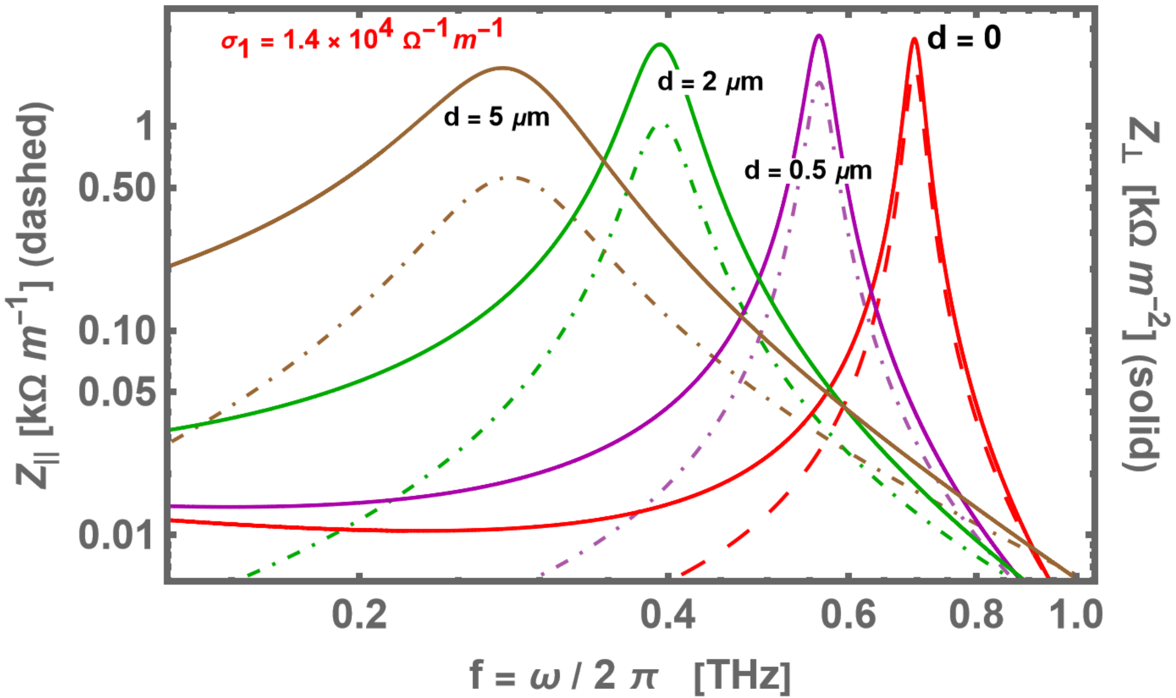


$\sigma_2 = 8 \cdot 10^5 \Omega^{-1} m^{-1}$

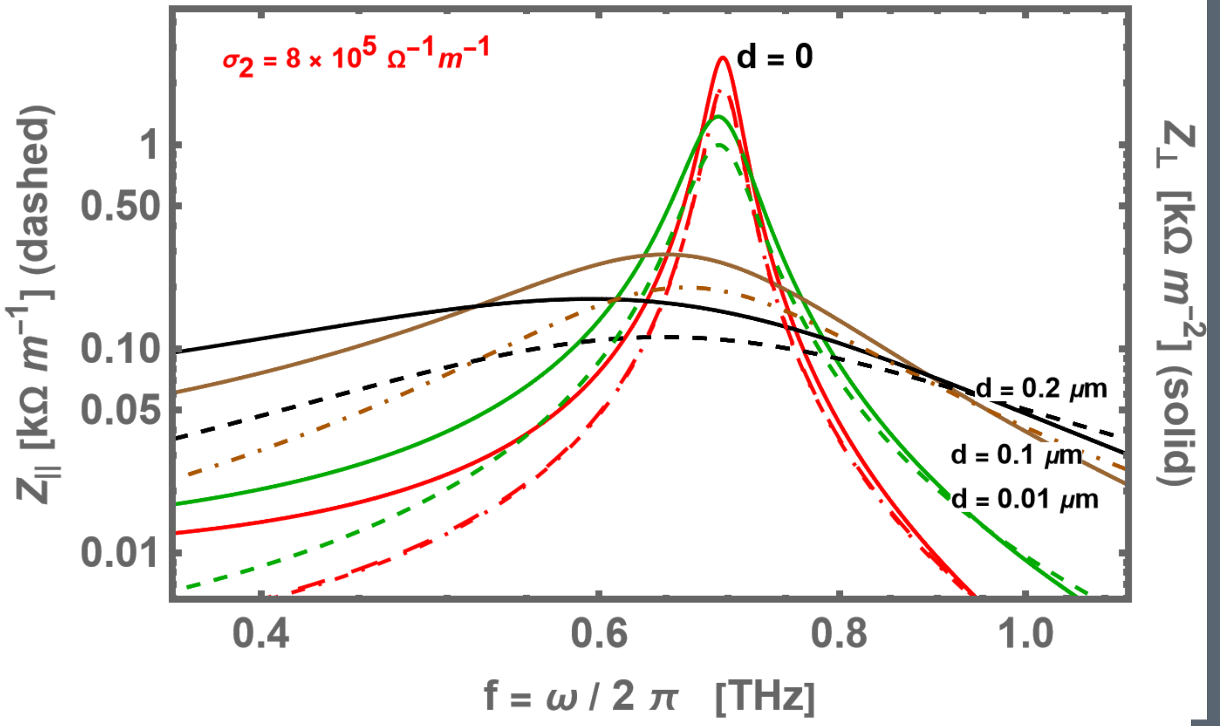


LONGITUDINAL MONOPOLE IMPEDANCE

Overlay of frequency distributions of longitudinal (dotted line) and transverse (solid lines) impedances.



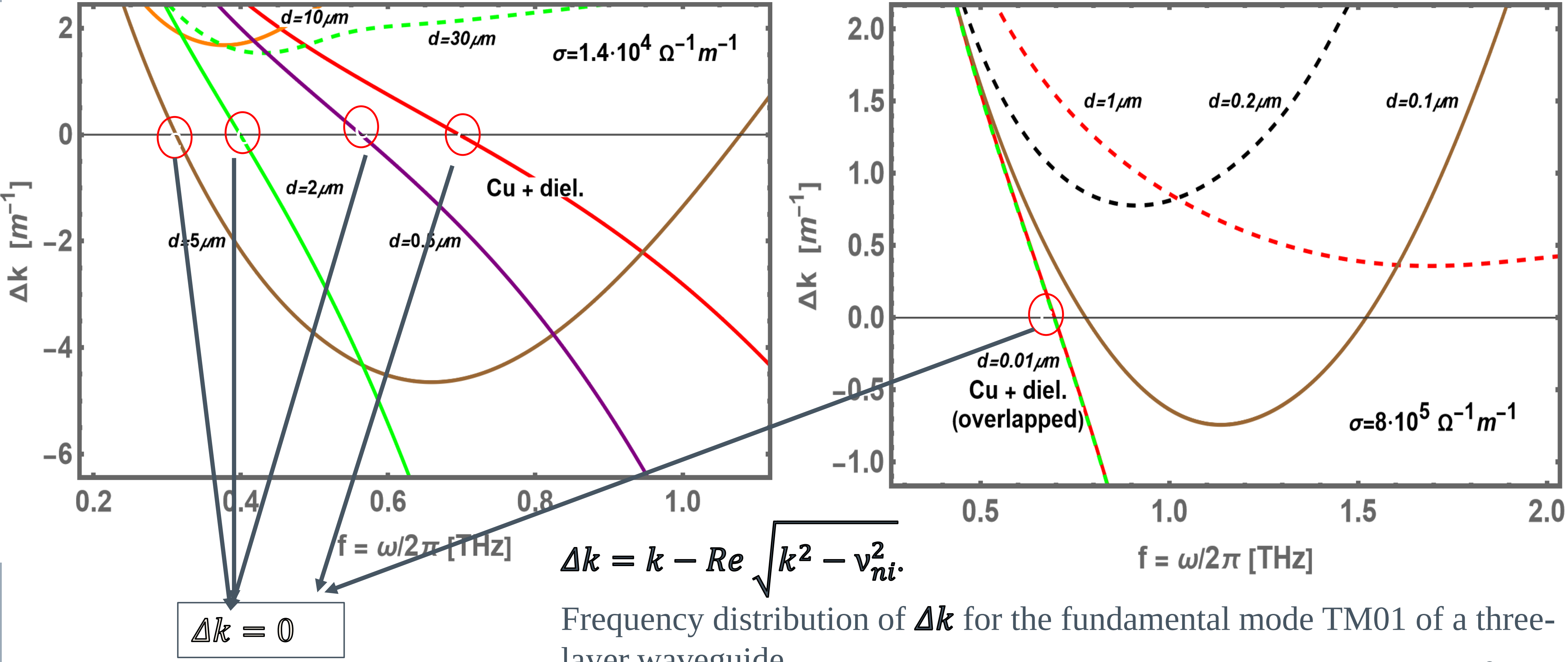
We can keep this syncronization up to 5 μm layer thikness.



Synchronization is maintained only at very small thicknesses of the internal layer (d=0.01μm)

DISPERSION CURVES

DETERMINING OF SYNCHRONOUS FREQUENCY OF WAVEGUIDE MODE WITH MOTION OF PARTICLE.



$$\Delta k = 0$$

$$\Delta k = k - Re\sqrt{k^2 - \nu_{ni}^2}.$$

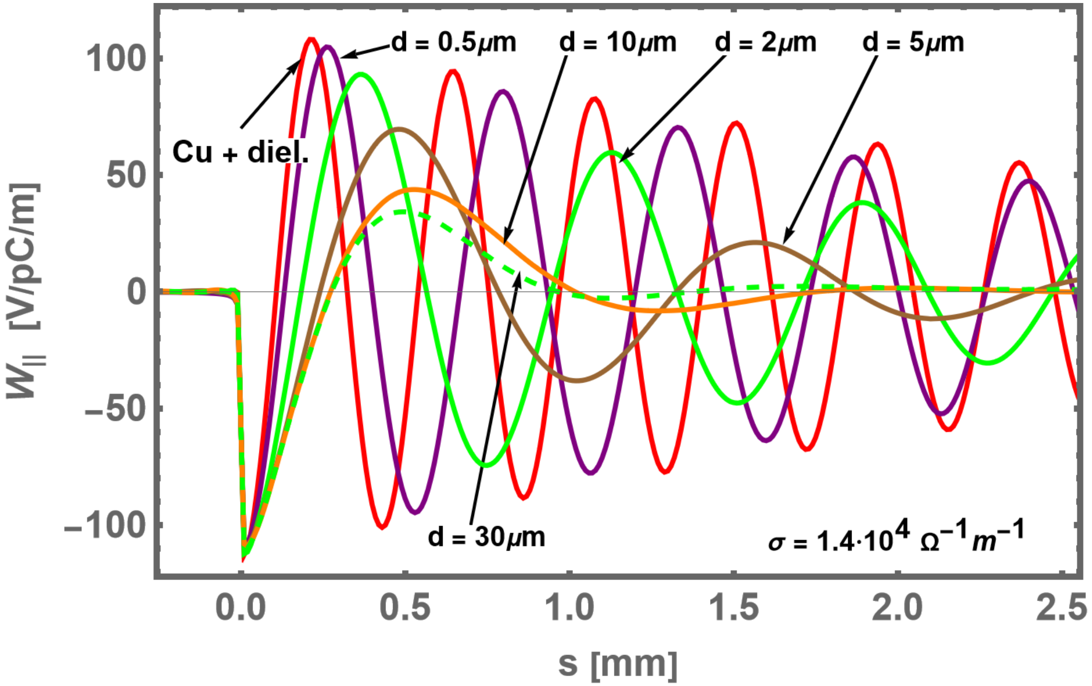
Frequency distribution of $\boldsymbol{\Delta k}$ for the fundamental mode TM01 of a three-layer waveguide.

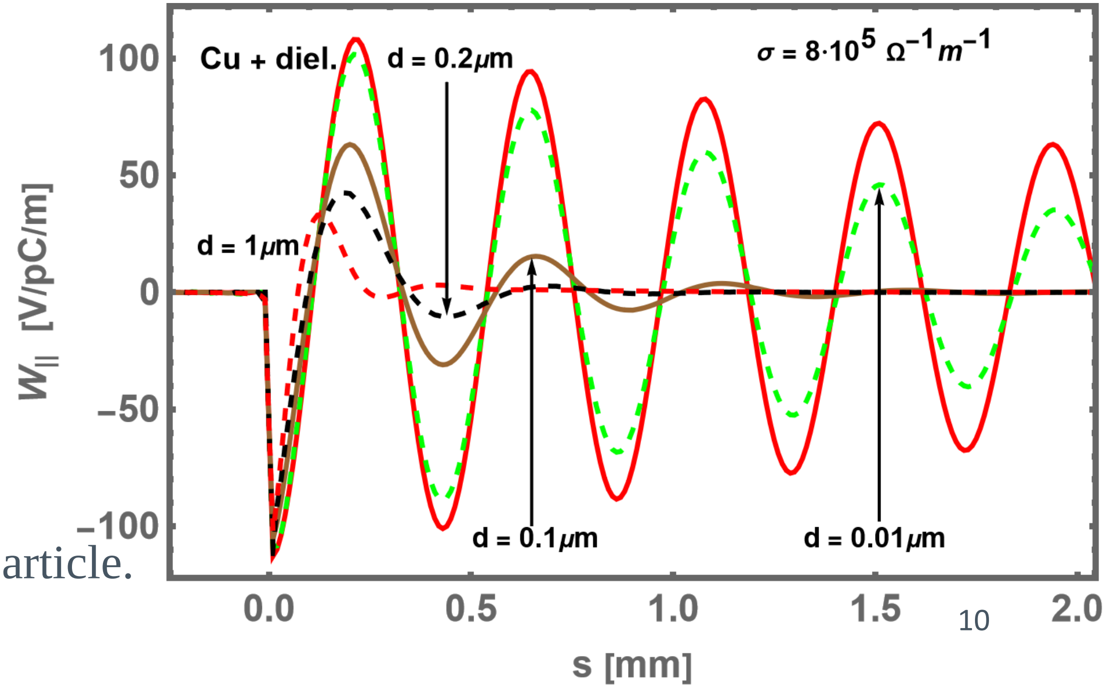
DISPERSION CURVES

Table 1. Synchronization and resonant frequencies of a three-layer waveguide

$\sigma_1 = 1.4 \cdot 10^4 \Omega^{-1} m^{-1}$				$\sigma_2 = 8 \cdot 10^5 \Omega^{-1} m^{-1}$			
d_{NEG} (µm)	f_{rez} (THz)	f_{sync}(THz)	Amp (kΩ/m)	**dNEG (µm)**	f_{rez} (THz)	f_{sync}(THz)	Amp (kΩ/m)
0	0.696	0.696	1.951	**0**	0.696	0.696	1.951
0.5	0.562	0.563	1.633	**0.01**	0.693	0.6953	1.
2	0.394	0.399	1.037	**0.1**	0.666	0.7789	0.2
5	0.281	0.312	0.562				

WAKE FUNCTIONS





s < 0: field ahead of the particle; s > 0: field behind the particle.

SUMMARY

- A main result of the present research is the demonstration of the possibility of keeping the resonant properties of the wakefield of a two-layer metal-dielectric waveguide when an additional coating of a low-conductive metal is applied to its inner surface.
- The NEG material with low conductivity, without significantly distorting the initial resonant properties of two-layer metal-dielectric waveguide, allows the use of coatings of an acceptable thickness that retains its absorbing properties, while simplifying the deposition process.
- Instead of NEG material, a metal that does not have absorbing properties can also be useful as an internal coating: having low electrical and thermal conductivities, it will help prevent charge accumulation on the inner surface of the dielectric and its overheating and damage.

Thanks for your attention. Questions!!!

ACKNOWLEDGMENT

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