

Numerical Study of the Influence of within Human Skin Interfaces on THz Wave Propagation

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ABSTRACT

The influence of the rough interface between epidermis and dermis is investigated in this paper by introducing a 3-D sine wave as the interface. By investigating the relationship of the power losses to distance and different roughness, it can be concluded that the span change affects the power loss much more than the amplitude one.

Keywords

Nano-Communication, Numerical Model, THz Wave

1. INTRODUCTION

Nano communication has driven great research interest since its proposal in 2008 [1] [2]. The interconnection and interaction between nano-devices defines new radio propagation scenarios which need to be characterised using novel and expanded radio propagation principles [2]. Such new models can define a wide range of applications for future wearable technologies not only for radio communication, but also for sensing, organ imaging. Due to the characteristics of the emerging new materials like Carbon Nano-Tube (CNT) and Graphene which can be used to make future nano-resonators, nano-antennas and potential nano-transceivers, THz band has been considered as the most promising candidate operation band for nano-communication network [10] [12] [9] [5]. Therefore, the investigation on the wave performance of the THz wave is essential for the development of Nano-Communication resulting many published papers on this topic [8] [7] [13] [11]. In [13], the concept of Body-Centric Nano-Communication was proposed and the wave propagation performances in various human tissues were discussed and the channel capacity was studied in detail in [11]; but the models used are all homogeneous effective medium. Also in [4], a detailed skin model was produced with the rough interface between different layer and effects of the helical sweat duct on the reflection of mm-wave was investigated. From the 3-D cross-sectional images depicting the different layers of the skin [6] [3], it can be seen that the

interface between the layers was not flat. From the model shown in [4], the roughness was at the order of millimetre which was considerable to the wavelength of the applied THz band (300 GHz to 10 THz [1]) of Nano-Communication Network. It is evident that more detailed models are required in order to understand the effects on EM wave propagation. In this paper, we aim to understand the effects of a rough skin texture model and its impact on the behaviour of EM waves going through the skin.

2. NUMERICAL MODELS

In this study, we start from the simplest model, i.e. homogeneous one, shown in Fig. 1a, followed by the flat model (the interface between epidermis and dermis is flat), shown in Fig. 1b. Finally, the stratified model, shown in Fig. 1c is build where the interface between epidermis and dermis is regarded as a uniform 3D sine wave. From Fig. 1, it can be seen that one dipole is put on the skin surface while another one in the skin. In the roughness study, the amplitude and span, shown in Fig. 2, of the interface is changed. The relationship between power loss and distance is investigated and will be discussed in section 3.

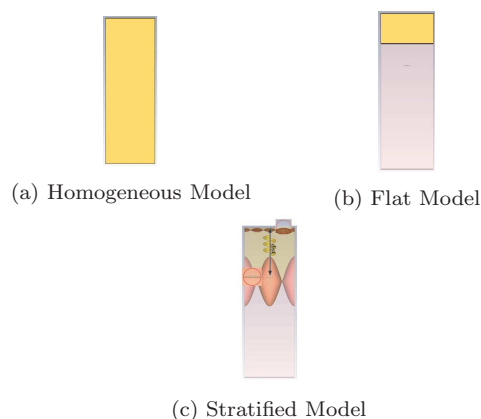


Figure 1: Different models studied

3. RESULTS AND DISCUSSION

3.1 Roughness effects of the stratified model

The effects of the span change and amplitude change on the power loss are shown in Fig. 3 and Fig. 4, respectively. It can be easily seen that the effect of the span change is more obvious. From Fig. 3, we can see that with the increase of the span, the power losses decrease slightly. However, for

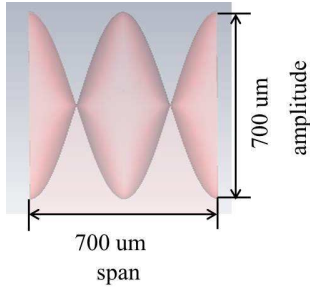
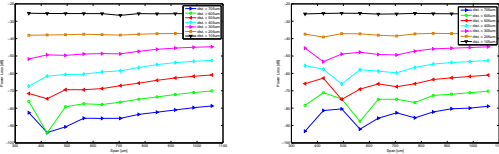


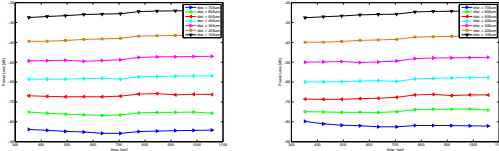
Figure 2: Details of the interface

the larger distance and smaller span, such trends no longer exist. From Fig. 4, it can be seen that the change of the power loss is not obvious so that the trend seems flat.



(a) Open Boundary (b) Periodic Boundary

Figure 3: Effects of the span change



(a) Open Boundary (b) Periodic Boundary

Figure 4: Effects of the amplitude change

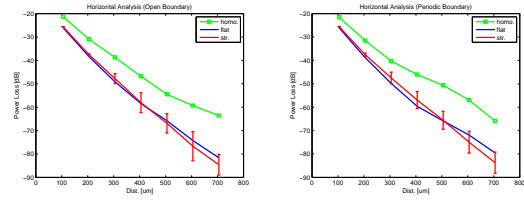
3.2 Statistic Study

The relationship of the power loss to the different models is given in Fig. 5 and Fig. 6. From the figures, it can be easily seen that by introducing the interface the power loss increase because of the reflection. Furthermore, the effects of the span change is obvious than the one caused by amplitude change because the deviation is bigger. Finally, as shown in section 3.1, the deviation of the power loss for stratified model increases with the increase of distance proving that the roughness could affects the power loss while the mean value of the power loss for flat model and stratified one is approximate to each other.

4. CONCLUSIONS

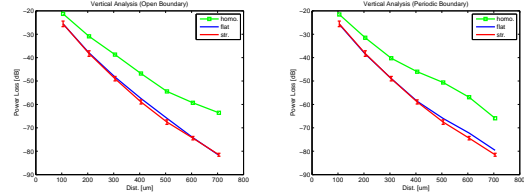
In this paper the effects of the roughness on the power loss is mainly studied. From the above investigation, we can see that the span change affects the power loss much more obviously than the amplitude one. However, further studies should be considered: the study of the power loss inside skin, the study of the non-uniform interface and the study of the effects on the wave propagating along skin surface.

5. ACKNOWLEDGMENTS



(a) Open Boundary (b) Periodic Boundary

Figure 5: Effects of the span change



(a) Open Boundary (b) Periodic Boundary

Figure 6: Effects of the amplitude change

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