Longitudinal effects of window index in THz burn imaging

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***Abstract*—A reflective terahertz (THz) imaging system was used to image a full thickness burn wound in an *in vivo* preclinical model using windows of varying refractive index. Imagery was continuously acquired of a 200°C burn with both a thin mylar (12 µm) and quartz (500 µm) window over a period of 72 hrs. Large differences in contrast between the windows were observed, with quartz and mylar being sensitive to the burn contact area and peripheral regions, respectively.**

I. Introduction

The novel use of Terahertz (THz) imaging for the detection of burn wounds continues to spur advances in both medical THz system design and choices of dielectric substrate windows. Specifically, time domain spectroscopy (TDS) and reflective THz imaging technologies have been used to explore contrast and frequency resolved properties of skin burns due to superficial access and the limited penetration depth associated with THz wavelengths (33 µm to 3000 µm). A recent study (n=10) by our group has reported the use of a novel, reflective THz imaging technology to acquire high contrast (>200:1) imagery of burns and detect spatiotemporal differences in reflectivity between partial and full thickness. Similar to most THz imaging systems, the aforementioned imager employs a low-loss, optical window, specifically composed of mylar, to minimize the confounding effects from surface-roughness and non-planar geometry.

Electromagnetic modeling predicts that THz images acquired with different dielectric windows vary in both hydration sensitivity as well as the tissue depth probed. To empirically investigate this hypothesis, a pilot study (n=1) that co-registered the spatial distribution of THz reflectivity of the same full thickness *in vivo* burn wound under thin mylar and under quartz was performed over a period of 5 hours in a rat model [1]. In addition to large differences in image contrast and variability in contour placement distal to the burn wound, the quartz abdominal pixel distribution was closer to a uniform distribution. Effective assessment of the effects of window index on hydration sensitivity and image contrast, however, necessitates a longitudinal observation of window performance over a time period relevant to burn injury monitoring. It has been demonstrated that the distribution and flow of water throughout the wound bed occurs over the course of 72 hrs, at which time the wound visibly manifests as either a partial or full thickness burn. To this end, these results compare spatiotemporal variations in THz reflectivity of a full thickness burn wound under thin mylar (12 µm) and quartz (500 µm) in an *in vivo* rat over 72 hours.

II. Results

A Sprague Dawley (SD) rat was anesthetized with isoflurane and a 60 mm x 60 mm area of the abdomen was shaved. A cartridge system enabling multiple windows to be exchanged was placed on the rat abdomen prior to and ensuing burn induction. A contact burn was induced using a rectangular brass brand (19 mm x 2 mm) heated to 200°C and positioned on the abdomen. The rat was imaged continuously for 7 hrs, at 24 hrs, 48 hrs, and 72 hrs, with the windows exchanged after every image (Figure 1).

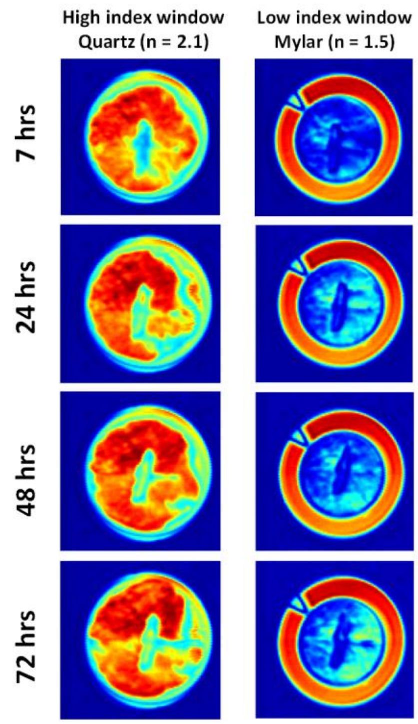

Fig. 1: *In vivo* THz imagery of a full thickness burn at 7 hrs, 24 hrs, 48 hrs, and 72 hrs following burn induction using a quartz and thin mylar window.

The results indicate that image contrast varies between the two modalities. Structure and reflectivity changes within the burn are more evident in quartz imagery and are difficult to distinguish in parallel mylar images. In contrast, local changes in reflectivity in peripheral areas of the burn are more noticeable in mylar images between 7hrs and 72 hrs post thermal insult. Dielectric substrate window choice, therefore, may alter hydration sensitivity of THz medical imaging to specific regions of burn wound pathophysiology.

III. Summary

Windows of varying index used in THz medical imaging are sensitive to hydration in specific regions of wound pathophisology.

References

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