Terahertz sensing of materials

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Abstract

Terahertz is the frequency range generally considered from 0.3 to 20 THz. Biomolecules such as DNA and proteins are predicted to exhibit a wealth of modes in this range since the rotational, vibrational and stretching modes of biomolecules lie in this spectrum range. Additionally, many materials such as dry wall that are opaque to human eyes are transparent in the Terahertz region. Therefore, Terahertz can be used as a powerful tool for biomolecular sensing, biomedical analysis and through-the-wall imaging. In this paper, experiments were carried out to study the absorption characteristics of various materials including DNA and see-through imaging of dry wall using FTIR spectrometer and Time Domain Spectroscopy (TDS) system.

In the DNA spectrum study, we measured modes for DNA molecules in the Terahertz range, and that different DNA molecules show different features. Some features are shown to be associated with conformational states and others are shown to be related to DNA molecular length. During the measurements, none of the DNA molecules were labeled. This study suggests that Terahertz wave might be exploited for label-free, in-situ and real-time DNA analysis applications.

Dry wall is the most prevalently used building materials in the world. It is opaque in the visible range. However, this study found out that Terahertz can penetrate through up to 1” thick dry wall. Transmission characteristics on dry wall samples of different thicknesses were studied. The scattering mechanism of Terahertz propagation inside the dry wall was also studied. These results suggest that Terahertz can be used for through-the-wall imaging applications.

In summary, we have studied absorption characteristics of DNA and dry all materials in the Terahertz range. The results demonstrated the capability of Terahertz to be used as biomolecular sensing, biomedical analysis and through-the-wall imaging.

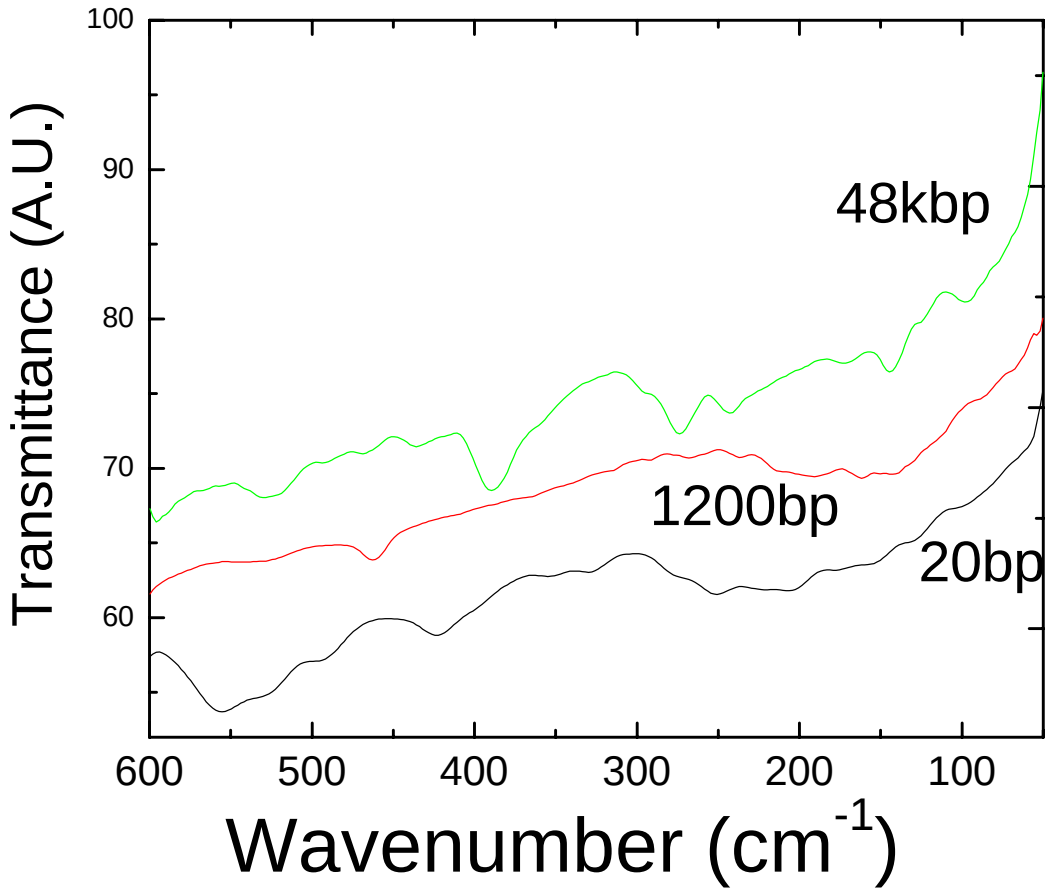

Figure 1. Terahertz spectrum of double-stranded DNA molecules of different lengths. Measurements results show that DNA molecules with different lengths show different modes.

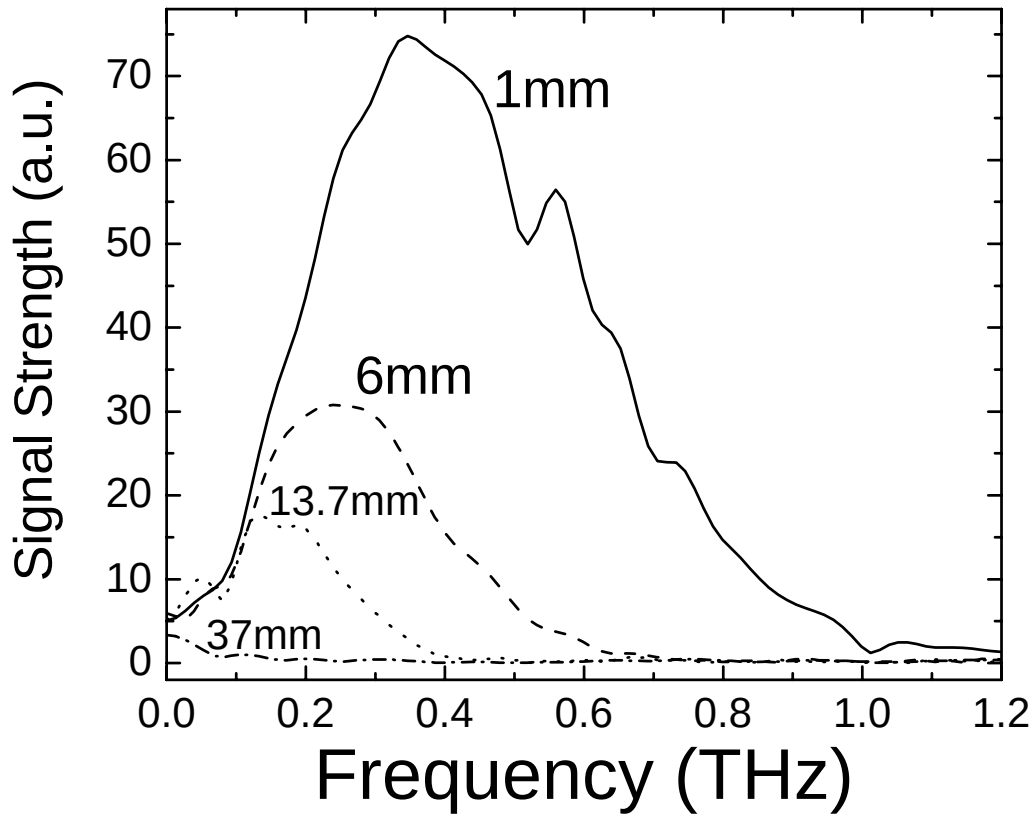

Figure 2. Terahertz spectrum for dry wall of different thicknesses. It shows that lower Terahertz radiation does go through dry wall material and that at 13.7mm (~1/2", which is the most commonly used thickness in buildings), there is still a significant signal going through although most of which is below 0.3 Terahertz. At 37mm (~1.5"), there was barely any Terahertz going through the wall.