# Time-Domain Terahertz Imaging and Spectroscopy of X-Ray Blocking and Scattering Coatings

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The terahertz (THz) band of the electromagnetic spectrum is the gap between the microwave/millimeter wave band and the far infrared band. This band has been historically defined to be around 0.1 to 10 THz, due to the long-standing difficulties in efficient generation and detection of these frequencies. Only recently have efficient and practical commercial THz systems become available. Imaging with THz waves offers several unique advantages. THz waves can penetrate several millimeters into non-conducting materials. This allows for imaging of features that are covered in an optically opaque coating. Since THz waves have a shorter wavelength than microwaves, they are able to resolve smaller features. Unlike the x-ray imaging that is often associated with imaging into materials, the low photon energy of THz waves cannot ionize materials. This negates the risk of irreversible material damage inherent with x-ray imaging.

Manufactures of electronics often have to develop ways to prevent the reverse engineering of their devices. Previously, x-ray imaging was the only way to image into packaged circuits at a high enough resolution to gather any useful information. As such, x-ray blocking and scattering (XBS) coatings are developed to prevent this possible damage. However, with the recent advent of THz technology it becomes important to determine if THz imaging, like x-ray imaging, presents a potential method of reverse engineering and if these XBS coatings also prevent imaging with THz waves.

The purpose of this research is to investigate the THz properties of XBS coating materials. Utilizing a TPS$^{TM}$ Spectra 3000 spectrometer (Teraview Limited, Cambridge, UK), spectroscopy of the XBS coatings will be performed to determine the electrical properties of the material, absorption and transmission coefficients. In addition, the effects of the coatings on the resolving power of the THz waves in reflection imaging mode will be determined. By imagin circuit features of known sizes covered in the various XBS coatings, minimum resolvable feature as a function of coating thickness will be determined.