Characterization of building materials in the THz range

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Motivation

Propagation Channel Models
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Propagation Channel Models

Ma et al. APL Photonics, 3, 051601, 2018.
Building Materials (50 samples)

- Plastic
- Wood
- Glass
- Ceramic
- Cement
- Brick

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Material Characterization

Calculate the optical parameters (refractive index & absorption) in Transmission setup

THz time-domain spectroscopy (THz-TDS) technique
Refractive Index
Surface roughness characterisation

Photogrammetry
Surface roughness characterisation

\[ \sigma = 16 \, \mu m \]

Reconstructed Sample

surface height distribution of the sample
Surface Scattering Models

Smooth surface

Slightly rough surface

Rough surface

Classical Fresnel equations

Modified Fresnel equations

Rayleigh roughness factor

- Kirchhoff approximation
- Small perturbation method
- Radar cross-section
- Integral equation model
Reflection / Scattering Measurements

THz time-domain spectroscopy (THz-TDS) + Goniometer setup
Measured Scattering Power at 300 GHz

- Glass
- Marble mats
- Marble mats poly mosaic
- Marble mats polygonal mosaic
- Ceramic
- Gypsum + cartons
- Wood paste
- Mixture gypsum + stones
- Installation glue
- Mixture gypsum + cartons
- Spruce fir wood
- Ceramic - rough
- Concrete
- Finishing filler
- Kitchen Silicone
- Acrylic
- Sanitary Silicone
- Nitrile rubber (NBR)
- Wall/ceiling color
- Gypsum with air gaps

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Results

High density fiber board

\[ \sigma = 18 \, \mu m \]

Simulated and measured scattering coefficient at 300 GHz.

Simulated and measured scattering coefficient
Results

polyurethane (PU) coating

\[ \sigma = 130 \, \mu m \]

Simulated and measured scattering coefficient

Simulated and measured scattering coefficient at 300 GHz
CONCLUSION

➢ We characterize 50 samples building materials. These models are for required for a reliable channel simulation.

➢ The angle-dependent scattering patterns of building materials with smooth or rough surfaces can easily be determined by Fresnel, Rayleigh or Kirchhoff models.

➢ More complex geometries, for example, a multilayered composition and/or a microscopic anisotropic structure can lead to a strong multiple reflection behavior.

➢ For these complex samples, the "traditional" scattering theories are not enough to describe the reflection properties and, further refinement of the models is required.
Thank you very much for your Attention

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