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Nondestructive Inspection of Reagents under High Attenuated Cardboard Box Using Injection-Seeded THz-Wave Parametric Generator

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Abstract : In recent years, there have been numerous attempts to smuggle narcotic drugs and chemicals by concealing them in international mail. Combatting this requires a non-destructive technique that can identify such illicit substances in mail. Terahertz (THz) waves can pass through a wide variety of materials, and many chemicals show specific frequency-dependent absorption, known as a spectral fingerprint, in the THz range. Therefore, it is reasonable to investigate non-destructive mail inspection techniques that use THz waves. For this reason, in this work, we tried to identify reagents under high attenuation shielding materials using injection-seeded THz-wave parametric generator (is-TPG). Our THz spectroscopic imaging system using is-TPG consisted of two non-linear crystals for emission and detection of THz waves. A micro-chip Nd:YAG laser and a continuous wave tunable external cavity diode laser were used as the pump and seed source, respectively. The pump beam and seed beam were injected to the $LiNbO_3$ crystal satisfying the noncollinear phase matching condition in order to generate high power THz-wave. The emitted THz wave was irradiated to the sample which was raster scanned by the x-z stage while changing the frequencies, and we obtained multispectral images. Then the transmitted THz wave was focused onto another crystal for detection and up-converted to the near infrared detection beam based on nonlinear optical parametric effects, wherein the detection beam intensity was measured using an infrared pyroelectric detector. It was difficult to identify reagents in a cardboard box because of high noise levels. In this work, we introduce improvements for noise reduction and image clarification, and the intensity of the near infrared detection beam was converted correctly to the intensity of the THz wave. A Gaussian spatial filter is also introduced for a clearer THz image. Through these improvements, we succeeded in identification of reagents hidden in a 42-mm thick cardboard box filled with several obstacles, which attenuate 56 dB at 1.3 THz, by improving analysis methods. Using this system, THz spectroscopic imaging was possible for saccharides and may also be applied to cases where illicit drugs are hidden in the box, and multiple reagents are mixed together. Moreover, THz spectroscopic imaging can be achieved through even thicker obstacles by introducing an NIR detector with higher sensitivity.

Keywords : nondestructive inspection, principal component analysis, terahertz parametric source, THz spectroscopic imaging
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