THz QCL - based active imaging applied to composite materials diagnostic

Fabien Destic\textsuperscript{a}, Yoann Petitjean\textsuperscript{a} and Jean-Claude Mollier\textsuperscript{a,b}

\textsuperscript{a}Université de Toulouse, ISAE - OLIMPES, Toulouse, France
\textsuperscript{b}ONERA / DOTA, Toulouse, France

Abstract — This paper is a presentation of the recently developed researches at OLIMPES laboratory in the field of active imaging using THz Quantum Cascade Laser applied to composite materials diagnostic.

I. INTRODUCTION AND BACKGROUND

This paper describes the recently developed works conducted at OLIMPES, a laboratory resulting from a collaboration between ISAE and ONERA/DOTA. The experimental setup is based on a Quantum Cascade Laser (QCL) as a source and a NTD-Ge bolometer as a detector. One of our objectives is to perform materials diagnostics, both in transmission and reflection, at various frequencies in the 1 - 5 THz range. Many works have been conducted about THz imaging of various objects or materials hidden behind or into different materials: plastics in powdered sugar \cite{1}, weapon behind clothes \cite{2}, ink inside an envelope \cite{3} are some well known examples. As we know, composite materials diagnostic with the help of THz waves has not yet been investigated.

II. RESULTS

The experimental setup used is shown below.

The QCL is driven by an ILX Lightwave LDP3840P pulsed current source (Duty Cycle = 1\%, Pulse Width = 60 µs). A peak power close to 1 mW at 2.3 THz is available at the output of the cryostat. The emitted beam is then collected by a set of four off-axis parabolic mirrors (OAPM) that allow us to focus it on the sample to be imaged. The object is moved in X and Y by two motorized translation stages. The signal from the NTD-Ge bolometer (QMC Instruments Ltd., NEP = 2.8 pW.Hz\textsuperscript{-1/2}) is acquired via an EG&G SR5209 lock-in amplifier. As an illustration, the raw image of a key and a plastic ruler (fig. 2), hidden behind a cardboard sheet, is presented in figure 2. The image (size = 31 x 31 points) is obtained with a 2 mm step both in X and Y. The Signal-to-Noise Ratio is estimated to 70.

![Figure 1: Experimental setup](image)

![Figure 2: Image of a key hidden behind a cardboard sheet](image)

The first experiments on composite materials (Kevlar, glass fibre, carbon fibre ...) have shown that some of them can be “transparent” to THz waves. We are now studying the transmission through various materials with specific qualities and different mesh sizes. Work is in progress to use THZ transmission imaging to detect defaults or damages caused by an impact in the composite materials structure.

The authors wish to thank Pr. Carlo SIRTORI and Stefano BARBIERI for their supply of QCLs.

REFERENCES

\cite{1} Hermann et al. “Terahertz imaging of objects in powders”, Optoelectronics, IEE Proceedings, 2002, vol.149, pp16-120

\cite{2} Jacobs et al. “Concealed weapon identification using terahertz imaging sensors” Terahertz for Military and Security Applications IV, SPIE, 2006, 6212, 62120J

\cite{3} Lee et al. “Real-time imaging using a 4.3-THz quantum cascade laser and a 320 x 240 microbolometer focal-plane array”, Photonics Technology Letters, 2006, vol.18, pp 1415-1417