ELECTRONIC SPECKLE PATTERN INTERFEROMETRY AT THERMAL INFRARED WAVELENGTHS : A NEW TECHNIQUE FOR COMBINING TEMPERATURE AND DISPLACEMENT MEASUREMENTS

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ABSTRACT: We present a novel technique which suitably combines thermographic and displacement full-field measurement by performing electronic speckle pattern interferometry at thermal infrared wavelengths, associating CO2 lasers with microbolometer thermal imagers. Application in observing thermomechanical behaviour of composite structures is presented.

1. INTRODUCTION

Holographic and speckle based techniques are well known for measuring full-field displacements and performing non destructive testing on solid objects. The measurement range and accuracy of these techniques are related to the wavelength of the laser. In visible light they are often not well suited for field applications or for large displacement measurement due to the short wavelength used, which imposes high stability constraints. One way to decrease this sensitivity is to use a longer wavelength. Our purpose is to investigate holography in the Long Wave InfraRed (LWIR) range and more specifically at 10 µm with CO_2 lasers. This provides a typical 20 factor of decrease of the stability requirements; meantime the range of measurement is increased by the same factor.

We present here advanced results obtained within the FANTOM FP7 project. Besides the lower sensitivity to external perturbations, another interesting feature that is put forward in this project is the possibility to develop a sensor which combines displacement by holography/speckle and thermography measurements. Here we take advantage to the fact that the necessary observation device for the holographic signal is a thermographic camera. This has an interest in various applications such as analysis of thermo-mechanical behaviour of structures or non destructive testing, where often displacements and temperature fields need to be observed and correlated one to another. We already presented preliminary results on out-of-plane and in-plane ESPI at 10.6 µm, and also on digital holographic interferometry [1], however without combining thermography. Recently we presented an improved digital holographic interferometry set-up [2], and a study of the scattering problems arising when working at such long wavelengths [3]. In this paper we present for the first time to our knowledge the combination of full-field temperature and displacements, with a single sensor.

2. DESCRIPTION OF THE TECHNIQUE

The set-up is a classical ESPI one (figure 1), except that all components and equipments are working in the range of 10 µm. The laser is a CO2 emitting up to 8 Watts. The camera is a Variocam HR from Jenoptik LOS, with a 640x480 uncooled microbolometer array. It is equipped with a 50 mm focal length objective lens, made of Germanium. Other lenses are made of ZnSe glasses. A beam combiner is used to recombine the object beam (in red) and the reference beam (in green) at the level of the sensor. The ESPI technique is the same as is applied in visible, with the possibility of phase-shifting for quantification of phase.

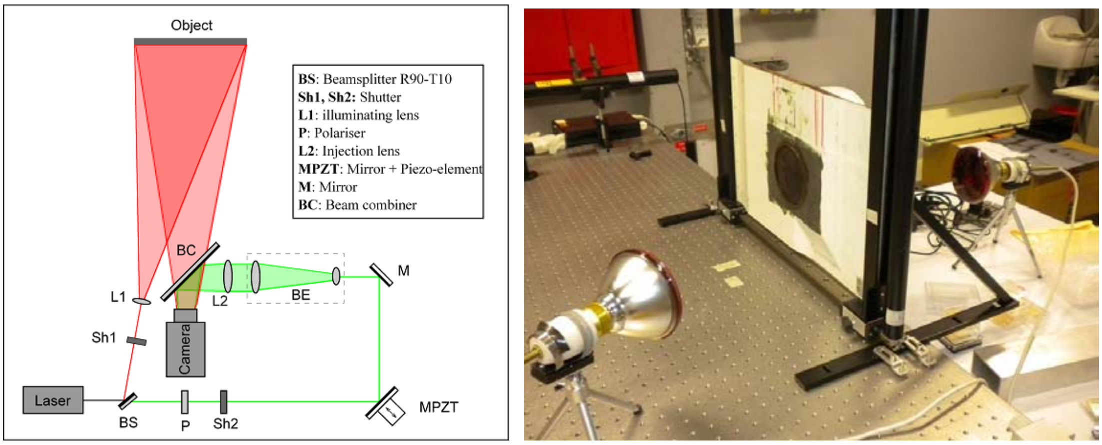
(a)  (b)

Figure 1 (a) Infrared ESPI setup, (b) view of helicopter composite structure with heating lamps

3. RESULTS

Figure 2 presents interferograms obtained after substraction of phases calculated from a set of phase-shifted specklegrams. They correspond to various thermal loads of a helicopter composite structure (figure 1(b)). Figure 3 shows the combination of deformation and temperature fields, respectively left and middle images.

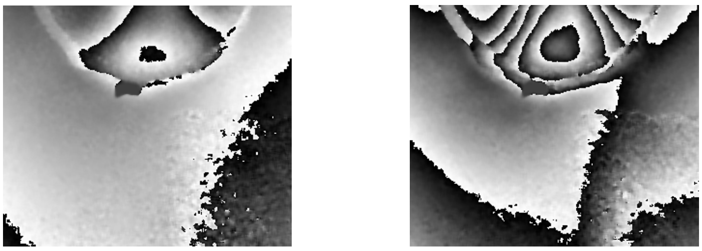
(a)  (b)

Figure 2 Interferograms obtained with thermal infrared ESPI after heating of the helicopter composite structure

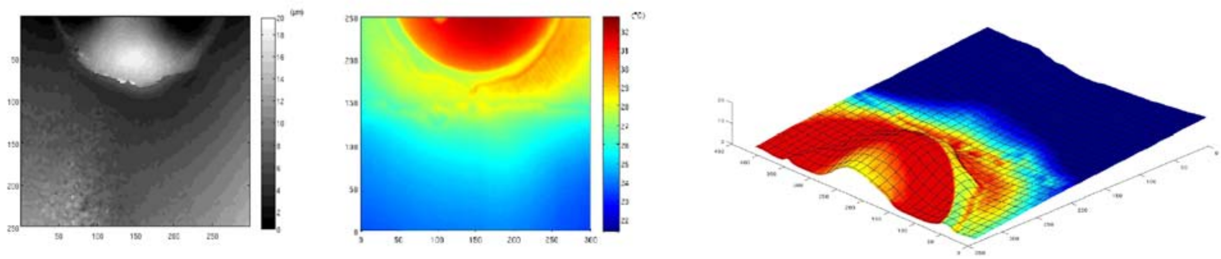


Figure 3. (Left) Unwrapped phase image, (middle) temperature field, (right) superimposition of displacement and temperature fields.

4. REFERENCES

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