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Spatial heterodyne flying spot technique for in-situ thermal characterisation of metallic sample under tensile test

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Abstract

This paper addresses the problem of the quantitative orthotropic estimation of thermal diffusivities fields of metallic sample under tensile stress. This investigation gives us a promising possibility for estimation of an effect of irreversible deformation on thermal conductivity of metal and, consequently, experimentally determine the additional part in the thermodynamic potential of the material caused by structure evolution. The main difficulty of such measurement is the very high thermal conductivity of such metallic sample. To develop an appropriate technique we used samples made from (i), Titane ($a = 9.4.10^{-6}\ m^2.s^{-1}$), Nickel ($a = 2.3.10^{-5}\ m^2.s^{-1}$),) and Iron ($a = 2.3.10^{-5}\ m^2.s^{-1}$). For the most conductive sample figure 1.a, the characteristic diffusion time can reaches around 0.1 s for 1 mm of diffusion length. Then, to be able to monitor the thermogram the minimum frequency rate of acquisition should be between 1 to 10 kHz. To realize such performance with InfraRed Thermography in full frame mode, the only solution comes from heterodyne or cardbox methods [1]. If usually the high frequency modulation is realized in time domain, we propose here to realize same frequency range by using spatial flying spot modulation as illustrated figure 1.b. With this new experimental technique, thermogram of such metallic sample can be acquired with a good temporal resolution lower than 10 µs time step. Finally, from the acquired thermogram, the Logarithmic Parabolas Method [2] is applied in order to measure the orthotropic along x, y and z directions thermal diffusivities fields for the several samples where different stress stage was applied. One result is to link the thermal properties change as function of the stress applied to the sample as well as the anisotropy behaviour.

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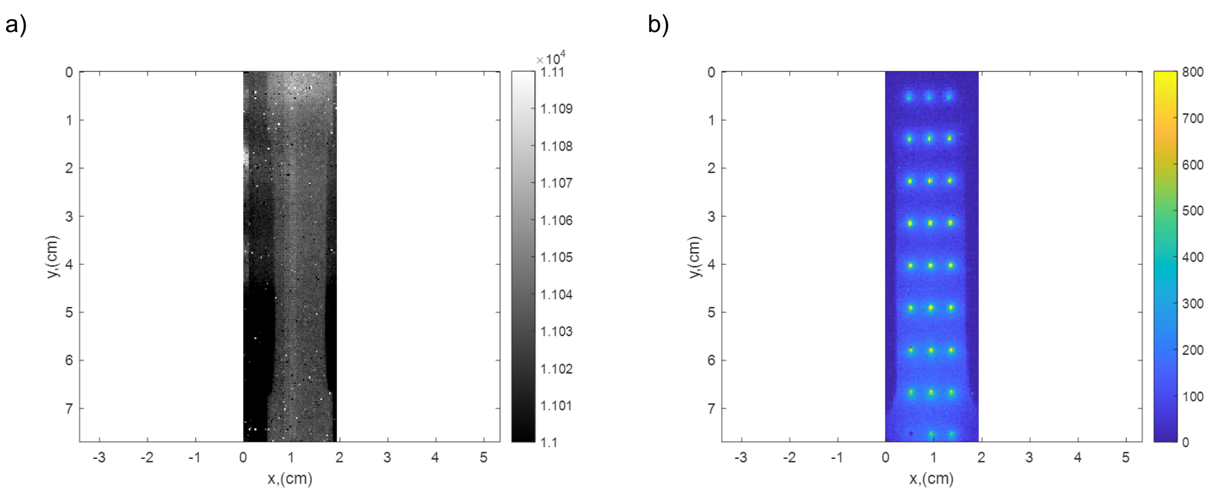

Fig. 1. *a), IR imaging at room temperature of the titane sample and b), hidh frequency rate temperature acquisition in heterodyne Grid Pulses Flying Spoti.*