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INFRARED THERMOGRAPHY AND DIC USED TO INVESTIGATE GUM METAL LOCALIZATION EFFECTS

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ABSTRACT

This paper presents an investigation of strain localization phenomena during tension of a β-Ti alloy Gum Metal that can deform reversibly to large strains (around 2%). Digital image correlation (DIC), with the especially developed PAN algorithm at IPPT, and infrared thermography were used to determine strain and the related temperature distributions with high accuracy. The analysis of strain and temperature distributions showed that the increase in the strain rate affects both the onset and development of the strain localization process.

Keywords: infrared thermography, thermomechanical behavior, gum metal.

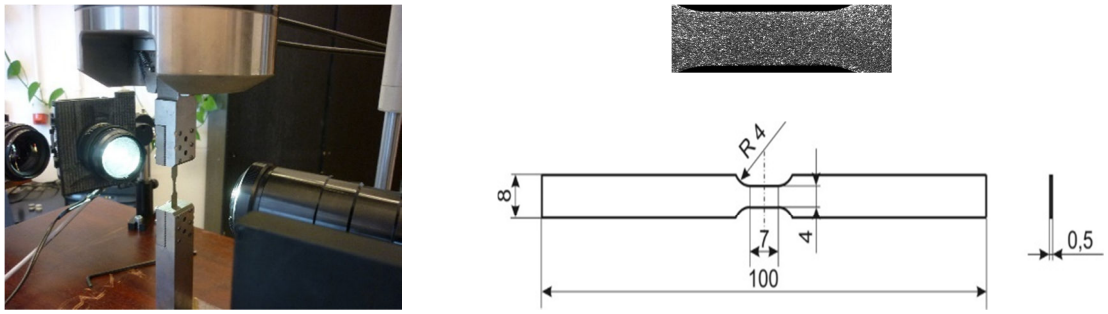
INTRODUCTION

Since the first reports on Gum Metal published in English in 2003 [1], main research directions in several studies focused on the role of chemical composition, in particular oxygen content which significantly influences the Gum Metal properties hindering stress-induced phase transformations, specifically in the nonlinear range of initial deformation.

To the best of the author's knowledge, an analysis of the strain localization phenomena in the Gum Metal basing on effects of mechanical and thermal effects has not been reported too often. Therefore, the goal of the presented paper was to study and discuss the nucleation and development of the strain localization in Gum Metal, basing on the results of thermomechanical couplings [2]. The thermal response of the Gum Metal under loading reveals the thermodynamic nature of the governing deformation mechanisms, which are still discussed in the literature. Correlation between the mechanical behavior and the thermal response of the alloy was analyzed in details for critical instants of the loading. Nucleation and development of the strain localization, leading to the Gum Metal specimen necking and rupture, were discussed.

RESULTS AND CONCLUSION

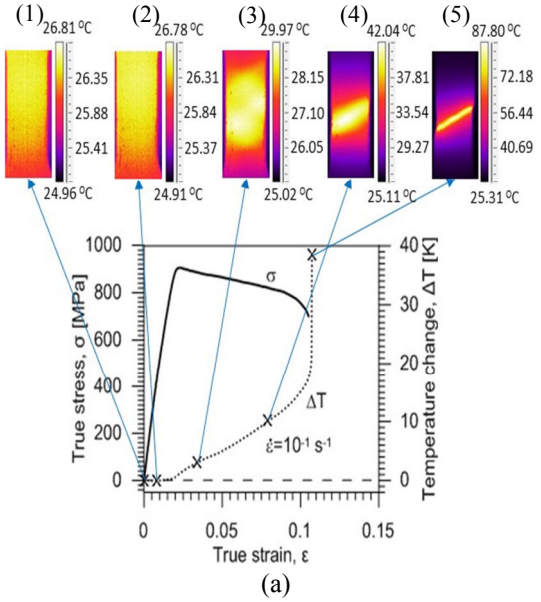
The set-up consists of MTS 858 testing machine and two cameras working in two different spectral ranges, i.e. in visible range (0.3 - 1 μm) Manta G-125B camera and in infrared range (3 - 5 μm) ThermaCam Phoenix IR camera placed on the opposite sides of the specimen. One side, observed using visible range camera, was covered with speckle pattern of paint with micrometer size metal particles in order to perform DIC (Figure 1b). The other one, observed by IR camera, was covered by soot to increase and uniform the surface emissivity as to determine the temperature distribution with high accuracy. The strain measurements were performed using a mechanical extensometer. A photo of the experimental set-up is shown in Figure 1(a). Shape and dimensions of the Gum Metal specimen are presented in Figure 1(b).



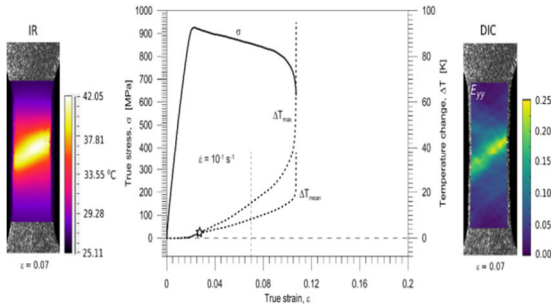
(a) (b)

Fig. 1 - (a) Photo of experimental set-up; (b) Gum Metal specimen geometry and surface prepared for DIC analysis

Stress-strain curves and corresponding temperature distributions obtained for the strain rate 10-1s-1 are presented in Figures 2 (a) and (b), respectively. Thermogram (1) was captured before the loading, thermogram (2) pointed maximal drop in temperature (thermoelastic effect), thermogram (3) showed increase in temperature, thermogram (4) depicted localization effects leading to the specimen necking and rupture noticed in thermogram (5).



(a)



(b)

Fig. 2 - (a) Stress and temperature vs. strain and related temperature distribution for Gum Metal in tension at $10^{-1}s^{-1}$. (b) Stress, maximal ΔT_{max} and mean ΔT_{mean} temperatures vs. strain with thermogram (left side) and corresponding E_{yy} strain component distributions (right side) obtained for the strain 0.07 pointed by vertical dashed line

Effects of thermomechanical couplings occurring in Gum Metal subjected to tensile loading at high strain rate were investigated using digital image correlation and infrared thermography.

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