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RESEARCH ON THE SPATIAL DISTIBUTION OF MECHANICAL CHARACTERISTICS IN A CADMIUM TELLURIDE CRYSTAL

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Abstract *The article presents a study on the evolution of mechanical properties such as hardness, elastic modulus, creep trend of a cadmium telluride macrocristall grown from melt using charging / discharging automatic cycles of the indenter made by a microhardness tester Martens equipped with force and motion sensors and with specialized software for processing and displaying data.*
Key words: *cadmium, telluriue, hardness, creep*

1. INTRODUCTION

Cadmium telluride use in the production of solar cells, exposed during a long exploitation of considerable mechanical stress due to weather influences and succession of seasons, requires both the achievement of photovoltaic structures with adequate mechanical strength as well as knowledge and development of advanced methods for rapid testing of their mechanical characteristics (Gutt, 2002, Fröhlich, 1977, Grau,1993, Weiler, 1990). Currently, one of the most efficient and quick method for advanced materials characterization in terms of important characteristics of mechanical strength is the instrumental Martens hardness test. (DIN EN ISO 14577, Dengel, 1989, Dorner, 1986). For this type of hardness from the loading-unloading cycle of indenter, some important mechanical properties can be measured such as Martens hardness, elasticity modulus, work of elastic deformation, work plastic deformation, total work, creep tendency and strain hardness tendency and its degree.

2. EXPERIMENTAL

Experimental measurements were performed by an automatic Martens hardness tester produced by Schimadzu Company and located in the Instrumental Analysis Laboratory of Food Engineering Faculty of Suceava.

During experimental research the following mechanical characteristics were determined:
Martens Hardness (HM) from the relationship between load and depth of indentation by the following relationship:

$$HM = \frac{F}{26{,}43 \cdot h^2} \qquad (1)$$

Where: F - force applied to indenter, [N]
h - depth of indentation under load [mm]

Modulus of elasticity of indentation (E_{IT}) with the relationship:

$$E_{IT} = \frac{1-(v_s)^2}{\frac{1}{E_r} - \frac{1-(v_i)^2}{E_i}} \qquad (2)$$

$$E_r = \frac{\sqrt{\pi}}{2C\sqrt{A_p}} \qquad (3)$$

where: v_s - Poisson number of tested material, v_i - Poisson number of indenter material (for diamond 0.07), Er - reduced modulus of penetrating contact, E_i - elasticity modulus of indenter (for diamond 1.14 x106 N/mm^2), C - contact failure, the report dh/dF of curve for loading and unloading at discharge when the force has a maximum value (reciprocal value of stiffness), A_P - contact projection surface (for h> 6 µm and using Vickers indenter, A_p is valid for the folllowing relationship:

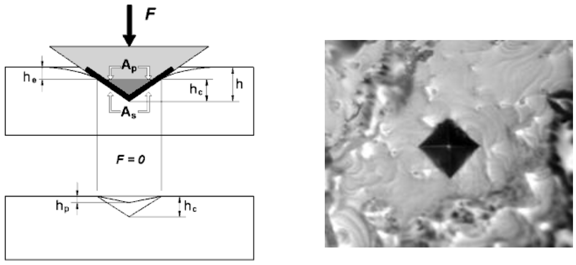
$$\sqrt{A_p} = 4{,}950 x h_c \qquad (4)$$

Creep tendency in indentation (C_{IT})

$$C_{IT} = \frac{h_2 - h_1}{h_1} \cdot 100 \qquad (5)$$

Where: h_1 - depth of indentation at time (t_1), corresponding to the load force which will be kept constant [mm],
h_2 – depth of indentation at time (t_2) corresponding to the constant maintenance of load force, [mm].

Figure 1 presents schematically the geometric characteristics of Martens hardness test and in figure 1b a trace of test on cadmium telluride after indenter removal is shown.



a) b)

Fig. 1. a) the main geometrical characteristics in Martens hardness testing and instrumental hardness test, b) after removal of indenter from the tested material

3. RESULTS AND DISCUSSION

In a cycle of continuous loading/unloading the Martens hardness tester allows the obtaining of stress cyclogrames of the same kind as those from figure 2. From a cyclogram the Martens hardness HM is automatically calculated at the maximum loading force, by relationship (1) and modulus of elasticity of indentation by relationship (2).

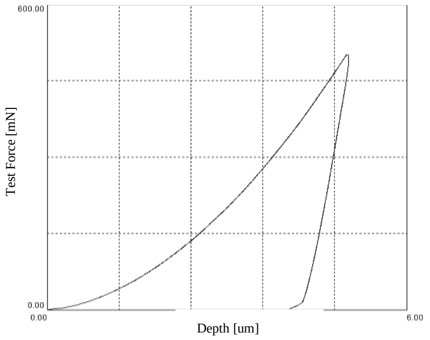


Fig. 2. Cyclogram of Martens loading-unloading

To determine the creep tendency the indenter is loaded gradually until up to maximum load and when load is constant, the specific curve looks as in figure 6. The relationship (3) was used to calculate the creep tendency of cadmium telluride.

The actual problem to be solved was that of determining the mechanical properties distribution: Martens hardness, modulus of elasticity, tendency to creep for a flat section of a cadmium telluride macrocristal of about 86 mm length, figure 3, obtained by crystallization of melt.

Fig. 3. Measuring of mechanical characteristics of resistance, positions and distances on cadmium telluride crystal

After tracing the axis of symmetry zones from 5 to 5mm areas were scored on crystal axis and the Martens hardness test was made in the points scored, with loading in the full cycle.

After these tests have been made curves like those in Figure 4 for Martens hardness variation on the crystal length and curve of figure 5 for the variation of modulus of elasticity along the length of the crystal.

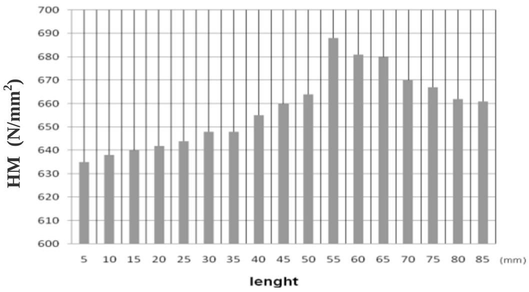


Fig. 4. Evolution of Martens hardness depending on symmetry axis of the crystal

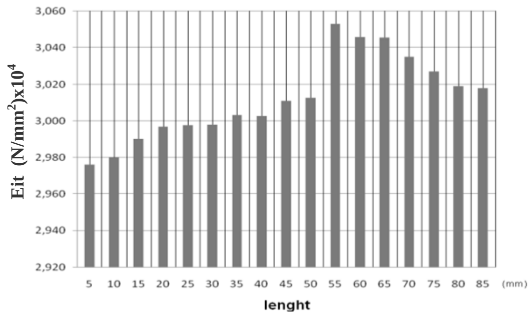


Fig. 5. Evolution of elasticity modulus depending on symmetry axis of the crystal

To determine the creep tendency in every test point shown in figure 3 an attempt of the indenter has been made maintaining a constant load for 15 seconds.

A family of curves results from depletion of all points as seen in figure 6.

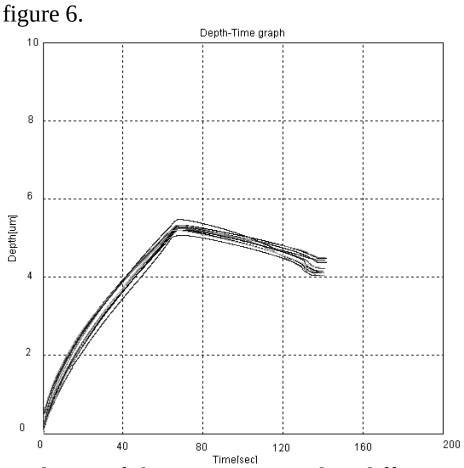


Fig. 6. Evolution of the creep measured in different points on the cadmium telluride crystal constant load of 500 mN and times of stress 15 seconds

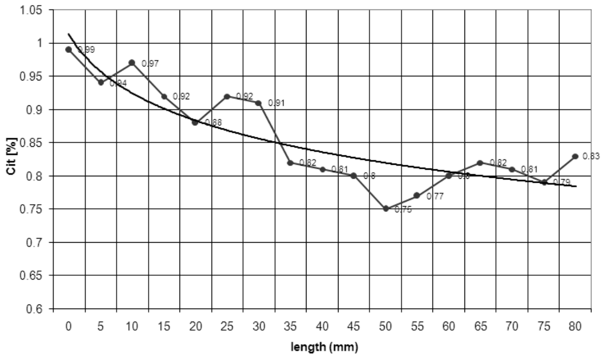


Fig. 7. Variation of maximum indentation depth under load (creep trend) determined at different measuring points on the cadmium telluride crystal to a time test of 15 seconds

4. CONCLUSIONS

By using a Martens hardness tester equipped with an automatic loading system of indenter and assisted by specialized software, it is possible to obtain quick and advanced characterization of cadmium telluride in terms of hardness, modulus of elasticity and creep tendency.

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