PHYSICAL CHEMISTRY 2006

Proceedings

of the 8th International Conference on Fundamental and Applied Aspects of Physical Chemistry

September 26-29,
Belgrade, Serbia

ISBN	86-82139-26-X
Title:	Physical Chemistry 2006. (Proceedings)
Editors	Prof. dr A. Antić-Jovanović
Published by:	The Society of Physical Chemists of Serbia, Studentski trg 12-16, P.O.Box 137, 11001 Belgrade, Serbia
Publisher:	Society of Physical Chemists of Serbia
For publisher:	Prof. dr S. Anić, president of the Society of Physical Chemists of Serbia
Printed by:	"Jovan" Printing and Published Comp; 250 Copies; Number of Pages: x + 442; Format B5; Printing finished in September 2006.
Text and Layout:	Aleksandar Nikolić

250 – copy printing

SURFACE MODIFICATIONS OF TIN COATING BY PULSED TEA CO_2 LASER

M. S. Trtica and B. M. Gaković

VINČA Institute of Nuclear Sciences, P.O. Box 522, Belgrade, Serbia (etrtica@vin.bg.ac.yu)

Abstract

Interactions of a TEA CO_2 laser, 100 ns pulse, with titanium nitride (TiN) coating deposited on AISI D2 steel, were studied. The energy absorbed from the laser beam is partially converted to thermal energy, which generates a series of effects such as melting, vaporization of the molten material, shock waves, etc. Morphological modifications of the titanium nitride surface can be summarized as follows: (i) ablation of the TiN coating in the central zone of the irradiated area with creation of grainy and cracked features, (ii) appearance of a hydrodynamic structure like resolidified droplets of the material in the periphery region. The process of sample irradiation was accompanied by the appearance of plasma. Color modifications of the sample, upon laser irradiation, indicate possible chemical changes like oxidation.

Introduction

Surface modification studies of titanium-based ceramic coatings, especially TiN deposited on steel substrates, by various types of energetic beams including laser beam are of great fundamental and technological interest. The last decade saw most of the studies of laser beam interaction with TiN. Beams of the Nd:YAG-[1], Ti:Sapphire-[2], excimer-XeCl-[3], and CO_2-[3,4] lasers have so far been used for this.

Interactions of pulsed TEA CO_2 [3,4] laser beams with TiN are not extensively reported in literature. TiN has extraordinary physical and chemical properties like a high melting point, thermodynamic stability, high hardness, etc. From these reasons it is attractive for industry, nuclear technology, bio-medicine, etc.

The present paper deals with effects of a pulsed infrared laser emitting at ~10.6 μm (TEA CO_2 laser) on TiN coatings deposited on high quality steel AISI D2. Special attention was paid to morphological surface modifications of TiN.

Experimenal and Discussion

The TiN coatings, thickness of 10 μm, were deposited on AISI D2 steel substrate by CVD method. Sample irradiations were performed with the laser beam focused by a KBr lens of 6.0 cm focal length. The angle of incidence of the laser beam with respect to the surface plane was 90°. The irradiation was carried out in air atmosphere. The TEA CO_2 laser, during the experiment, was operated typically in the TEM_{00} mode. Conventional (1 atm) CO_2/He gas mixtures were used for the laser operation. The FWHM of the laser pulse was about 100 nanoseconds. Various analytical techniques

were used for characterization of the samples: X-ray diffraction, optical microscopy, and scanning electron microscopy (SEM).

Laser induced TiN morphological changes showed dependence on the beam characteristics: primarily on the laser energy density (LED), peak power density, pulse duration, number of pulses. Morphological changes of the TiN after 500 laser pulses are presented in Figures 1 and 2. The LED of 25 J/cm^2 induces significant surface modifications and they can be presented as follows: (i) Partially ablation of the

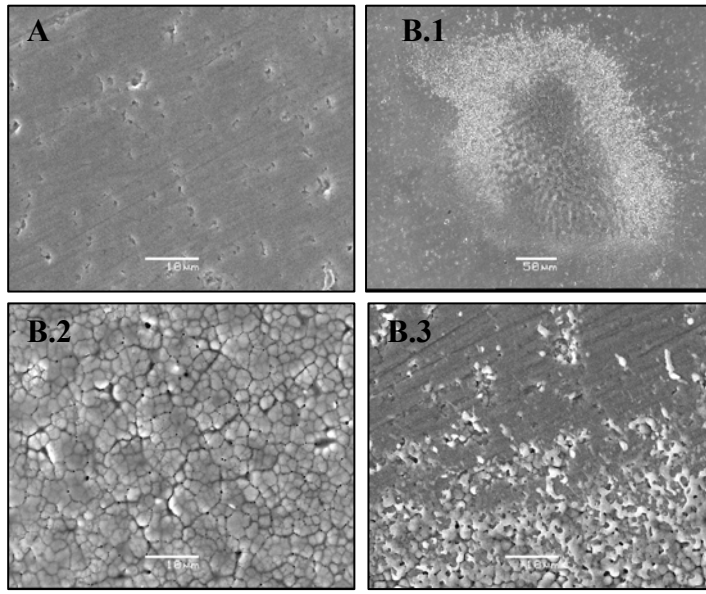

Fig. 1. TEA CO_2 laser-induced morphology changes of the TiN coating (SEM). (A)- The TiN coating prior to the laser action; (B)- TiN coating after 500 laser pulses. B.1, B.2 and B.3, entire spot, center and periphery of the damage area, respectively (LED, 25 J/cm^2).

coating in the central part. In this case the processes of rapid heating and cooling led to cracking (Fig.1, B2) as well as appearance of grainy structure (Fig.2, B) in the coating. Average size of grain was about 1.5 micron. (ii) roughly two zones in the periphery can be distinguished (Fig.1, B1 and B3). In these zones hydrodynamic effects resembling resolidified material are visible.

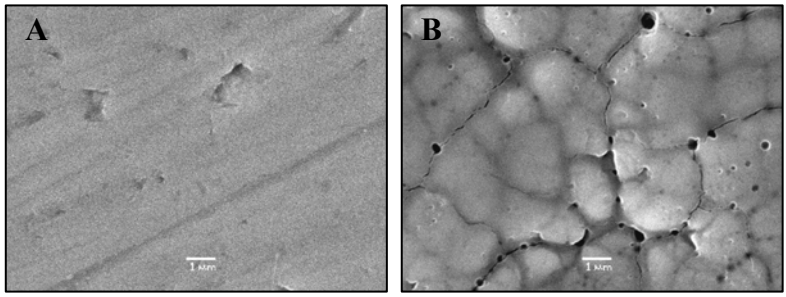

Fig. 2. TEA CO_2 laser-induced morphology changes of the TiN coating (SEM). (A)- The TiN coating prior to the laser action; (B)- The center after 500 laser pulses (LED, 25 J/cm^2).

A form of spark-like plasma started to appear after about 20 cumulated laser pulses. Generally, the TEA CO_2 laser radiation interaction with TiN surface is complex. In a simple approximation the energy absorbed from the laser beam is converted to thermal energy, which causes melting, vaporization of the molten material, dissociation or ionization of the vaporized material and shock waves in the vapor and the solid.

Conclusion

A study of morphological changes of titanium nitride coating, deposited on AISI D2 steel, induced by a TEA CO_2 laser is presented. It is shown that laser energy density of 25 J/cm^2 was sufficient to induce structural changes in the target. The energy absorbed from the CO_2 laser beam is mainly converted to thermal energy, causing melting, vaporization, etc. The morphological modifications of the TiN coating can be considered as: (i) ablation of the coating in the central zone of the irradiated area with creation of grainy and cracked changes, (ii) appearance of a hydrodynamic feature like resolidified material in the surrounding peripheral zone. Upon laser irradiation the color modifications of the target indicate possible chemical changes, resembling oxidation.

Acknowledgement

This research was financially supported by the *Ministry of Science and Environmental Protection of the Republic of Serbia,* Contract No. 142065.

References

[1] T.V. Kononenko, S.V. Garnov, S.M. Pimenov, V.I. Konov, V. Romano, B. Borsos, H.P. Weber, Appl. Phys. A, 2000, **71**, 627-631.
[2] J. Bonse, H. Sturm, D. Schmidt, W. Kautek, Appl. Phys. A, 2000, **71**, 657-665.
[3] M.S. Trtica, V.F. Tarasenko, B.M. Gakovic, A.V. Fedenev, Lj.T. Petkovska, B.B. Radak, E.I. Lipatov, M.A. Shulepov, Appl. Surf. Science, 2005, **252**, 474-482.
[4] B.M. Gakovic, M.S. Trtica, T.M. Nenadovic, B.J. Obradovic, Thin Solid Films, 1999, **343-344**, 269-272.