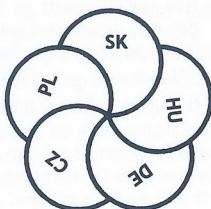


**UNIVERSITY OF ŽILINA**  
**Faculty of Mechanical Engineering**  
**Department of Materials Engineering**

## **33<sup>rd</sup> INTERNATIONAL COLLOQUIUM**



## **ADVANCED MANUFACTURING AND REPAIR TECHNOLOGIES IN VEHICLE INDUSTRY**

**Western Tatras – Zuberec, Slovakia**  
**May 25 – 27, 2016**

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# ADVANCED MANUFACTURING AND REPAIR TECHNOLOGIES IN VEHICLE INDUSTRY

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Western Tatras - Zuberec, Slovakia

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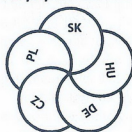
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Advanced Manufacturing and Repair Technologies in Vehicle Industry

May 25 – 27, 2016 Western Tatras - Zuberec, Slovakia

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## INVESTIGATION OF LASER TREATED COPPER SURFACE LAYER

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### 1. Introduction

There is a need in different industry sectors to improve the performance of material surface under wear and corrosion environments, which cannot be fulfilled by the conventional surface modifications and coatings [1]. Laser surface engineering is rapidly developing because of the presence of new and more cost-effective lasers. The compact and energy efficient direct diode and fibre lasers, for example, give higher process efficiency, making them more attractive for integration into a manufacturing line [2].

Sometimes the research goal is to change the surface energy or wettability of different materials such as copper [3-6]. Our goal is to change the surface energy without modifying the surface topography, for this it has to be investigated what happened on the copper surface layer after laser treatment. Better understanding of continuous wave laser interaction with a copper target requires explanation of the relation between the basic mechanisms of laser interaction.

Generally, surface modification of the copper depends on the laser output parameters (continuous wave or pulse energy density, intensity, wavelength, feed rate) as well as the sample properties (for example absorptivity) and also irradiation conditions (e.g. working atmosphere) [7]. The effect of the pulsed Nd:YAG laser irradiation on the surface energy of the copper plate was investigated in some papers [3, 8]. We wanted to change the copper surface properties like wettability without modifying the surface topography with laser treatment. So the effects of laser surface treatments were investigated on copper surface layer using a continuous wave Nd: YAG laser.

### 2. Experimental

The laser surface treatments were carried out on Cu ETP R240 (CW004A) copper plates. The plates were sectioned into 15 x 15 mm squares. Before the laser treatments the copper plates were grinded and polished to remove the oxide layer and reach similar surface properties in every sample and washed with 96 % ethanol (C<sub>2</sub>H<sub>6</sub>O).

The laser used in the study was Rofin DY 027, Nd:YAG pulsed laser with emission of 1064 nm wavelength CW laser beam (TEM<sub>00</sub>), which was focused directly onto a 0.4 mm diameter spot. During the treating process, the laser beam was traversed across the copper samples by means of a laser scanner at speed of 500 mm/min. Different laser powers, from 100 W to 2500 W, were used in this process. Argon gas was used as shielding gas to protect the samples from oxidation during laser irradiation with the flow-rate of 12.5 l/min.



In order to analyse the influence of the laser treatment on microstructure, the specimens, before and after laser treatment, were sectioned with a cutting machine using a diamond-rimmed cutting blade. The sectioned specimens were mounted with methyl-methacrylate casting resin then, subsequently, grinded with SiC paper and polished with diamond suspension to 1  $\mu\text{m}$ . The copper surface were examined on the cross sectioned samples by optical microscope and SEM.

SEM investigations were carried out using a SEM equipment FEI Inspect S50 SEM machine. The SEM was operated with a beam acceleration of 20 kV.

### 3. Results

After the laser treatments of the copper surface optical microscope measurements were performed. In Fig. 1. cross sections show the surface layer microstructures of the optical metallographic samples before and after laser treatments with different laser power.

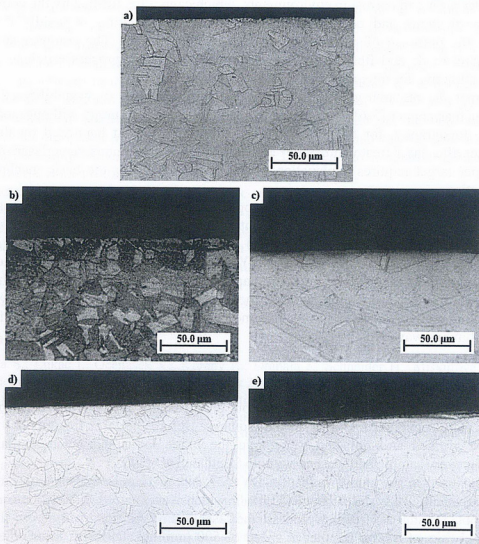


Fig. 1 Optical microphotographs after laser irradiation with different laser power  
a) untreated, b) 300 W, c) 600 W, d) 900 W and e) 2500 W.



As shown in Fig. 1. a) and b), when treated with 300 W, it does not show changes in the close range of the surface. The same effect was observed with 600 W (Fig. 1. c) and 900 W (Fig. 1. d). The grain size of the surface layer does not changed. Fig. 1. e) shows when the energy was increased to 2500 W, there was no identical change detected in the surface layer. The microstructure of the copper sheet was observed and the laser surface treatment with these technical parameters could not show changes of the copper sheet microstructures on this resolution. In order to find out what happened on the laser treated copper surface layer higher magnification required.

SEM micrographs of laser irradiated copper plates are shown in Fig. 2. These samples were treated with 300, 600, 900 and 2500 W laser power.

SEM studies of the copper surfaces reveal that, the laser treatments do not cause any changes on the copper microstructure with 300 W, 600 W and 900 W laser beam power. Fig. 2 a), b) and c) shows that the grain sizes do not changed and on the microstructure nothing changed significantly.

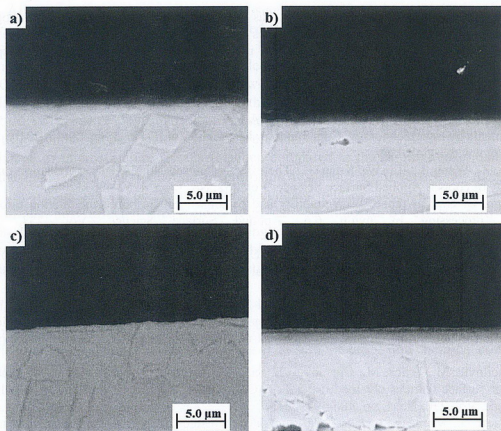


Fig. 2 SEM image of copper microstructure near surface for laser treatment a) 300 W, b) 600 W, c) 900 W and d) 2500 W.

During analysis we could only reveal a different layer close to the surface on the 2500 W laser treated copper sheet (Fig. 2. d). This layer thickness is about 300-700 nm. This could be the effect of the laser treatment. In macroscopic scale the copper sheet does not show changes after laser surface treatment. The surface conditions and the grain structure did not change.



#### **4. Conclusion**

In summary, the effects of laser surface treatments were investigated on copper surface layer using a continuous wave Nd: YAG laser. Previous studies showed that the surface energy and the wettability have changed after the surface treatment. Our purpose was to change the wettability without changing the surface topography.

It was shown by optical microscope and SEM that there was no change of the surface topography in the system up to 2500 W laser power. Optical metallographic measurements were found no change on the microstructure. With higher magnification SEM investigation also verified that. Based on the investigations we can conclude that with these laser parameters if anything was changed on the surface layer, it is below 1  $\mu\text{m}$ .

#### **Acknowledgement**

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