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DOUBLE PULSE LIBS OF JEWELRY, ARTIFACTS, PVD-COATINGS OF WATCH DETAILS AND DRILLING AND CUTTING TOOLS

Double pulse LIBS is a technique to perform quantitative analysis of multicomponent objects based on measurements of plasma emission spectra for the evaporated substance using a double pulse Nd:YAG laser.

Advantages of laser evaporation and spectrum excitation:

- high locality of sampling (laser spot size on the target surface $\sim 50 \mu\text{m}$);
- small quantities – $\sim 10^{-10-11}$ g – of the substance evaporated per single laser pulse;
- analysis of solid samples and solutions is possible;
- insignificant dependence of the material evaporation process on the physical and chemical properties of analyzed substances;
- no need in chemical or mechanical pretreatment of samples;
- applicability to a wide range of substances;
- high sensitivity – detection of elements in concentrations $\sim 10^{-4}$ %.

The experiments were performed with the help of a LSS-1 laser spectrometer produced by the Belarusian–Japanese joint venture LOTIS-TII (Minsk, Belarus).

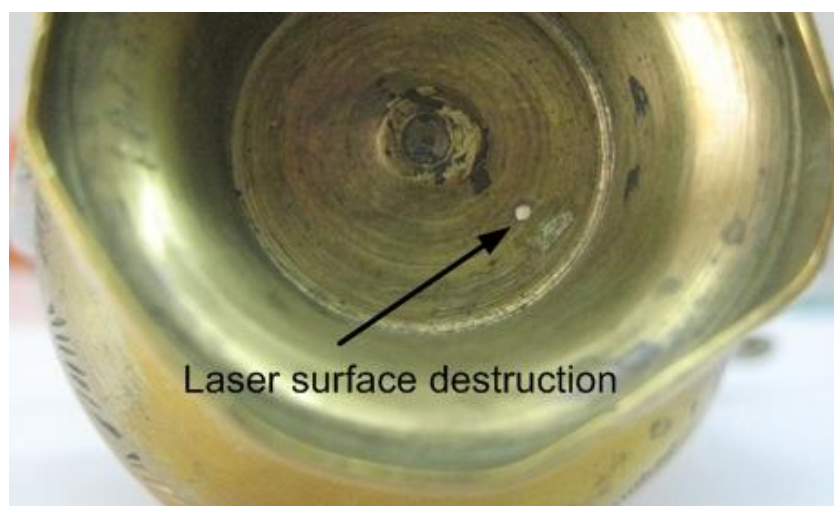


Investigated object:

- **BRASS JUG;**
- **A FIGURE OF COCK FROM GERMAN SILVER.**



Surface destruction: the crater diameter – 50 μm , the crater depth – 15 μm .



Element content C (%) in the brass jug

Element	Cu	Zn	Pb	Al	Ni
Concentration, %	59,13	36,27	3,45	0,78	0,37

Element content C (%) in the German silver figure of the cock

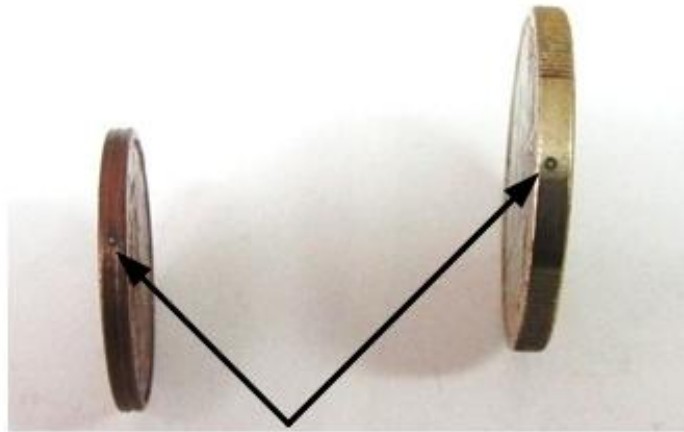
Element	Cu	Ni	Mn
Concentration, %	71,04	28,13	0,83

Investigated object:

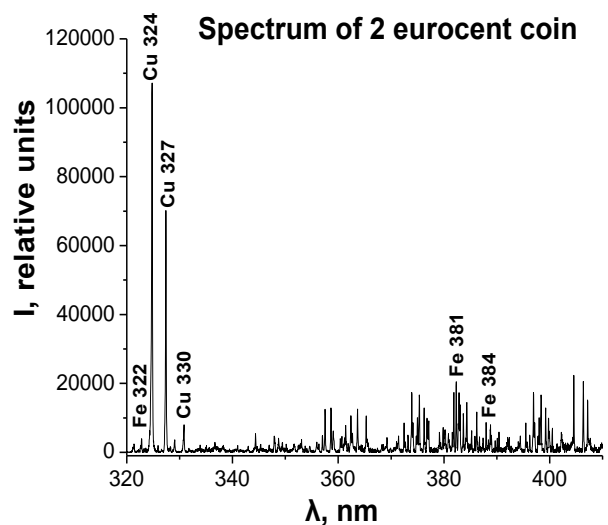
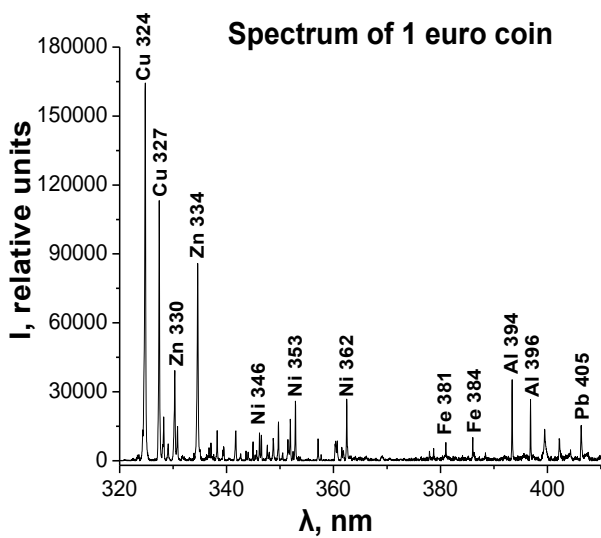
- **1 EURO COIN (STEEL WITH COPPER COATING),**
- **2 EUROCENT COIN (BRASS AND NICKEL).**



Surface destruction: Due to the peculiarities of the laser pulses interaction with the sample surface analysis may be performed in any point of the sample. The investigation was performed on the lateral side of coins. The crater diameter – **50 μm** , the crater depth – **15 μm** .



Laser surface destruction



Investigated object: **SILVER COIN**



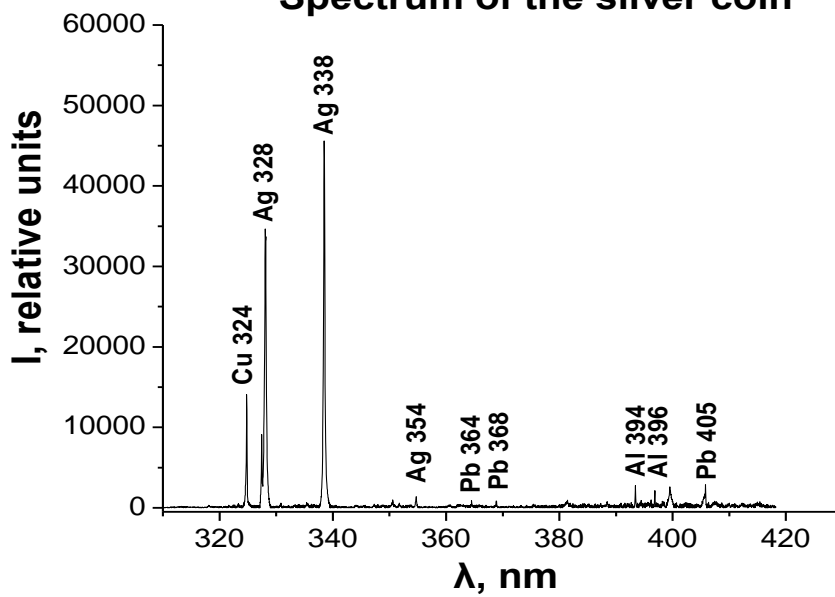
Surface destruction: the crater diameter – 50 μm , the crater depth – 15 μm .



Crater on the coin surface

Photo of crater (*300)

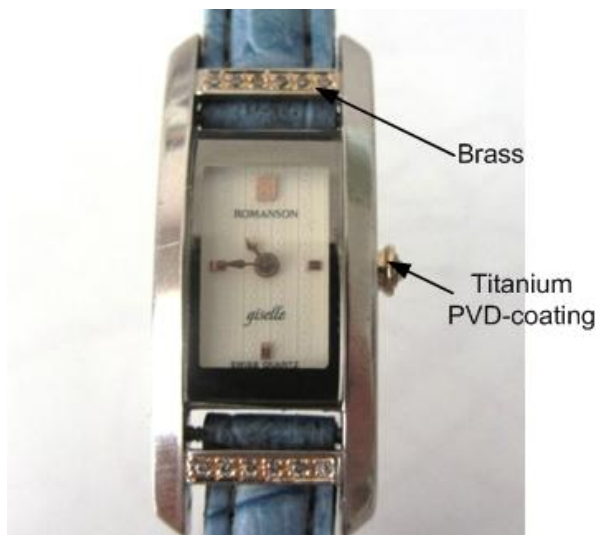
Spectrum of the silver coin



Element content C (%) in the silver coin

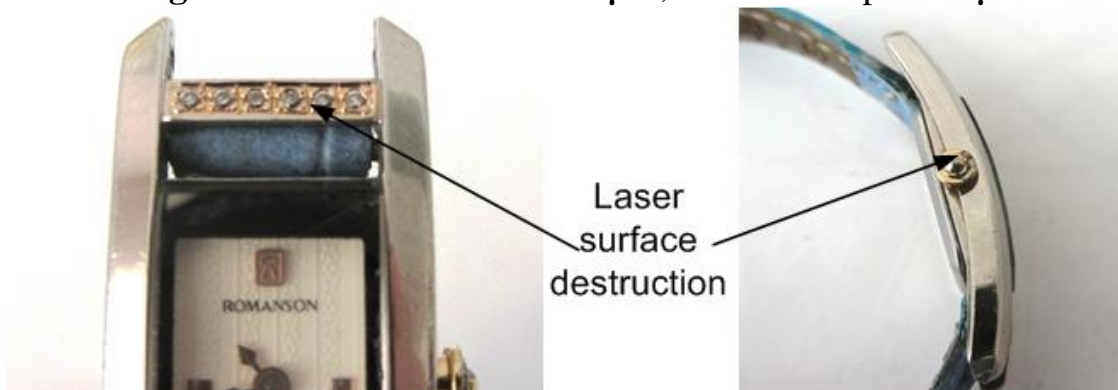
Element	Silver Ag	Copper Cu	Tin Pb	Aluminium Al
Concentration, %	82,49	16,78	0,72	0,012

Investigated object: **WATCH WITH BRASS DETAILS AND TITANIUM PVD-COATING**

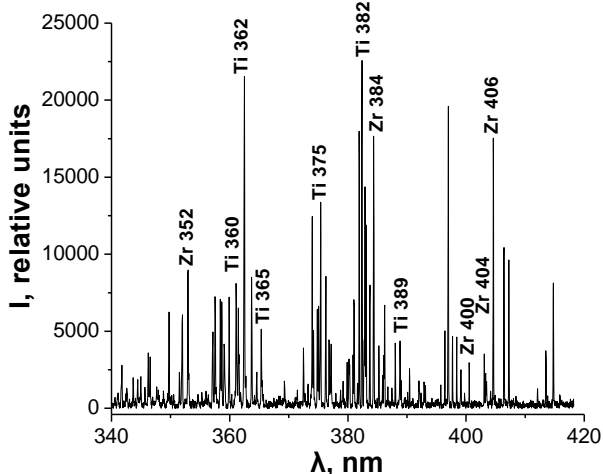


Surface destruction:

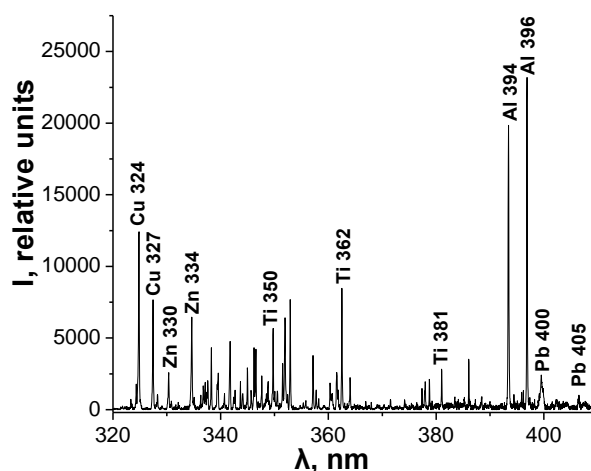
- **Brass-** the crater diameter – **50 μm**, the crater depth – **15 μm**.
- **PVD-coating** – the crater diameter – **500 μm**, the crater depth – **5 μm**.



Spectrum of the PVD-coatings of the watch



Spectrum of the brass details of the watch



Element content C (%) in brass details of the watch

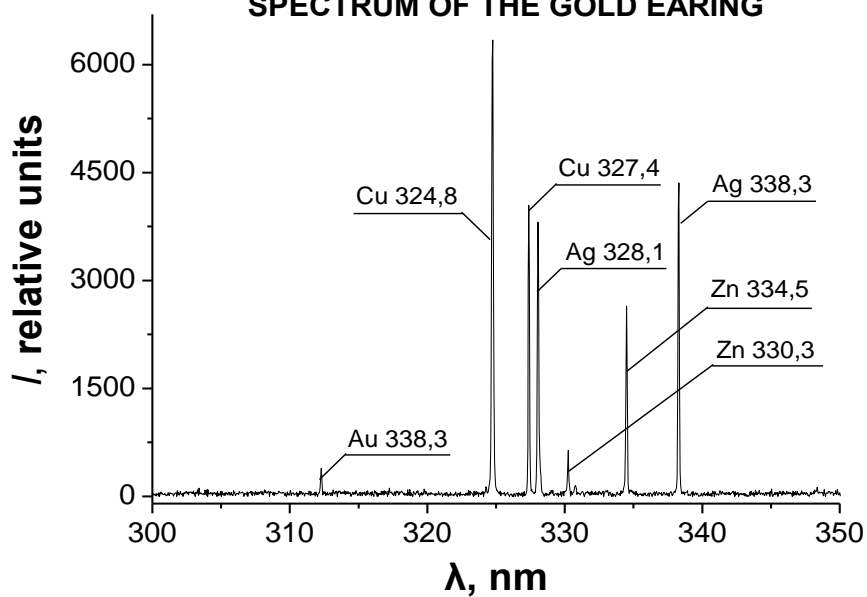
Element	Cu	Zn	Pb	Ti	Al	Fe	Sn
C, %	59,74	28,87	2,18	8,13	0,59	0,22	0,27

*high titanium concentration in brass is explained by the presence of titanium PVD-coating on investigated details

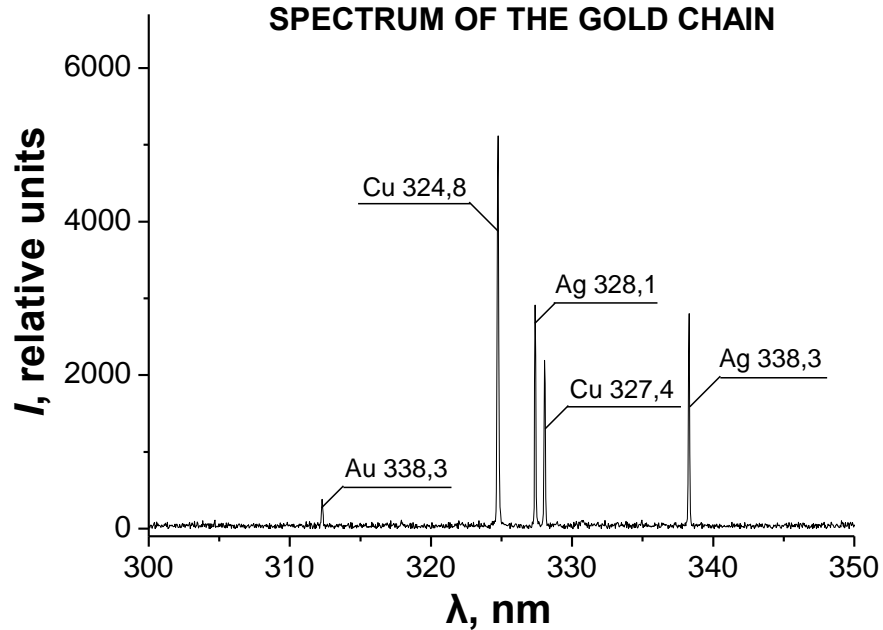
Investigated object: GOLD JEWELRY



SPECTRUM OF THE GOLD EARRING

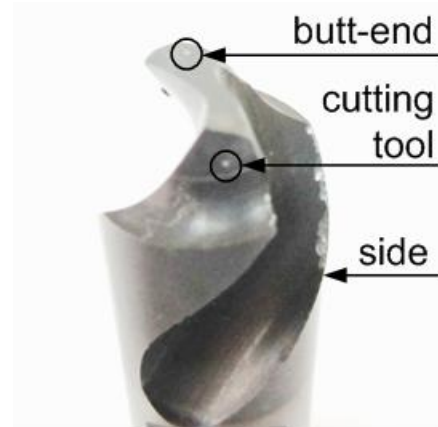


SPECTRUM OF THE GOLD CHAIN

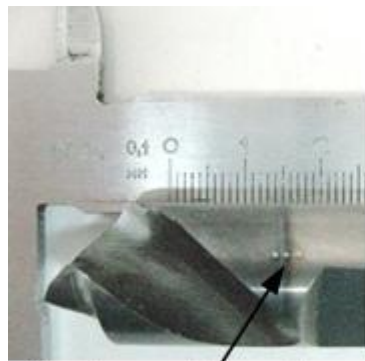


Investigated object: **THE STEEL MILLING CUTTER WITH PVD-COATING (TiAlN/TiN) (Guhring, Germany)**

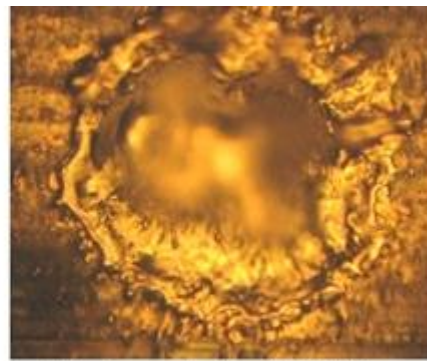
The deposited **PVD-coating** was investigated at three different points arbitrary designated as a **side**, a **cutting-tool**, and a **butt-end**.



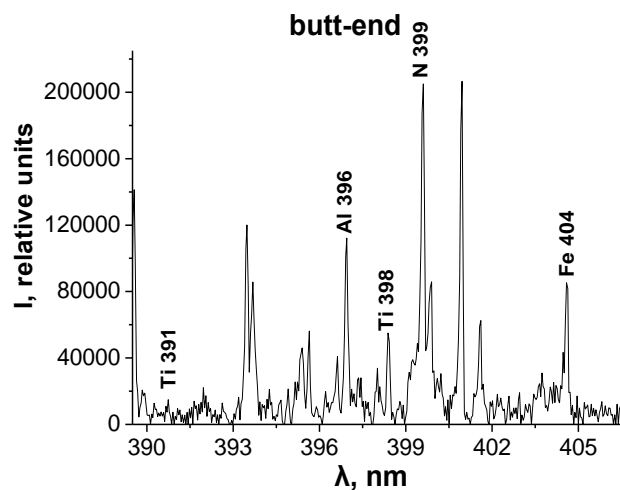
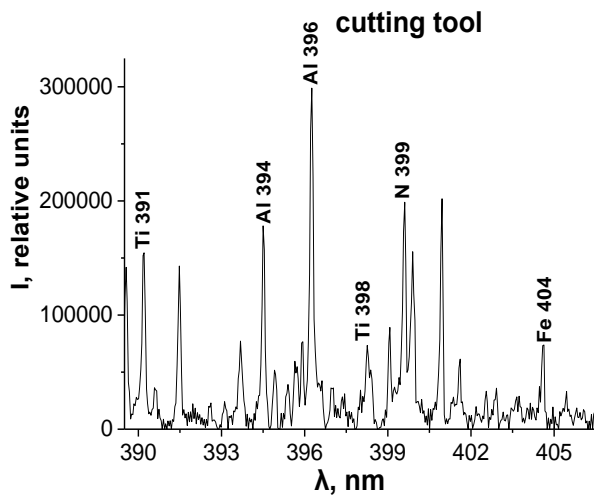
Surface destruction: the crater diameter $d=100\ \mu\text{m}$; the layer thickness h , evaporated by double laser pulses - $0,2\ \mu\text{m}$.



Crater on the cutter surface



Crater photo (*300)



Layer thickness h_i and elemental content in PVD-coating on steel milling cutter

Layer	1	2	3	4	5	6	7	8	9	10
$h_i, \mu\text{m}$	1,73	0,40	0,27	0,24	0,46	0,20	0,48	0,21	0,37	0,40
$C_{\text{Ti}}, \%$	*29÷2,9	34	41	47	52	56	62	66	61	73
$C_{\text{Al}}, \%$	*7÷0,6	9	11	12	14	15	16	18	16	19

* Within the deepest layer with a thickness of $1.73\ \mu\text{m}$ the content of titanium and aluminum linearly decreases with a growing depth.