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NOTE

SURFACE ANALYSIS OF A MODERN SILVER COIN: SEM/EDS MEASUREMENTS

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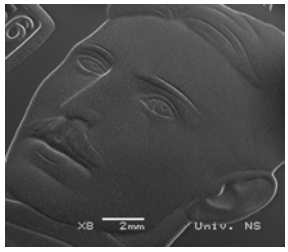
The objective of this work was to investigate the applicability of SEM/EDS technique for microchemical and micromorphological surface characterization of a modern silver coin, which was issued in 2006 on the occasion of the 150th anniversary of Nikola Tesla's birth.



INTRODUCTION

Precious noble metal objects are high value objects for their intrinsic nature and for the great and sophisticated skill used to produce them. In many cases, these artifacts were used not only as jewels or precious artistic items but also as currency, a medium of exchange and a form of saving thereby acquiring historical, artistic and economic value.[1] Nowadays, the nondestructive analytical techniques are widely used for the analysis of cultural-heritage materials, including also noble metal artifacts.[2] The combination of morphological and microchemical surface analysis techniques provides deeper insight in the nature of the investigated object in comparison with independent techniques.[1,3] Such combined techniques are regularly used for the investigation of ancient noble metal coins,[1-3] while the literature about the analysis of new and non-corroded noble metal coins is quite poor. The aim of this work was to demonstrate the applicability of scanning electron microscopy/energy dispersive spectrometry (SEM/EDS) in the surface analysis of a modern commemorative silver coin (Fig. 1A).

EXPERIMENTAL

Sample

The analyzed commemorative silver coin was issued in 2006 by the National Bank of Serbia. Its main parameters are as follows: nominal value, 1000 dinars; weight, 13.000 g; diameter, 30 mm; fineness, Ag 925/1000; maximum quantity, 2000. Before analysis, the coin was protected from environmental effects by plastic coin holder.

Apparatus

The surface morphology of the coin was studied on a Jeol JSM-6460LV scanning electron microscope (Japan Electron Optics Laboratory, Japan). The EDS microanalysis was

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performed on an INCA microanalysis system (Oxford Instruments, United Kingdom).

Procedures

All measurements were done without special surface pretreatments, except surface polishing with cotton cloth and removal of remained textile fibers with fast nitrogen stream.

RESULTS AND DISCUSSION

To study the morphological surface properties and visible surface inhomogeneities several micrographs were taken from the analyzed silver coin. Two main characteristics are visible even at low magnifications (100×, Fig. 1B): the elemental distribution is not homogeneous and on the other hand some small dark spots are present on the surface. Deeper investigation under higher magnifications (2,000–50,000×) showed that most of the dark spots are small holes (micromorphological structures) formed during the production process. Generally, the elemental composition (determined with the aid of EDS) in and around these holes was approximately the same like for another average surface areas. Significantly different composition was identified only in one case (spot analysis): high content of oxygen and silicon indicated the possible presence of a silicon dioxide particle (contamination). EDS analysis of the coin surface confirmed the presence of the main element of the coin, silver, together with its most frequent alloying element, copper (Fig. 1C). The presence of oxygen and carbon was also confirmed (Fig. 1C). In the case of such well protected new coin, the presence of real corrosion products (patinas) could be excluded. On the other hand, adsorption of oxygen and carbon dioxide on silver is a well known process.[4] Similar conclusion is valid also for copper.[5] The interaction of humidity with adsorbed surface oxygen may also result in increased oxygen content through formation of surface hydroxyl groups.[6,7]

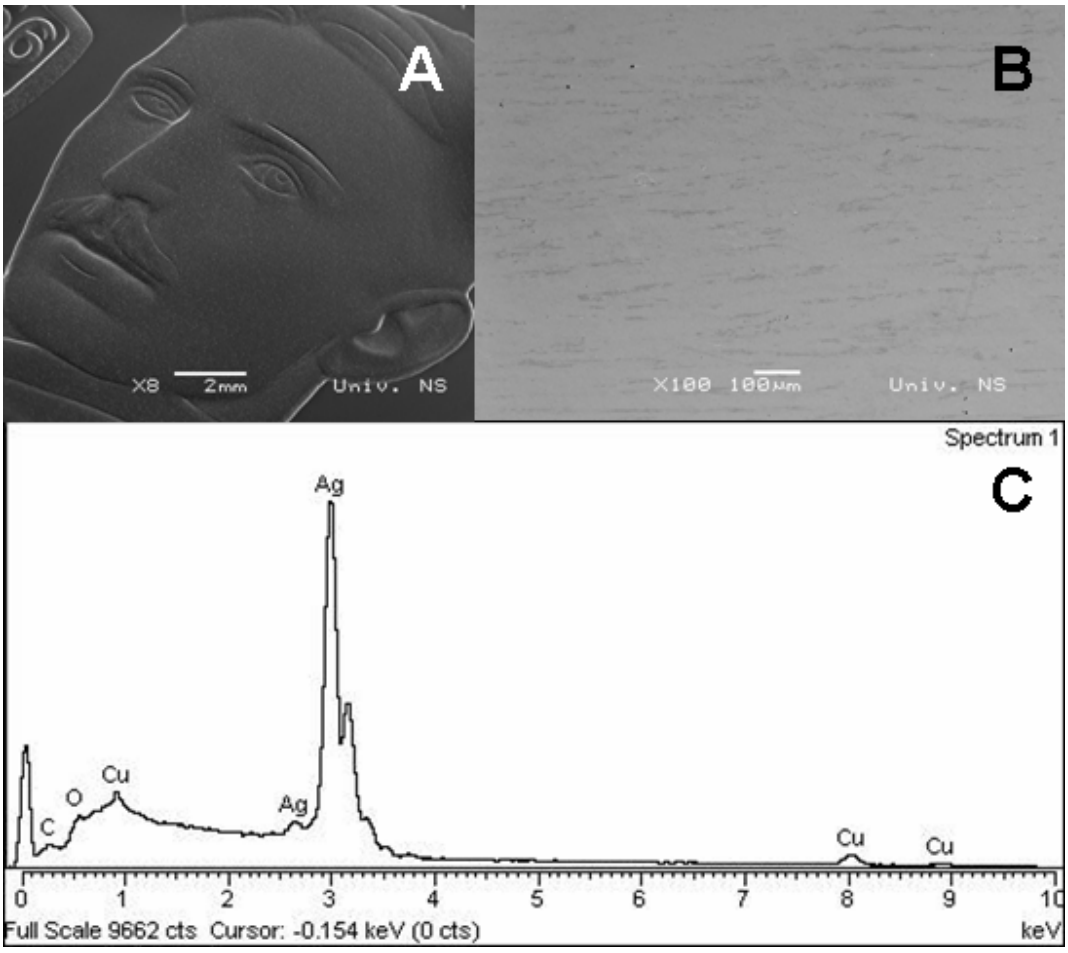

Fig. 1 – Surface micrographs taken at different magnifications (A, 8×; B, 100×) together with the EDS spectra of a representative surface area (C).

The distribution of oxygen and carbon on the coin surface is quite homogeneous (except some edge parts of the identified holes, where the oxygen content is somewhat higher). On the other hand, significantly inhomogeneous distribution of silver and copper was observed (silver rich and copper rich areas could be easily identified, Fig. 1B) and their amount is interdependent. The concentration (w/w%) of the analyzed elements was determined for 4 randomly selected surface segments (≈1 mm^2) and were as follows: carbon, 1.5%; oxygen, 10.6%; silver, 82.6%; and copper, 5.3%. The average ratio of silver to copper is 15.7. In individual spots, this ratio is varying from 6.2 (copper rich parts) to 20.3 (silver rich parts), which corresponds to a surface silver content from 86.0 to 95.3%, if another elements are neglected. The average value of approximately 94% is close to the official fineness (92.5%). It is clear, that this value very often does not correspond with the bulk content. On the other hand, it is also known that surface enrichment in silver in case of silver-copper alloys could be even a result of production process.[8]

CONCLUSIONS

To best of our knowledge this work represents the first microchemical and micromorphological study of a Nikola Tesla memorial coin from 2006. Clear evidences are presented about the presence of some surface defects. Elemental distribution patterns were also discussed. This note confirms important position of the SEM/EDS technique in surface microanalysis. Nevertheless, for the full chemical surface characterization of noble metal coins it is necessary to apply additional instrumental techniques.

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REFERENCES

1. G. M. Ingo, S. Balbi, T. de Caro, I. Fragilà, E. Angelini and G. Bultrini, *Appl. Phys. A*, **2006**, *83*, 493-497.
2. R. Linke, M. Schreiner, G. Demortier and M. Alram, in "Comprehesive Analytical Chemistry XLII", K. Janssens, R. van Grieken, Eds., Elsevier, Amsterdam, Netherlands, 2004, p. 605-633.
3. G. M. Ingo, E. Angelini, T. de Caro and G. Bultrini, *Appl. Phys. A*, **2004**, *79*, 171-176.
4. C. Rehren, M. Muhler, X. Bao, R. Schögl and G. Ertl, *Z. Phys. Chem.*, **1991**, *174*, 11-52.
5. K.-H. Ernst, D. Schlatterbeck and K. Christmann, *Phys. Chem. Chem. Phys.*, **1999**, *1*, 4105-4112.
6. M. Klaua and T. E. Madey, *Surf. Sci.*, **1984**, *136*, L42-L50.
7. C. Qin and J. L. Whitten, *J. Phys. Chem. B*, **2005**, *109*, 8852-8856.
8. L. Beck, S. Bosonnet, S. Réveillon, D. Eliot and F. Pilon, *Nucl. Instrum. Meth. B*, **2004**, *226*, 153-162.