materials

Effect of TiO_2 Concentration on Microstructure and Properties of Composite Cu–Sn–TiO_2 Coatings Obtained by Electrodeposition

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Scheme 1. Microhardness and visual appearance.

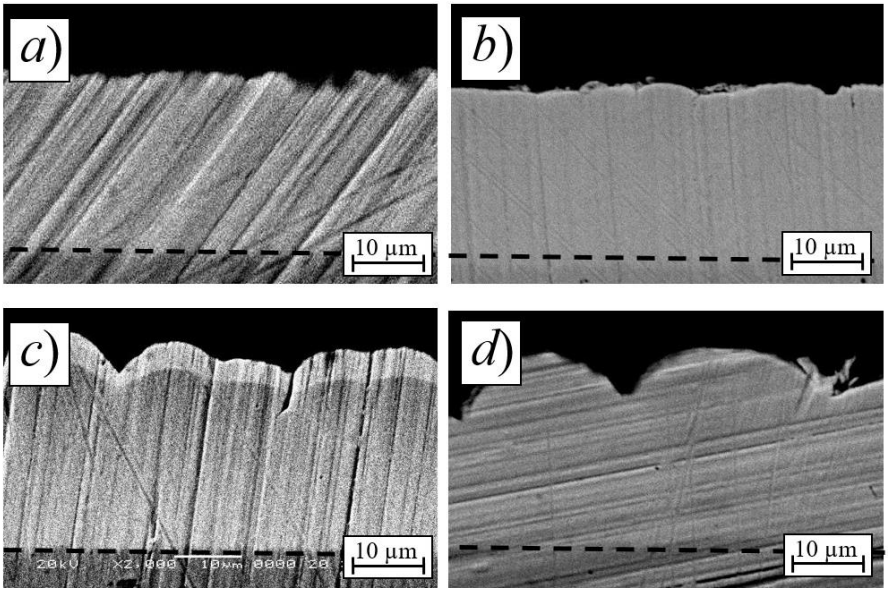


Figure S1. Cross-sectional images of (**a**) Ti-0, (**b**) Ti-1, (**c**) Ti-5, and (**d**) Ti-10 composite coating. The dashed line indicates the substrate (bottom) and the coating (top) border.

The microhardness of the obtained coatings was measured using an AFFRI–MVDM8 hardness tester. Before the deposition of the studied alloys, 1 µm of copper from a pyrophosphate electrolyte (pH 9) of the following composition, mol/L: 0.44 $Cu_2P_2O_7$, 1.00 $K_4P_2O_7$, 0.04 $C_3H_8O_3$, was deposited on the surface. The thickness of the examined coatings was 15 µm.

The luster of the obtained coatings was examined using a photoelectric gloss meter BF 2 M–45/0/45. The luster values are given relative to a silver mirror.

Table S1 shows the results of measuring the microhardness and luster of the obtained coatings. The microhardness of the Ti–0 coatings was 269.6 HV. Modification of coatings with TiO_2 particles leads to an increase in their microhardness. The highest microhardness values were observed for Ti–5 coatings, which have the highest TiO_2 content. TiO_2 particles incorporated into the alloy matrix prevent the movement of dislocations in the coating structure, which leads to an increase in their microhardness.

Semi-lustrous coatings with a luster of 43.4% are formed from the sulfate electrolyte that does not contain TiO_2 particles. The introduction of a dispersed phase into the electrolyte composition leads to a significant decrease in the luster of the formed coatings, which decreased from 30.1 to 18.7% for Ti–1 and Ti–10 coatings, respectively. The decrease in the reflectivity of the coatings with an increase in the TiO_2 content is due to the more inhomogeneous surface morphology of the formed coatings.

Table S1. Luster and microhardness of Cu–Sn and Cu–Sn–TiO_2 coatings.

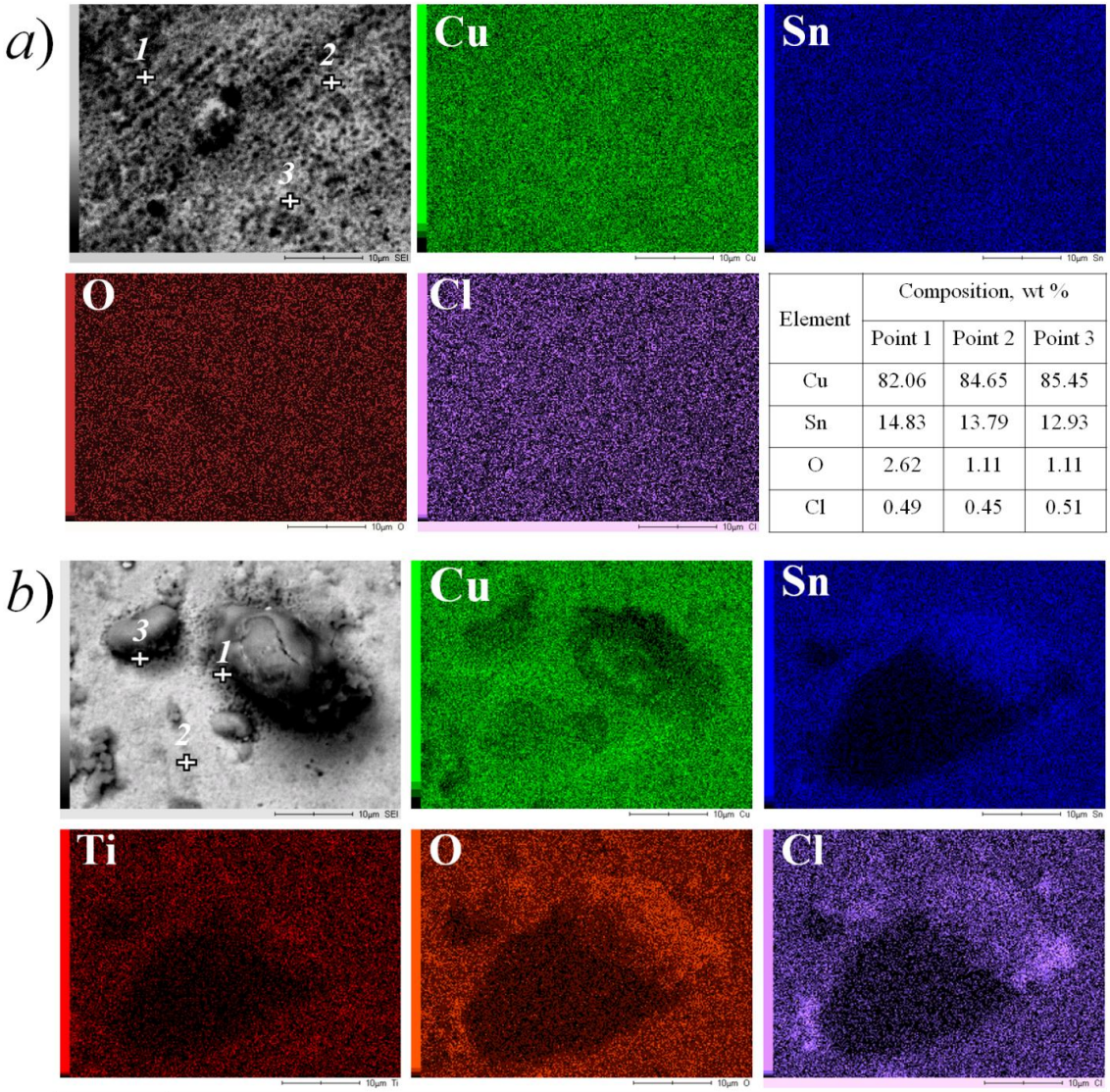
Coating	Luster, %	Microhardness, HV
Ti-0	43.7 ± 3.3	269.6 ± 15.1
Ti-1	30.1 ± 4.1	302.6 ± 19.6
Ti-5	26.5 ± 4.2	320.4 ± 15.6
Ti-10	18.7 ± 2.1	316.4 ± 22.6

S2. XPS analysis

Table S2. The XPS surface chemical analysis of Cu–Sn and Cu–Sn–TiO_2 coatings.

	Cu2p$_{3/2}$		**Sn3d$_{5/2}$**	**Ti2p$_{3/2}$**
	Cu^{+}	**Cu^{2+}**	**Sn^{4+}**	**Ti^{4+}**
BE / eV	932.7	934.1	486.6	458.4
Cu–Sn, at%	56.4	41.2	2.5	–
Cu–Sn–TiO_2, at%	53.4	32.8	10.7	3.1

S3. Corrosion analysis in NaCl solution.



Element	Composition, wt %		
	Point 1	Point 2	Point 3
Cu	82.06	84.65	85.45
Sn	14.83	13.79	12.93
O	2.62	1.11	1.11
Cl	0.49	0.45	0.51

Point	Composition, wt %				
	Element				
	Cu	Sn	Ti	O	Cl
1	71.01	20.79	0.54	7.02	0.63
2	79.28	15.66	0.20	4.27	0.59
3	74.50	19.23	0.44	5.24	0.6

Figure S2. EDX elemental distribution maps of Ti-0 (**a**) and Ti-5 (**b**) coatings after 168 h of corrosion experiments in 3% NaCl solution.

S4. Corrosion analysis in bacterial media.

The composition of the examined medium is presented in Table S3.

Table S3. Composition of bacteria medium.

Component	Composition, g/L
Fishmeal pancreatic hydrolysate	8
Enzymatic peptone	8
NaCl	4
pH	7.0–7.4