

UNIVERSITY OF BELGRADE
TECHNICAL FACULTY BOR

**52nd International October Conference on
Mining and Metallurgy**



PROCEEDINGS

Edited by

Saša Stojadinović

and

Dejan Petrović

November 29th – 30th 2021

Bor, Serbia

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TABLE OF CONTENTS

Aleksandra Milosavljević	
THE COMPLEXITY OF SEM-EDS – WHAT AFFECTS THE QUALITY OF OBTAINED RESULTS?	1
Zoran Karastojković, R Perić, M Srečković	
LASER QUENCHING OF CUTTING TOOL STEELS - A REVIEW	5
Slavica Miletić, D Bogdanović, E Požega	
IMPACT OF EXTRAORDINARY SECURITY MEASURES TO EMPLOYEES DURING THE PANDEMIC COVID-9	15
Daniela Grigorova, R Paunova	
KINETIC STUDY OF SOLID-PHASE REDUCTION OF POLYGRADIENT IRON-CONTAINING MATERIAL	19
Emina Požega, D Simonović, S Marjanović, M Jovanović, L Gomidželović, M Mitrović, Z Stanojević Šimšić	
PART I: WHAT MAKES A GOOD THERMOELECTRIC	23
Emina Požega, D Simonović, S Marjanović, M Jovanović, L Gomidželović, M Mitrović, S Miletić	
PART II: WHAT MAKES A GOOD THERMOELECTRIC	27
Dragan Manasijević, Lj Balanović, I Marković, M Gorgievski, U Stamenković, K Božinović, D Minić, M Premović	
STUDY OF MICROSTRUCTURE AND THERMAL CONDUCTIVITY OF THE Ag–Bi–Sn ALLOYS	31
Vladimir S. Topalović, S Matijašević, S Grujić, J Stojanović, J Nikolić, V Savić, S Zildžović	
THE INFLUENCE OF THE PARTICLE SIZE ON CRYSTALLIZATION OF GLASS POWDERS FROM THE SYSTEM $\text{Li}_2\text{O}-\text{Al}_2\text{O}_3-\text{GeO}_2-\text{P}_2\text{O}_5$	35
Vesna Marjanović, R Marković, V Krstić	
TECHNOLOGIES FOR PHYSICAL TREATMENT OF WATER CONTAINING SELENIUM: A REVIEW	39
Vesna Marjanović, R Marković, V Krstić	
TECHNOLOGIES FOR BIOLOGICAL TREATMENT OF WATER CONTAINING SELENIUM: A REVIEW	43
Milenko Jovanović, M Mikić, M Maksimović, D Kržanović, R Rajković, E Požega	
USAGE SPECIFICS OF GEOGRIDS	47

Srećko Manasijević, Z Zovko Brodarac, N Dolić, M Djurdjević, R Radiša	
INTERMETALLIC BONDING BETWEEN A RING CARRIER AND AN ALUMINUM PISTON ALLOY	51
Snežana Šarboh	
PATENTED INVENTIONS OF LJUBOMIR KLERIĆ	55
Miomir Mikic, M Jovanović, R Rajković, D Kržanović, E Požega	
DEGRADED AREA OF VELIKI KRIVELJ QUARRY RECOLTIVATION	59
Dragana Adamović, D Ishiyama, H Kawaraya, O Yasumasa	
EFFECTS OF TAILINGS ON GROUNDWATER ALONG BOR AND BELA RIVERS IN THE BOR MINING AREA, EASTERN SERBIA	63
Ana Kostov, Z Stanojević Šimšić, A Milosavljević,	
CHARACTERIZATION OF ALLOYS CuAlAu0.5	67
Marija Milenković, V Jovanović, J Paunković, V Krstić	
MULTICRITERIA ANALYSIS OF THE LEVEL OF SUSTAINABLE DEVELOPMENT OF THE TOPLICA DISTRICT USING THE ELECTRE METHOD	71
Daniel Kržanović, R Rajković, D Stevanović, M Mikić, M Jovanović, S Petrović	
LONG-TERM PLANNING OF MINING THE LEAD AND ZINC ORE DEPOSIT IN THE BRSKOVO ORE FIELD, THE REPUBLIC OF MONTENEGRO	75
Radmilo Rajković, D Kržanović, M Mikić, M Jovanović	
CALCULATION OF SAFETY DISTANCE FOR THE OPERATION OF MINING EQUIPMENT IN THE WORKING ENVIRONMENT WITH WEAKENED CHARACTERISTICS AT THE OPEN PIT "NORTH MINING DISTRICT" OF THE COPPER MINE MAJDANPEK	79
Zdenka Stanojević Šimšić, A Kostov, A Milosavljević, E Požega	
HARDENSS, MICROHARDNESS AND ELECTROCONDUCTIVITY OF ALLOYS WITH VARIABLE Cu CONTENT IN Cu-Al-Ag SYSTEM	83
Miodrag Banješević	
STRATIGRAPHY AND AGE OF ROCK UNITS AND MINERALIZATION IN THE TIMOK MAGMATIC COMPLEX AND THE BOR METALLOGENIC ZONE – A REVIEW	87
Milan Radivojević, Z Stević, M Tanasković	
DUALPHASED FOURWAY INTERSECTION REGULATED BY TRAFFIC LIGHTS WITH FIXED AND ADAPTIVE MOD OF OPERATION	93
Filip Gramić, N Rančić, S Filipović, J Đorđević	
USE OF COPPER TAILING AND COPPER SLAG IN 3D PRINTED CONCRETE PROCESSES	97
Filip Gramić, N Rančić, S Filipović, J Đorđević,	
POSSIBILITY OF USING MINING WASTE IN THE PRODUCTION OF BRICK PRODUCTS	101

Stepan O. Vidysh

GOLD-SILVER ALLOYS ANODIC DISSOLUTION RESEARCH IN HYDROCHLORIC ACID ELECTROLYTES 105

Milan Gorgievski, M Marković, D Božić, Vr Stanković, N Štrbac, V Grekulović, M Zdravković

ADSORPTION ISOTHERMS FOR COPPER IONS ADSORPTION ONTO WALNUT SHELLS 109

Miljan Marković, M Gorgievski, N Štrbac, V Grekulović, A Mitovski, K Božinović, M Zdravković

pH AND CONDUCTIVITY CHANGE DURING THE RINSING AND ADSORPTION OF COPPER IONS ONTO WALNUT SHELLS 113

Vesna Grekulović, A Mitovski, M Rajčić Vujasinović, N Štrbac, M Zdravković, M Gorgievski, M Marković

ELECTROCHEMICAL BEHAVIOR OF COPPER IN CHLORIDE MEDIUM IN THE PRESENCE OF WALNUT SHELL MACERATE 117

Marija Šljivić-Ivanović, S Dimović, I Jelić,

EXPERIMENTAL DESIGN APPROACH IN RADIONUCLIDE SORPTION 121

Ivana Jelić, A Savić, M Šljivić-Ivanović, S Dimović

INFLUENCE OF SILICA FUME ON SCC CONCRETE PROPERTIES 125

Milan Radovanović, A Simonović, M Petrović Mihajlović, Ž Tasić, V Nedelkovski, M Antonijević

L-LYSINE AS CORROSION INHIBITOR OF STAINLESS STEEL IN RINGER'S SOLUTION 129

Dragana Marilović, M Trumić, M Trumić, Lj Andrić

THE INFLUENCE OF CALCIUM IONS ON DEINKING FLOTATION RECOVERY UNDER DIFFERENT CONDITIONS 133

Dragana Medić, S Milić, S Alagić, M Nujkić, S Đorđević, A Papludis

OPTIMIZATION OF CATHODIC MATERIAL LEACHING PROCESS IN ACID-SULPHATE SOLUTION 137

Milijana Mitrović, D Gusković, S Marjanović, B Trumić, E Požega, U Stamenković, J Petrović

OBTAINING MULTILAYER COPPER STRIPS BY ARB (ACCUMULATIVE ROLL BONDING) ROLLING PROCESS 141

Nataša Đorđević, S Mihajlović, N Obradović, A Peleš, S Filipović

THE INFLUENCE OF HIGH COMPACTION PRESSURE ON CORDIERITE-BASED CERAMICS 145

Nataša Đorđević, S Mihajlović, M Sokić, B Marković

SEM AND X-RAY ANALYSES OF SINTERED MgO / Bi₂O₃ BINARY SYSTEM 149

Ivana Ilić, J Sokolović, M Trumić, Z Stirbanović	
COMPARATIVE RESULTS OF COPPER FLOTATION FROM SLAG BEFORE AND AFTER THE PROCESS OF MAGNETIC CONCENTRATION	153
Daniela Grigorova	
FERROSILICON OBTAINING USING IRON-SILICATE –FAYALITE	157
Slavica Mihajlović, M Jovanović, N Đorđević, A Patarić, M Vlahović, V Kašić	
THE CLAY PRELIMINARY TESTING FROM MUNICIPALITY AREA OF REKOVAC	161
Milan Milosavljević, M Premović, D Minić, Dn Mansijević, Ar Đorđević, M Kolarević	
EXPERIMENTAL AND THERMODYNAMIC STUDY OF ISOTHERMAL SECTIONS AT 600 °C AND 400 °C OF TERNARY Bi-Cu-Ge SYSTEM	165
Aleksandar Đorđević, D Minić, M Premović, D Mansijević, M Milosavljević, V Ristić	
STUDY OF TEMPERATURE PHASE TRANSFORMATION OF THE TERNARY Bi-Cu-Ge SYSTEM	169
Aleksandar Savić, I Jelić, M Šljivić-Ivanović, S Dimović, N Pudar, A Pfandler	
RECYCLED COARSE AGGREGATE AND FLY ASH EFFECT ON COMPRESSIVE STRENGTH OF SELF-COMPACTING CONCRETE	173
Vladan Kašić, D Životić, V Simić, A Radosavljević-Mihajlović, J Stojanović, S Mihajlović, M Vukadinović	
FORECAST RESOURCES OF ZEOLITHIC TUFFS OF SERBIA	177
Vladan Kašić, A Radosavljević-Mihajlović, S Radosavljević, J Stojanović, S Mihajlović, M Vukadinović	
GEOLOGICAL AND MINERAL CHARACTERISTICS OF ZEOLITHIC TUFF TOPONICA DEPOSITS NEAR KOSOVSKA KAMENICA	181
Konstantin Petkov, V Stefanova, P Iliev	
METHOD FOR UTILIZATION OF THE SULFURIC ACID OBTAINED DURING AUTOCLAVE DISSOLUTION OF PYRITE CONCENTRATE	185
Stefan Đorđević, D Ishiyama, Y Ogawa, Z Stevanović, O Osenyeng, D Adamović, V Trifunović	
MONITORING OF pH VALUE AND CONCENTRATION OF COPPER IN RIVERS DOWNSTREAM FROM BOR MINE IN PERIOD 2015-2021	189
Viša Tasić, M Cocić, B Radović, T Apostolovski-Trujić	
CHEMICAL COMPOSITION OF PARTICULATE MATTER IN THE INDOOR AIR AT THE TECHNICAL FACULTY IN BOR (SERBIA)	193
Snežana Ignjatović, I Vasiljević, M Negovanović	
DEFINING STRUCTURAL CORRELATION USING OF TOTAL HORIZONTAL GRADIENT	197

Velizar Stanković, M Janošević

**INCREASING THE CAPACITY OF THE COPPER SMELTING COMPANY IN THE COMPANY
"SERBIA ZIJIN COPPER" - CHALLENGES AND CONSEQUENCES TO THE ENVIRONMENT** 201

Vladimir Jovanović, D Todorović, B Ivošević, D Radulović, S Milićević, D Nišić

**CHARACTERIZATION OF PELLET SAMPLES OBTAINED BY PELETIZATION OF LIMESTONE
AND SEAWEED** 205

Vanja Trifunović, L Avramović, R Jonović, S Milić, S Đorđievski, M Jonović

**HYDROMETALLURGICAL TREATMENT OF ELECTRIC ARC FURNACE DUST IN AIM OF ZINC
SEPARATION** 209

Jovana Bošnjaković, N Knežević, N Čutović, M Bugarčić, A Jovanović, Z Veličković, S
Manasijević

**EVALUATION OF ADSORPTION PERFORMANCE OF PHOSPHATES REMOVAL USING CELL-
MG HYBRID ADSORBENT** 213

Dragan Radulović, Lj Andrić, D Božović, V Jovanović, B Ivošević, D Todorović,

**POSSIBILITY OF USING LIMESTONE FROM "PJEŠIVAČKI DO"-DANILOVGRAD DEPOSIT AS
FILLER IN VARIOUS INDUSTRY BRANCHES** 217

Predrag Stolić, J Ivaz, D Petrović, Zoran Stević

**ADVANTAGES OF MINING ENGINEERING CURRICULUM REALIZATION USING
SOLUTIONS BASED ON FREE SOFTWARE** 221

Slađana Krstić, E Požega, S Petrović, S Magdalinović, D Urošević, S Miletić, Z Stojanović
Šimšić

**QUALITY INVESTIGATION OF SAND FOR THE PRODUCTION OF AGGREGATES ON
VINOGRADI LOCALITY (DELIBLATSKA PEŠČARA)** 225

Saša Marjanović, D Gusković, M Mitrović, E Požega, B Trumić, U Stamenković

**INFLUENCE OF COLD ROLLING AND ANNEALING ON HARDNESS OF BIMETALLIC STRIP
Cu– Al** 229

INFLUENCE OF COLD ROLLING AND ANNEALING ON HARDNESS OF BIMETALLIC STRIP Cu– Al

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Abstract

Samples of bimetallic strip Cu-Al were cold rolled with different reduction degrees, and the ones deformed with the highest reduction degrees were annealed afterwards at different temperatures for a period of one hour. The values of the hardness of the layers of the bimetallic strip were obtained as a function of the degree of deformation, and the annealing temperature. Global flow of curves hardness - total deformation, increases, where the increase in the hardness of aluminum with increasing degree of deformation is approximately linear. A decrease in hardness was observed with an increase in the annealing temperature, in both the aluminum layer and the copper layer.

Keywords: *bimetallic strip, hardness, deformation degree, annealing temperature*

1. INTRODUCTION

Thanks to combination of different properties in one material, bimetallics are widely used in industry, because of saving expensive scarce metals, and for their specific properties which separate metals-components doesn't have.

In a bimetal, expensive metals and alloys are used as plating materials, with thickness of up to 25% of the bimetal's thickness. Thanks to that it is possible to get relatively cheap materials with required properties where performing layer keeps the properties it's got before joining into bimetal, while cheaper, basic material acts as carrying material that provides required mechanical properties.

Corrosion-proof bimetallics with copper as a plating layer are used more and more.

Cold rolling of a plated strip is a final operation in plastic processing in all cases when enhanced strength and deformation resistance are required [1, 2, 3, 4, 5].

2. EXPERIMENTAL

The samples cut from trilayer sheet Cu - Al - Cu, 10,4 mm thick, obtained by plating by explosion, were used for examination. One Cu layer was removed, so bimetallic strips, 8,4 mm thick, were obtained. The initial thickness of Al, in those strips, were 6,4 mm, and 2 mm for Cu.

Prior to rolling of the bimetallic strip, the gap between the working rolls was set to 8,4 mm, and then the strip was let between for a few times till the total deformation of 10% was reached.

In order to simplify it, it was accepted that the deformation for a single pass was 2,5%. After the deformation of 10% the total thickness and layers thicknesses were measured on various spots.

The same procedure was repeated for the total deformations of 20%, 30%, 40%, 50%, 60%, 70%, and 80%.

The samples deformed with maximum deformation degree, $\varepsilon_{\max}=80\%$, were subjected to annealing.

The annealing was done in a protective atmosphere of nitrogen, for a period of one hour, at temperatures of 200, 250, 300, and 400 °C.

Hardness measurements were performed after all degrees of deformation and after the annealing.

The experimental flow is shown schematically in figure 1.

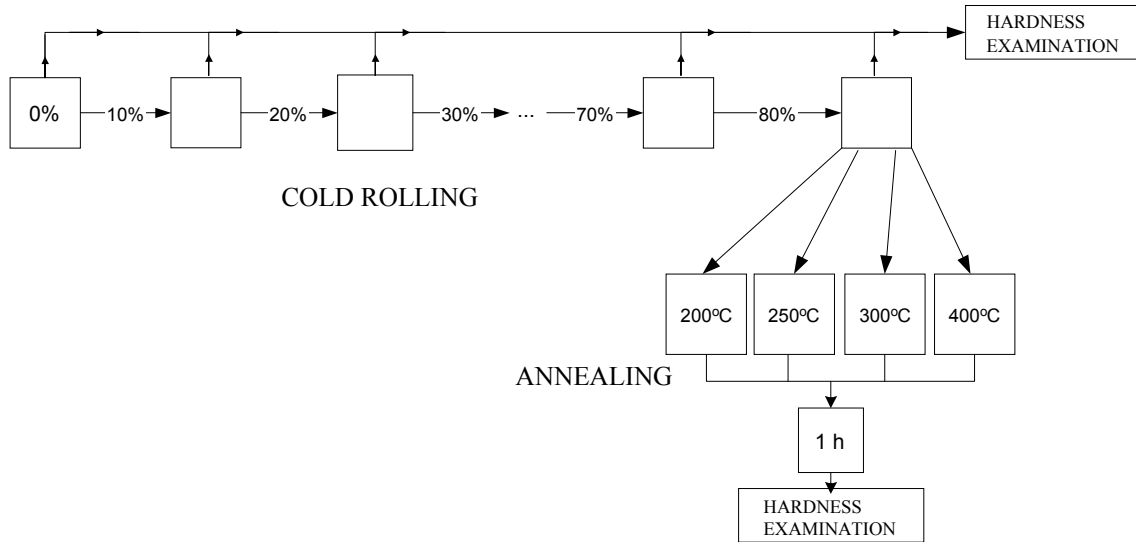


Figure 1. Schematic diagram of the experimental flow

3.RESULTS AND DISCUSSION

The obtained data for the hardness measurements, depending on the total deformation degree are given in Table 1. and Figure 2.

Table1. Dependence of the hardness of bimetallic strip layers on the degree of deformation

ε (%)	HV (daN/mm ²)	
	Al	Cu
0	43.83	106.00
10	44.20	115.75
20	46.33	117.00
30	47.27	120.40
40	48.04	121.67
50	48.44	125.50
60	49.20	131.80
70	49.80	136.00
80	51.05	146.75

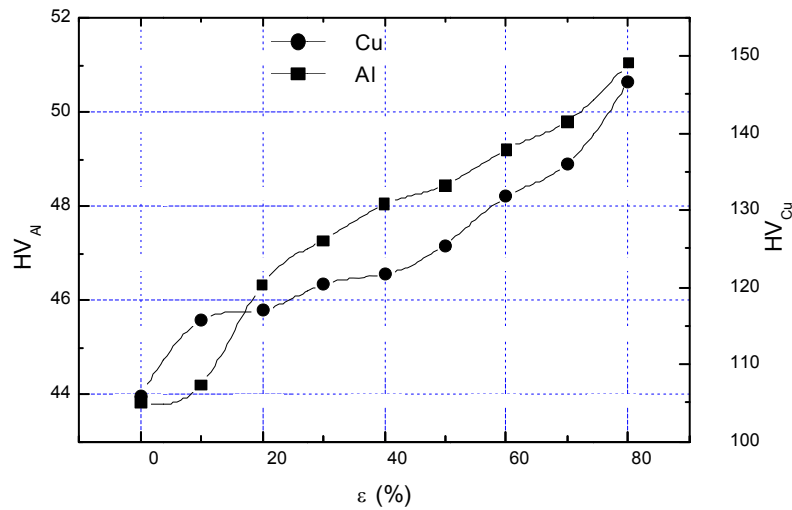


Figure 2. Diagram of the dependence of the hardness of the bimetallic strip layers on the degree of deformation

Global flow of curves hardness - total deformation, increases, where the increase in the hardness of aluminum with increasing degree of deformation is approximately linear.

The curve that represents dependence of the hardness of the copper layer on the degree of deformation, can be divided into three parts. In the first part of the curve, up to a deformation of 10%, the hardness of the copper layer increases sharply, in the second part of the curve, up to a deformation of 50%, slightly, and then increases rapidly again to a maximum value of 146.75 daN/mm², at a total deformation of the bimetallic strip of 80%.

The obtained test results, dependence of hardness (HV) from the annealing temperature are shown in Table 2 and the diagram in Figure 3.

Table 2. Dependence of the hardness of bimetallic strip layers on the annealing temperature

t(°C)	HV (daN/mm ²)	
	Al	Cu
200	42.30	137.00
250	40.12	130.50
300	28.86	63.52
400	25.57	55.72

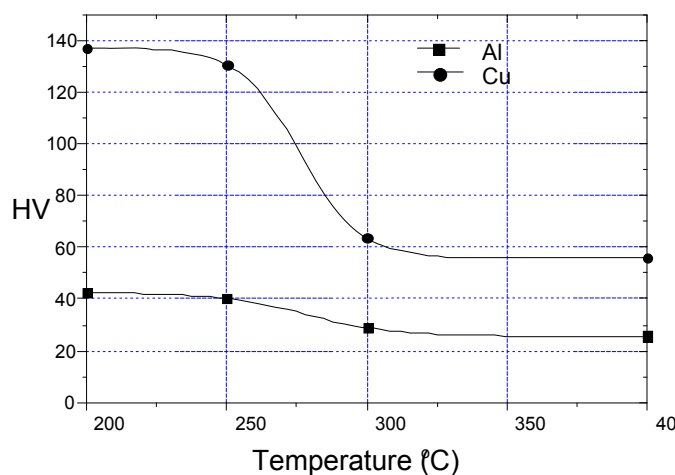


Figure 3. Diagram of the dependence of the hardness of the bimetallic strip layers on the annealing temperature

A decrease in hardness is observed with an increase in the annealing temperature, both in the aluminum layer and in the copper layer.

The hardness decreases slightly to $T = 250$ °C, and then decreases sharply in both layers in the temperature range of 250 - 300 °C, when recrystallization of both layers occurs.

Further increase of the annealing temperature, up to 400 °C, does not significantly affect the reduction of the hardness values of the layers.

4. CONCLUSION

The maximum hardness values characterize the samples obtained with the maximum single reductions.

Global flow of curves hardness - total deformation, increases, where the hardness curve for aluminum is approximately linear and is always lower than the hardness curve for copper, whose flow can be divided into three parts.

As the annealing temperature of the cold deformed bimetal strip ($\varepsilon = 80\%$) increases, the hardness decreases in both the aluminum layer and the copper layer, slightly up to 250°C, and then sharply in the interval from 250 °C to 300 °C, when both layers recrystallize.

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