GOLD EXTRACTION FROM ELECTRONIC SCRAP

Tomášek K., Vadász P., Rabatin Ľ.

Institute of Metallurgy and Materials, Faculty of Metallurgy,

Technical University of Košice

Abstract

Various types of the extractive technologies for the treatment of the separated electro technic gold scrap in the laboratory scale were tested and verified. Separated electro technic scrap is mainly represented by various types of contacts from the electric and electronic devices and apparatuses. As a basic material of the body of these contacts is most frequently used copper alloys for example different types of brasses and bronzes. Contact layer is presented by galvanised coated gold surface. Gold content in such separated contacts is usually up to 1 wt. %, copper content approximately 75 - 80 wt. %.

Three leaching solutions were tested on the extraction efficiency of gold in the first part of this work. As leaching solution were mixture of inorganic acids, aqueous solution of thiourea and aqua regia used and obtained results were discussed. A treatment of separated electric gold-coated contacts by electrochemical process is suggested, described and verified in the second part of this paper. This method is based on the two - steps electrolysis, the first step is copper electrolysis and the second step is gold electrolysis.

There were verified, that it is possible Cu - electrolyses the metallic copper with 98,12 % purity with 85 % recovery. During Cu-electrolyses the gold is concentrated in anode slime. The anode slime is smelting and casting the Au/anodes from which is possible, by Au - electrolysis, to obtain gold with 99,99 % purity and 99,74 % recovery. Presented technology is possible to use also for another types of separated electric and electronic scrap with gold and copper content.

Key words: electronic scrap, gold, leaching, electrolyses

1. INTRODUCTION

Gold is a typical example of the noble metals, which found application in the electronics industry [1]. Gold is resistant to corrosion in air and in other gaseous environments, so that the contact area contacts made of gold metal is always clean, and its electrical and thermal conductivity is close to silver. Despite these advantages, the contacts of pure gold used in practice only rarely. The main drawback besides high cost, their low hardness, which causes deformation of the contacts even when using low thrust and considerable transfer of material between the contact surfaces in their switching [1]. Gold contacts were applied only in cases where the contact force is very small and the switching currents do not exceed a few milliamps. As with silver increases the hardness of gold added other metals (Ag, Cu, Pt, Ni, Zr) [1]. Given the higher mechanical properties and lower cost to find the binary, respectively. Ternary alloys of gold wider application than pure gold. In the production of contact are most frequently used alloys Au - 30 Ag, Au - 20 Cu, Au - Ag - Cu, Au - Ag - Pt, Au - Ni and others. Significant contact between gold alloy is an alloy of Au - 5 Ni, these alloys have satisfactory mechanical properties very well and resist corrosion. For example, an alloy of Au - 26 Ag - 3 Ni is preferably used in low-voltage electrical [2]. Alloys containing gold below 70% show lower resistance to atmospheric corrosion. One of the possibilities for increasing the hardness of gold is 10% Pt addition. Significantly increases the hardness and the alloy is corrosion resistant, has very

little material transfer in switching and low contact resistance. In the case of gold alloy with 3% Zr alloys, the hardness will increase nearly 8 fold compared to pure gold. This is called. "Hard Gold", produced by the company Degussa. In some cases, for reasons of efficient use pozlacované galvanic contacts. Gold plated contacts are cheaper and have good corrosion resistance; galvanic excluded gold is harder than gold cast. Such contacts are commonly used in high-frequency electrical engineering. As the media contact is largely used for copper alloys, such as. Brass, nickel-brass or beryllium bronze, or other materials [1, 3].

In the present work are referred to laboratory leaching tests separated electrical scrap containing gold, design and verification of electrochemical technology for obtaining gold. Does separated electrical contacts formed from scrap printed circuit connectors; basic material is brass contacts, respectively. Nickel-brass was electro-plated.

2. CHARACTERISTICS OF THE STARTING MATERIALS

Lúhovateľnosti tests were performed on a sample of Au-1, i.e. brass electroplated gold contacts; was about konektrové pins with dimensions 18 x 2 x 1 [mm], with remnants of Sn - Pb solder, which were manually vyseparované, the total weight of 1521.2 g. Electrochemical technology of obtaining gold electrical contacts was tested for sample Au-2, which consisted of two types of gold solder contacts with residues of 1 g. 262.25 These contacts were obtained after manual disassembly of connectors and printed circuit boards were formed pin (16 x 2 x 1 mm) and drawer (20 x 2 x 0.3 mm). Chemical analysis of samples remelted contacts is given in Table 1 Vyseparované contacts were contaminated with tin solder, possibly remnants of copper wires.

Table 1 Chemical composition of the gold-coated contacts after smelting [wt. %]

Where:

Au - 1 sample for leach ability [wt. %]

Au - 2 sample for electrochemical process [wt. %]

The above analysis shows that the basic material of contacts in the first sample (Au-1) was brass and the second sample (Au-2) nickel-brass. Both types of contacts were electroplated gold.

3. TEST LÚHOVATEĽNOSTI gold contacts

In the literature on the treatment of wastes containing precious metals is referred to many technologies based on chemical dissolution and the subsequent receipt of interest is selectively metal. For imaginative comparison between the effectiveness of our proposed electrochemical method and selected chemical methods, we also made an indicative test lúhovateľnosti separate electrical scrap. Optimization of selected chemical methods, we have not dealt with more and we used published parameters.

Lúhovateľnosť gold contact was performed on a sample of Au - 1, which was divided into three parts after 507 g. As leaching agents are tested three types of solutions:

A. acid mixture (160 g / l H_2SO_4 + 25 g / l HNO_3 + 10 g / l HCl) [4]

B. aqueous solution of thiourea (10 g / l CS (NH2) 2 + 1% H2SO4 + 5 g / l Fe3 +) [5]

C. Aqua Regia (HCl + HNO3) [6-8]

Sample was infused at constant conditions:

Test sample of 507 g

K: P = 10: 1

Total leaching time: 300 min.

Initial temperature of 23 ° C

Without stirring.

The test results of leaching gold contact, depending on the time of contact after leaching 60, 120, 240 and 300 min. defined parameters for leaching and the chemical analysis of metal concentrations in leachate are summarily listed in Tables 2 to 4

1.3 EVALUATION OF TESTS LÚHOVATEĽNOSTI gold contacts

From the above results it is clear that the effectiveness of leaching of gold contacts in these leaching solutions was very different. Table 2 presents the results of leaching of acid mixture (H2SO4 + HNO3 + HCL), used the results of work [4]. It is clear that the combination of the leaching of gold contacts to fit the circumstances. The effectiveness of leaching of gold in solution was only 1.65%, according to the authors [4], the efficiency of obtaining gold from electronic scrap to 100%

only at temperatures approaching the boiling point of the solution. According to those authors [4] to extract gold from selectively precipitated and filtered. The disadvantage of this technology is intense evaporation aggressive acids and the existence of nitrous gases, which must be disposed of.

Table 2 Concentration of some metals in the pregnant solution after leaching of the gold-coated contacts by acids mixture (A) versus time

Thiourea is a new type of solvent nekyanidového gold and silver, which is currently under review for the primary gold-bearing materials [5]. The leaching results, shown in Table 3, it is clear that this lúhovadlo the extraction of gold from the gold contact fit.

Table 3 Concentration of some metals in pregnant solution after leaching of the gold-coated contacts would thiourea solution (B) versus time

Leaching efficiency of gold contacts was only about 4.1%. Composition of leaching solution was consistently chosen from literature [5], it being understood that the selection of appropriate conditions of dissolution is dependent on the composition of the starting material and can not be generalized. We expect that more detailed research would be finding appropriate lúhovadla composition and leaching conditions, which would force to obtain the gold was much higher. To get gold from thiourea solutions can be advantageously used for carbon cathode electrolysis, to obtain a gold cathode purity min. 99.95% Au [9]. The advantage of this method is that it works in nekyanidovom environment, which has a favorable impact on employment and the environment.

Table 4 Concentration of some metals in pregnant solution after leaching of the gold-coated contacts by the aqua regia (C) versus time

The dissolution of gold in Aqua Regia, according to the literature [6-8] is well known and the test of leaching gold-plated electro-scrap is a standard chemical method. Ongoing feedback for dissolving in Aqua Regia contacts are highly exothermic, and therefore after the initial heating of the solution in due course of chemical reactions, the rate of leaching with increasing solution temperature increases. During the dissolution of forming a nitrating gases must be collected and disposed of [8]. When using Aqua Regia as lúhovadla achieves efficiency leaching gold into solution almost 100% the whole batch was dissolved. From the gold solution was obtained by selective precipitation of sodium sulphite and its purity was 97.54% Au [10]. Gold powder thus obtained is washed, dried, melting away, cast into anodes and electrolytically refined to gold purity of 99.99%, while the total force to obtain the metallic gold from the gold contact was 99.57%.

4. Electrochemical processing is gold-plated contacts

The results of hydrometallurgical test acquisition of gold from gold contacts, it is clear that the use of selected lúhovadiel, a mixture of acid and thiourea, in the circumstances of leaching was not appropriate. We assume that the more detailed study would be to find the optimum leaching conditions, which would be achieved favourable recovery of gold. From the literature [4, 7, 8 and 10] it is known that each type of electrical scrap requires a special approach to treatment. Based on literature review and the results are leaching processing electronics scrap, consisting of gold-plated brass contacts proposed electrochemical method of processing according to the technological scheme of Fig.1. Under that scheme, the Concentration of gold preferably uses electrolysis copper as primary treatment of waste electrical gold-rich copper. The second stage then the technology is electrolysis of gold.

Fig.1 Flow sheet of the gold - coated contacts by electrochemical treatment process

To test the proposed technology, we used separate electrical waste containing about 1 wt. % Au and about 75 wt. % Cu, the rest were mainly Zn, Ni, Sn and Pb (Table 1, sample Au-2). The process of processing this type of electrical waste was divided into two stages.

In the first stage of processing, the classical electrolytic refining of anode in sulphate electrolyte (aqueous solution of CuSO4 + H2SO4), under optimal conditions of electrolysis, obtained by electrolytic copper and gold is concentrated in the sludge. During electrolysis the obtained electrolytic copper cathode, which is selling a product in the electrolyte is concentrated Ni, Zn, Sn, and Fe in the sludge undergoing Au, Pt, Ag, as well as some metals as insoluble sulphates. Pp.

Copper electrolysis parameters:

Quantity of electrolyte about 10 l

Electrolyte composition: 30 g / l Cu

220 g / l free H2SO4

Current density 200 A / m 2

Distance between electrodes: 120-130 mm

Anode dimensions: 150x130x6 mm, dimensions of the cathode (2 pieces of copper-plate): 150x130x0, 5 mm

Electrolyte temperature about 23 to 25 ° C

In the second stage anode mud containing gold is treated as follows:

Leaching in hot HNO3

Washing

Melting with oxidizing troskotvornou added.

Gold is concentrated during melting in metallic phase, where its concentration reached to 95 wt. % Au. Base metals are fused with and concentrated mainly in the slag phase. Gold is further refined electrolytically in chloride electrolyte (aqueous solution AuCl3 + HCL), under the following conditions:

Quantity of electrolyte: 1.2 liters

Electrolyte composition: 150 g / l Au

150 g / l of free HCl

Current density: 1 000 / m 2

Electrolyte temperature: 80 to 90 ° C

Electrolysis products are gold cathodes, which are melted and cast into ingots, which is the fineness 999.9 / 1000 Au.

4.1 EVALUATION Electrochemical treatment process gold-plated contacts

The proposed technology that uses an electrochemical process treatment of separated gold contact was tested in model scale. Very good results of the proposed technology are characterized by data on the purity and efficacy obtained gold and copper:

Gold purity of 99.99% was obtained with 99.74% efficiency

Copper of purity 98.12% was obtained with 85% efficiency

The rest of copper and zinc sulphates, nickel and tin are concentrated in the electrolyte from the copper electrolysis.

Selective electrolysis of copper spent electrolyte will increase the efficiency of obtaining copper min. to 95%. Consequently, it can also get zinc and nickel in the form of sulphates.

The advantage of the proposed technology is already in the first stage, i.e. electrolytic copper was removed about 90% of electrical components and scrap the second phase is already under way with a minimum amount of charge. The process of electrolysis is energy efficient and environmentally

acceptable process. By properly adjusting the starting materials can be processed and electrical scrap with another composition.

Table 5 Chemical composition of the Products Obtained by the gold-plated contacts treatment by electrochemical process

From an environmental point of view, the proposed technology, the worst of the gold leaching process sludge in hot nitric acid. Given the small amount of sludge is also a number of emerging small nitrous gases and their destruction is therefore not technically difficult.

5. CONCLUSION

The present paper describes the processing technology of separated electrical scrap gold - gold-plated brass contacts.

The first part of the test lúhovateľnosti waste in three different type's lúhovadiel. From the results obtained, it is clear that under the given conditions of leaching achieve usable results only when using the Aqua Regia. Won the gold purity of 97.54% Au, which are electrochemically refined gold purity of 99.99% Au with virtually 100% efficiency.

The second part was designed and tested by electrochemical processing technology electronics scrap gold. In the laboratory verified the proposed technology on a sample of about 1260 g gold contacts to obtain a purity of 99.99% Au, with effect from 99.74% and sales as a by-product of copper purity 98.12% Cu, 85% efficiency.

Achievements proven technologies allow its wider application in the processing of other types of electrical scrap.

Literature

[1] Vamberský, A. : Contacts and sintered in precious metals, Springer Praha, 1955

[2] and high-melting precious metals (catalog). SAFINA, n.p. Vestec, ST Prague 1980

[3] Bednar, J. et al.: Mechanical table. Bratislava, 1965 SVTL

[4] Krupkowa, D., Imriš, I.: Acta Metallurgica Slovaca, 2 (1996) 3

[5] Štofko, M., Štofková, M., Harvanová, J.: Acta Metallurgica Slovaca, 3 (1997) 2 / 2 special issue, 547-550

[6] Georgius Agricola: De Re Metallica. Twelve books on mining and metallurgy. Translated by B. and J. Jezek Hummel. National Technical Museum, Prague, 1954

[7] Maslenickij, I. N., Čugajev, L. V., Borba, V. F. Nikitin, M. B., Střížkov, L. S. Metallurgija blagorodnych metallov. Moscow, Metallurgy 1987

[8] Loewen, R.: Small Scale Gold Refining. IPMI, London 1980, England

[9] Gaspar, V., Spalek, O., Bures, R., Schmiedl, J.: Electrolytic precipitation of gold and silver from acidic thiourea solution on carbon-graphite cathodes. In: Recycling of Metals, Dusseldorf, 13-15 May, 1992, 83-90

[10] Rabatin, Ľ., Tomasek, K., Vadász, P.: Recovery of gold from the dross and balances jewelery manufacturing. Acta Metallurgica Slovaca, 3 (1997), 540-542