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Recovery of Gold From Industrial Solutions via Electrodeposition-Redox Replacement

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Introduction

Currently, the adsorption methods are by far dominating the recovery of gold from leaching solutions. However, the presence of impurities reduces the metal recovery. As an alternative, electrodeposition-redox replacement (EDRR) method was recently introduced to recover pure gold from chloride process streams. This method can be applied directly after leaching without solution purification, thus decreasing the number of process stages and reducing the consumption of chemicals

Background

EDRR brings together conventional electrowinning with cementation. The idea is to electrodeposit first base metal(s) that is/are more abundant in the solution (e.g. Cu), then switch of the applied potential or current and let the noble metal (e.g. Au) to reduce on the cathode via redox replacement reaction (in hydrometallurgy, cementation). After repeating this for a number of cycles, significant quantity of Au will be recovered on the cathode.

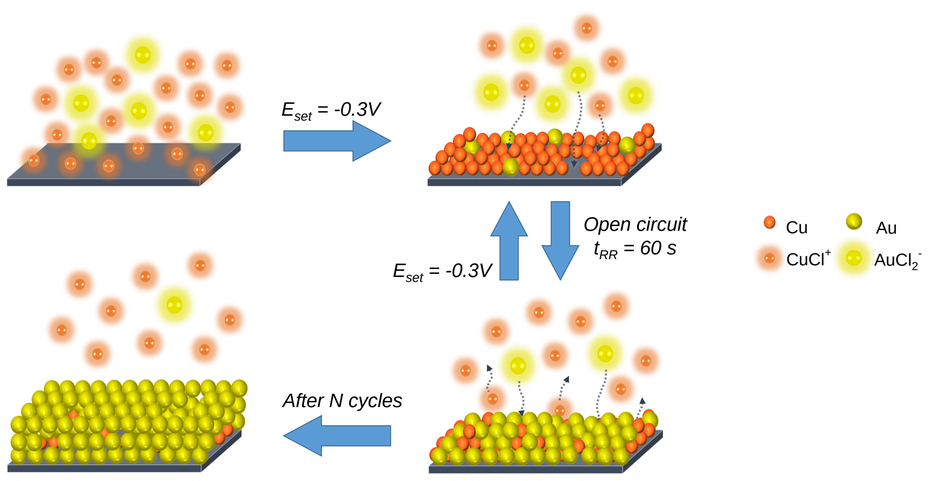

Figure 1. *Schematic of electrodeposition-redox replacement method [1]*

Process parameters

Three parameters dominate the EDRR process: deposition potential E_{set}, deposition time t_{dep} and redox replacement time t_{RR}. These variables depend on the metal concentrations in solution and could be established from cyclic voltammogram.

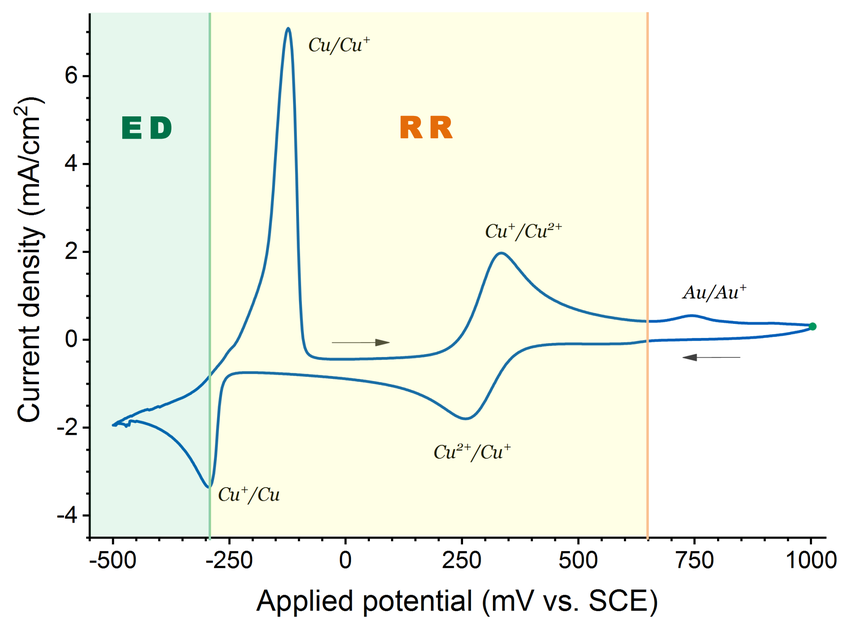

Figure 3. *Cyclic voltammogram of copper-gold chloride solution (3M NaCl + 40mM Cu + 0.5mM Au) @ 25 mV/s*

Electrochemistry of the process

When a constant potential is applied to the cell, Cu reduction is prevailing reaction on the cathode while other side reactions may take place, increasing the overall electricity consumption [2]. After potential is switched off, redox reactions commence: they are limited only by the amount of copper reduced in the first step.

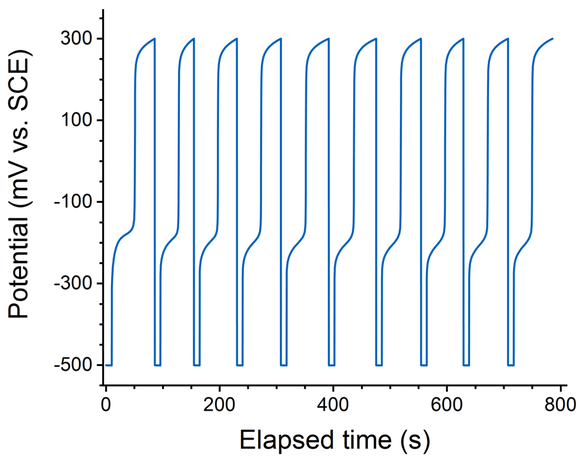

Figure 2. *Typical potential profile during EDRR process*

Electrodeposition (potential ON):

$$CuCl^+ + 2e^- \longrightarrow Cu + Cl^-$$

$$AuCl_2^- + e^- \longrightarrow Au + 2Cl^-$$

$$Fe^{3+} + e^- \longrightarrow Fe^{2+}$$

Redox replacement (potential OFF):

$$Cu + 2AuCl_2^- \longrightarrow 2Au + CuCl^+ + 3Cl^-$$

$$Cu + Cl^- \longrightarrow CuCl^+ + 2e^-$$

$$Fe^{2+} \longrightarrow Fe^{3+} + e^-$$

Results and discussion

EDRR was tested for gold recovery from an industrial solution from a low-grade ore chloride leaching, which contained **30 g/L Cu**, **0.9 g/L Fe** and just **1.2 mg/L Au** with impurities such as Zn, Pb, Co, Ni at mg/L level [3].

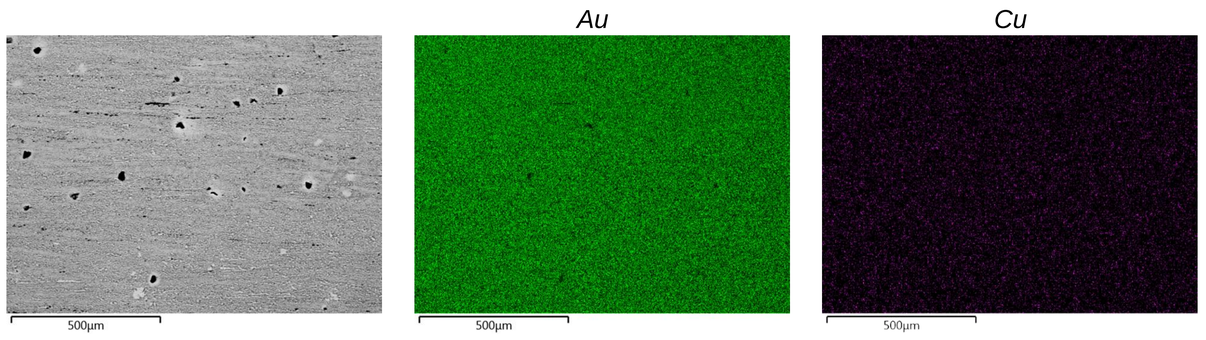

Figure 4. *SEM image of the cathode surface with EDX maps of Au and Cu distribution*

After 24 h of EDRR, **26.4%** of dissolved Au was recovered from the solution resulting in specific energy consumption of approximately **2.3 kWh/g** of Au. According to the EDX analysis of the cathode surface, deposited product consists of **99.7% Au** and only **0.3% Cu** with no other impurities detected.

Conclusions

EDRR has proved successful approach for recovering trace amounts of gold from the complex hydrometallurgical solutions. The advantage of EDRR lies in the fact that the process parameters rather than the solution composition are modified to obtain the desired quality of the product. Further optimization of the EDRR process could make it a viable alternative to existing best available technologies due to simplicity of the process flowsheet, resource efficiency and ability for selective recovery of elemental gold even from very low concentrations.

References

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[2] Yliniemi, Wang, Korolev, Hannula, Halli, Lundström, *ECS Trans* **85** (2018) 59-67.
[3] Korolev, Haapalainen, Kolehmainen, Yliniemi, Lundström, *EMC 2019,* in press.

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