Claims

1. A method for recovering copper indium gallium selenide material, comprising the following steps:

step A, in which the copper indium gallium selenide waste material is placed in a ball mill for ball milling;

step B, in which the copper indium gallium selenide powders are added to a sulfuric acid solution and heated to 90 to 100 °C, and air is introduced into the heated solution for leaching;

step C, in which sodium sulfite is added to the solution, and the solution is heated and stirred, during which sodium sulfite reacts with sulfuric acid to generate sulfur dioxide gas, which then reacts with selenic acid to produce selenium;

step D, in which sodium hydroxide is added to the solution to adjust the pH to 1.2 to 2.2, followed by adding a copper extractant to extract copper ions; the extract is then subjected to a reverse extraction to give a copper sulfate solution, which is electrolyzed to give copper metal;

step E, in which sodium hydroxide is added to the raffinate obtained in step D to adjust the pH to above 12; after standing, the supernatant is drawn, and the precipitate is filtered and washed with water; the obtained filter residue is indium hydroxide, and the obtained solution is a sodium gallate solution;

step F, in which the sodium gallate solution obtained in step E is electrolyzed to give gallium metal; and

step G, in which indium hydroxide obtained in step E is dissolved by hydrochloric acid, followed by replacement to give indium metal.

2. The method for recovering copper indium gallium selenide material according to claim 1, wherein, in step A, the copper indium gallium selenide waste material is ball milled to below 80 mesh.

3. The method for recovering copper indium gallium selenide material according to claim 1, wherein, in step B, a certain volume of a sulfuric acid solution having a molar concentration of 1.5 to 6 mol/L is taken, and the copper indium gallium selenide powders are added into the above sulfuric acid solution at a liquid-solid ratio of 2:1 to 8:1 and

heated to 95 °C; and air is introduced into the heated solution and the leaching lasts for 12 hours.

4. The method for recovering copper indium gallium selenide material according to claim 1, wherein, in step C, the solution is heated to above 60 °C, and stirred to react for at least 2 hours.

5. The method for recovering copper indium gallium selenide material according to claim 1, wherein, in step D, AD-100 extractant is used for extracting copper ions.

6. The method for recovering copper indium gallium selenide material according to claim 1, wherein, in step D, the conditions for the electrolysis of the copper sulfate solution are as follows: electrolysis voltage, 1.8 V; current density, 250 A/m^2; electrolyte temperature controlled at about 45 to 60 °C; electrolysis time, above 4 h.

7. The method for recovering copper indium gallium selenide material according to claim 1, wherein, in step E, sodium hydroxide is added to the raffinate to adjust the pH, followed by heating the solution to above 80 °C for 0.5 hours; after standing, the supernatant is drawn, and the precipitate is filtered and washed with water.

8. The method for recovering copper indium gallium selenide material according to claim 1, wherein, in step F, the conditions for the electrolysis of the sodium gallate solution are as follows: electrolysis voltage, 2.5 V; current density, 200 A/m^2, electrolyte temperature controlled at about 45 to 60 °C, electrolysis time, above 6 h.

9. The method for recovering copper indium gallium selenide material according to claim 1, wherein, in step G, indium hydroxide is dissolved by 0.5 mol/L hydrochloric acid, a zinc plate or an aluminium plate is used for the replacement at a temperature of 50 to 60 °C, and the replacement lasts for above 8 h.

10. A method for recovering copper indium gallium selenide material, comprising the following steps:

step A, in which the copper indium gallium selenide material is crushed;

step B, in which the crushed material obtained in step A is added to a sulfuric acid solution and heated to 90 to 100 °C, and air is introduced into the heated solution for leaching;

step C, in which selenic acid in the solution obtained in step B is reduced to produce selenium;

step D, in which pH of the solution is adjusted to 1.2 to 2.2, followed by adding a copper extractant to extract copper ions; the extract is then subjected to a reverse extraction to give a copper sulfate solution, which is electrolyzed to give copper metal;

step E, in which pH of the raffinate obtained in step D is adjusted to above 12; and the mixture is separated by filtration to a filter residue which is indium hydroxide, and a solution which is a sodium gallate solution;

step F, in which the sodium gallate solution obtained in step E is electrolyzed to give gallium metal; and

step G, in which indium hydroxide obtained in step E is dissolved by hydrochloric acid, followed by replacement to give indium metal.

11. The method for recovering copper indium gallium selenide material according to claim 10, wherein, in step C, sodium sulfite is added to the solution, and the solution is heated and stirred, during which sodium sulfite reacts with sulfuric acid to generate sulfur dioxide gas, which then reacts with selenic acid to produce selenium.