Charge And Discharge Science (1) (new basic science)

Theoretical study on the relationship between a flow mode of electric current and a material change in the electric circuits consisted of the electronic conductors and the ionic conductors

Title page

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Abstract

When an electric current flow in a closed electric circuit consisted of the electronic conductors and the ionic conductors, it is of great importance in the development of electrodynamics to clarify exactly how an electric current flows and why a material change occurs at the junctions (electrodes) of two conductors.

In a closed electric circuit consisted of an electronic conductor and an ionic conductor, it has been studied that the material changes at the electrode interface, which are the junctions of the two conductors under direct current, are not chemically but electromechanically induced material changes, and that these material changes are electromechanical material changes due to charge and discharge that are fundamentally different from the chemical redox reaction[1].

In [2], new principles of cell and electroplating have been investigated.

In this paper, we demonstrated that in the circuits consisted of the electronic and the ionic conductor, the material change phenomena that occur at the junction (electrode) between the conductors under direct current are not chemical reactions, but electrical material change by the current conversion.

Keywords: Current conversion, Ionic charge, Electronic charge, Positive current, Negative current, Ionic current, Electronic current, Ionic conductor.

Introduction

Phenomena which occurred when the current flows in an electric circuit consisted of an electronic conductor and an ionic conductor have been studied by chemists for almost two centuries, though these were electrical ones.

This was due to the fact that the material changes occurred when direct current flowed in these electrical circuits.

Chemists attached importance only to the material change and applied it, so that the causes of material change were not correctly understood.

In this paper, we have solved how the electric currents flow at the electrode interfaces which are the junctions between the conductors and how they are related to the material changes.

The electronic current can only flow in the electronic conductors and not flow in the ionic conductors.

The ionic current can only flow in the ionic conductors and not flow in the electronic conductors.

Then, how the continuous electric current flows in an electrical circuit when an electronic conductor and an ionic conductor are connected, and how the electric current flows at the electrode interface which is the junction of conductors, are a problem that electromagnetism has not solved.

When an alternative current flows in an circuit consisted of an electronic conductor and an ionic conductor, the material changes at the electrode interfaces, which are the junctions of two conductors, are not considered in chemistry, and in the field of electricity, the ionic conductors are used as the resistance of electric furnace and as the starting resistance of large motors.

Thus, if an alternative current flows in these circuits, it is the object of electricity.

At this time, only an alternative current flows at the junctions between the ionic conductor and electronic conductor.

If a semiconductor diode is connected to this circuit, a direct current will flow in the circuit and the material change will occur as a result of the direct current flowing at the electrode interface (the junction of ionic conductor and electronic conductor).

For example, if a cooper wire is placed in water and an alternating current flows without any material change, it is the object of electricity. If a semiconductor diode is connected to the circuit, the direct current flows and Phenomena which the direct current flows at the junctions are the object of chemistry because hydrogen produces at the cathode and oxygen at the anode.

In other words, the semiconductor diode or the type of current converts the electrical phenomena into chemical phenomena.

This is clearly a contradictory result.

Thus, the phenomenon that occurs when direct current flows in a circuit consisted of an electronic conductor and an ionic conductor is not a subject of chemical elucidation, but is the electrical problem of how the electric current flows in the contact surface when different conductors are connected.

In a closed electrical circuit consisted of an electronic conductor and an ionic conductor, it is necessary to clarify why the material changes occur at the junctions of the two conductors only when a direct current flows, and why the material changes do not occur when an alternative current flows.

When direct current flows in these electrical circuits, the material changes are observed at the electrode interfaces, the junctions between the two conductors and they can be divided into two types.

One is a material change that occurs by the change of ionic conductor and other is a material change that occurs by the change of electronic conductor.

The main examples are the electrical change of water and the electroplating process of copper.

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※Let us first give the concepts described in the Charge-Discharge science.

The Charge-Discharge science is a new basic science that has overcome the di screpancies and the limitations of electrochemical theory.

Charge is a phenomenon in which an atom or molecule is divided into the cha rged particles (electric charges) by the action of electrical, magnetic, or mechanica l forces.

Discharge is a phenomenon in which the charged particles that have been separ ated, are combined again to form atoms or molecules.

Example

$$Cu \underset{\text{discharge}}{\overset{\text{charge}}{\rightleftharpoons}} Cu^{2+} + 2e^{1-}$$

$$H_2O \underset{\text{discharge}}{\overset{\text{charge}}{\rightleftharpoons}} 2H^{1+} + O^{2-}$$

Cu^{2+}: positive or positive ionic charge, e^{1-}: negative or electronic charge

H^{1+}: positive or positive ionic charge, O^{2-} : negative or negative ionic charge.

An electric current is a flow of electric charges. The currents have an electronic current, an ionic current and an electrostatic current, and the ionic currents have an anionic current and a cationic current.

An electric charge is an electrically charged particle, which contains a negative and a positive charge.

An electronic charge, an anionic charge and a negative electrostatic charge are included in a negative charge and a positive ionic charge and a positive electrostatic charge are included in a positive charge.

An electron refers to an electron orbiting an atomic nucleus and an electronic charge refers to a free electron (an electrically charged electron) that is free from the orbit by the action of an electric field or a magnetic field.

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Consider the flow mode of electric current and the material-change process through the electrical transformation of water.

A. <u>The electrical change of</u>

water

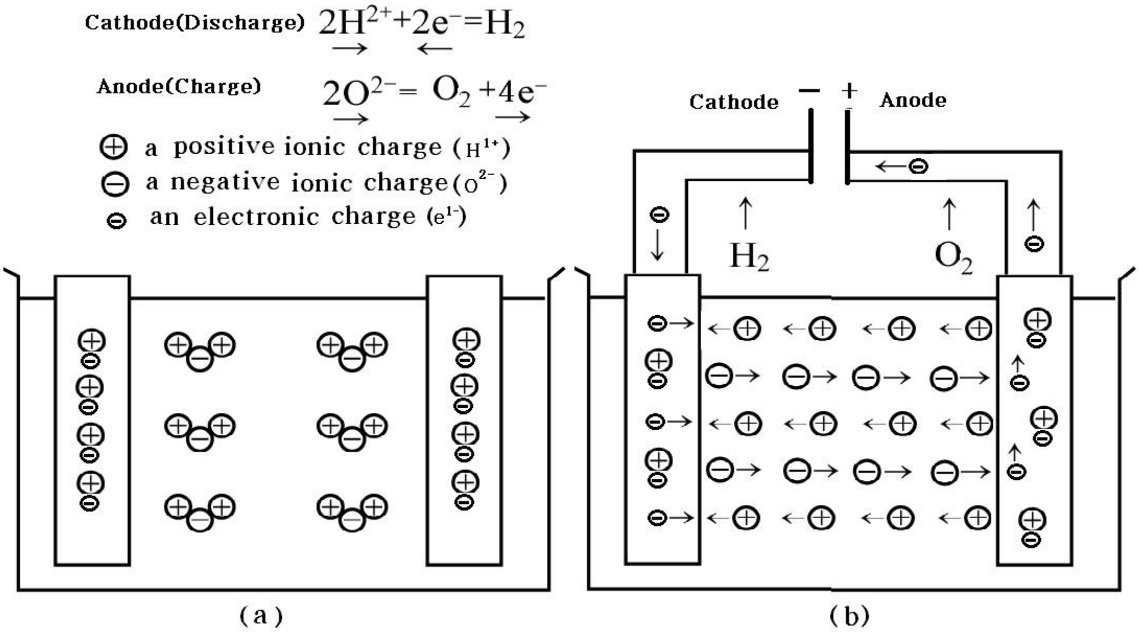

Fig.1. The flow mode of electric current and the material-change process at the electrodes when water is an ionic conductor.

The water molecules remain electrically neutral unless an electric field is applied to the electrodes, as shown in Fig. 1(a).

If a voltage is applied to both electrodes, the water molecules located between the two electrodes, as shown in Fig. 1(b), are first charged with a Hydrogen positive charge and an Oxygen negative charge, and then the Hydrogen positive charge and an Oxygen negative charge are transferred to the cathode and anode, creating the ionic current flows.

An Oxygen negative charge reached to the anode is too much greater than the electronic charge to flow into the metal, so Oxygen negative charge gives out the electronic charges that are bound to Oxygen and they causes the electronic current to flow continuously through the electronic conductor.

In other words, ***the ionic charge are converted into the electronic charges and the ionic current into electronic current at the anode*** ($O^{2-} \Rightarrow 2e^{1-}$), and the produced Oxygen atom is not charged again.

Thus, Oxygen atoms are bound to the molecule and floated up as a gas.

If Oxygen molecules are attached to the electrode interface, an insulating film is created and the electric current do not flow.

And the converted electronic charges move along the wire to the cathode, forming a continuous flow of electric current.

The electronic charges that reach the cathode are discharged with Hydrogen positive charge to form Hydrogen atom, so the Hydrogen atom is not charged again and does not make a charge, but is combined into a molecule to escape from the electric circuit.

From the cathode interface, Oxygen negative charges generated by the charge of water molecules create a continuous flow of anionic current to ensure the continuity of negative current flow.

Thus, in the cathode, ***the electronic charges are converted into the ionic charges and the electronic current is converted into the ionic current***($2e^{1-} \rightarrow O^{2-}$).

Like this, the ionic current is converted into the electronic current at the anode and at the cathode, the electronic current is converted into the ionic current, so a continuous flow of electric current is formed in the electrical circuit.

Just, this is the principle that the continuous electric current flows at the electrode interface (the junction of electronic conductor and ionic conductor) and is responsible for the material change.

In this case, in principle, there is little material change in the electron conductor and only a material change in the ion conductor.

Next, consider the flow mode of electric current and the material-change process that occur during the electroplating of copper.

B. Cu electroplating

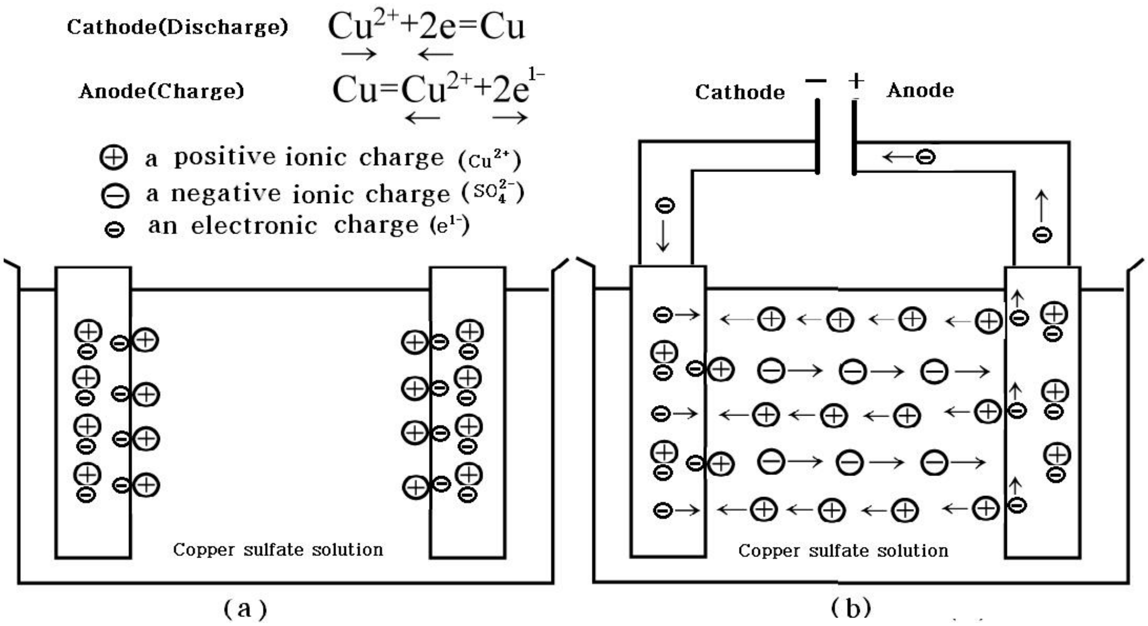

Figure.2. The flow mode of electric current and the material-change process at the electrodes when copper sulphate solution is an ionic conductor.

If an ionic conductor is copper sulphate solution and the electrodes and the electronic conductor are copper, the current conversion phenomena also have at the cathode and anode, but they occur differently compared to the case of water.

As shown in Fig. 2(a), the copper electrodes form an electric double layer in the copper sulphate solution.

If DC voltage is applied to the electrode, the electrical double layer of the anode is damaged and the electric charges are generated to form an electronic current and an ionic current, as shown in Fig. 2(b).

Cu^{2+} positive and electronic negative charges are generated at the anode, creating a current flow with opposite direction.

Meanwhile, the copper sulphate molecule is also charged with Cu^{2+} positive and SO_4^{2-} negative charges, creating the ionic current flows in opposite directions.

The SO_4^{2-}anionic charge goes to the anode and is converted to an electronic charge.

The electronic current flows from the anode to the cathode along the electronic conductor, and at the cathode the electronic charges ($2e^{1-}$) discharge with the Cu^{2+} positive charge.

From the cathode interface, the SO_4^{2-} anionic current flows, forming a continuous current flow from the electronic current to the ionic current.

Thus, in the case of copper electroplating, ***the electronic charges are converted to ionic charges and the electronic current to ionic current at the cathode($2e^{1-} \rightarrow SO_4^{2-}$), and at the anode, the ionic charges are converted to electronic charges and the ionic current to electronic current*** ($SO_4^{2-} \rightarrow 2e^{1-}$), providing the continuity of current flow.

When DC current flows in an electrical circuit with an electronic conductor and an ionic conductor, the electric current is consisted of a negative current and a positive current in opposite directions.

The negative current flows in whole region of electrical circuit and the positive current flows only in the ionic conductor region.

The negative current flows as the mode which in the region of ionic conductor the anionic current flows, then it is converted to an electronic current at the anode, the converted electronic current flows through the an electronic conductor from the anode to the cathode and at the cathode the electronic current is converted to the anionic current.

Thus, a continuous current flow is formed in whole region of a closed electric circuit. When an alternating current is applied to this circuit, no material change is observed, because the polarity is changed before the material change occurs perfectly, and returns to its original state.

For example, when 60 Hz alternating current flows through water, the water molecule becomes charged into a hydrogen positive charge and an oxygen negative charge, and before oxygen atoms generated by charge at the anode and hydrogen atoms by discharge at the cathode are combined to hydrogen and oxygen molecules, they return to their original states (a hydrogen positive charge and an oxygen negative charge) by the polarity changes of the electrodes. So hydrogen and oxygen are not generated at the electrodes. While these processes continue to be repeated, an alternating current flows at the interface.

When alternating current flows, it should also be noted that current conversion occurs at the cathode and anode, providing continuity of current flow at the interface between the two conductors.

Conclusion

When direct current flows in an electrical circuit consisted of an electronic conductor and an ionic conductor, the current-flow mode is the mode in which the electronic current is converted into the ionic current at the cathode (the junction of the two conductors) and the ionic current is converted into the electronic current at the anode, and the material change at the electrode interface is not due to redox reactions, but to current conversion.

Acknowledgment

The authors thank to Prof. Yon Hui. Kim, Director, Physical institute, National Academy for her advices and Song Hun. Hong, faculty of metallic technology, Kim Chaek University for his support.

Author Contributions

Chong Ryong.Chu found the discrepancies and the limitations of electrochemical theory and has illustrated the circuits consisted of the electronic and the ionic conductor, the material change phenomena that occur at the junction (electrode) between the conductors under direct current, are not chemical reactions, but electrical material change by the current conversion.

Su Ran. Chu has illustrated the material change phenomena that occur at the junction (electrode) between the conductors under direct current can be explained only by electrodynamics.

Competing Interests

There are no competing interests in this paper.

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