January 19, 2012

Tanaka Precious Metals
Tanaka Holdings Co., Ltd.

Tanaka Precious Metals Develops World's First Ruthenium Material Able to Form a Film Up to Six Times the Normal Depth for DRAM Capacitor Electrodes

Joint development with Kyushu University optimized for semiconductor miniaturization
20 nanometers or later, aiming for commercialization this year

Tanaka Kikinzoku Kogyo K.K. (*1) (a company of Tanaka Precious Metals, Head office: Chiyoda-ku, Tokyo; President & CEO: Hideya Okamoto) announced that it had succeeded in the joint development of ruthenium material able to form a film up to six times the normal depth for capacitor electrodes used in semiconductor memory DRAM (Dynamic Random Access Memory) with Professor Seiji Ogo of the Graduate School of Engineering Department of Applied Chemistry at Kyushu University. With the full-scale introduction of MOCVD (Metalorganic Chemical Vapor Deposition) used in technology for the miniaturization of next-generation DRAM, the Company aims to commercialize the material in 2012.

This ruthenium material is a MOCVD film formation material (precursor) used in next-generation DRAM with a circuit with of 20 nanometers (1 billionth of a meter) or later, and can form a uniform ruthenium film inside fine pores with a high aspect ratio (ratio of the depth and diameter of pores) of 40:1.(*2) This enables the manufacture of capacitor electrodes with six times the normal depth. Semiconductor manufacturers are considering the mass production of next-generation semiconductors in the 20-nanometer range during 2012, and by using this ruthenium precursor the manufacture of capacitor electrodes able to support miniaturization in the 20-nanometer generation and later.

With the increase in capacity of semiconductor memory, semiconductor manufacturers plan to adopt manufacturing methods that deeply carve memory cells to give capacitor electrodes a 3-dimensional structure, and MOCVD is expected to be used as a method for manufacturing 3-dimensioonal electrodes. However, the largest aspect ratio of pores making up electrode film that could be formed by conventional MOCVD ruthenium precursors was 6:1, and the inability to manufacture capacitor electrodes with the high aspect ratio required for the 20-nanometer generation and later has become a technical challenge.

Metallo-organic complexes that evaporate easier than normal metal are used in MOCVD film materials. The ruthenium precursor successfully developed for the first time by Tanaka Kikinzoku Kogyo is a metallo-organic complex made up of organic compounds (Cyclooctatetraene and Carbonyl) and a metallic element (Ruthenium). Because it has properties of high vapor pressure (tendency to evaporate when forming a film) and easy precipitation of metal by heating, it is possible to form a ruthenium film with a coverage factor of 70% within pores with the high aspect ratio of 40:1 at the low temperature of 165°C. The main features of this ruthenium precursor are as follows.

(i) High vapor pressure

Because the ruthenium precursor successfully developed here has a high vapor pressure and easily vaporizes, it is possible to sufficiently supply the necessary precursor gas on the base material when forming a film. These characteristics are very important for forming a uniform film to the edges of pores with a high aspect ratio.

(ii) Film can be formed at a low temperature

Because metal can be easily precipitated by heating, it is possible to form a film at the low temperature of 165°C. This can reduce the damage to the base material caused by heat when forming a film.

(iii) Low melting point

Solid precursors are harder to handle during transportation than liquid precursors, and have problems with the stable supply of vapor when forming a film. Many metallo-organic complexes are solids at room temperature, but the ruthenium precursor developed here has a low melting point, and is a liquid at room temperature.

(iv) Film can be formed in a hydrogen atmosphere

Normally, a reaction accelerator (reaction gas) such as oxygen is used to promote the thermal decomposition of the precursor to form a pure metal film when forming a film. Oxygen is a highly reactive gas that facilitates the formation of metal film, but it also has adverse effects such as oxidation of the base material. To address this, it is desirable to use a gas such as hydrogen that causes little damage to the base material, but hydrogen has the shortcoming of low reactivity and difficulty in forming metal film. The ruthenium material successfully developed here is a ruthenium precursor able to form a pure metal film even in a hydrogen atmosphere.

(v) High film smoothness

As memory elements become smaller, the metallic film used as electrodes needs to be smoother. Rough film with irregularities causes variability in electrical properties, and can also cause problems such as shorts and disconnections. Ruthenium films formed using the material successfully developed here show high smoothness with asperity of 1.1 nanometers or less (RMS value obtained from AFM observation with a film thickness of 12 nanometers).

(vi) Few impurities in film

It has been indicated that MOCVD presents a danger of film becoming contaminated due to precursor resolvent (organic components, etc.) becoming mixed into the metallic film. The ruthenium material successfully developed here can form a ruthenium film with high purity and little film contamination (confirmed through XPS measurement).

The results of development of this ruthenium precursor are scheduled to be published in Dalton Transactions published by the United Kingdom's Royal Society of Chemistry. Tanaka Kikinzoku Kogyo will continue to strive to make technical improvements to ruthenium precursors able to form films in electrode pores with higher aspect ratios.

(*1) Tanaka Kikinzoku Kogyo K.K.

The core company conducting manufacturing operations in the Tanaka Precious Metals, which has Tanaka Holdings Co., Ltd. as its holding company.

(*2) When the depth of a pore is 10 micrometers (micro is 1 millionth), and the aperture diameter is 250 nanometers.

<Reference Materials>

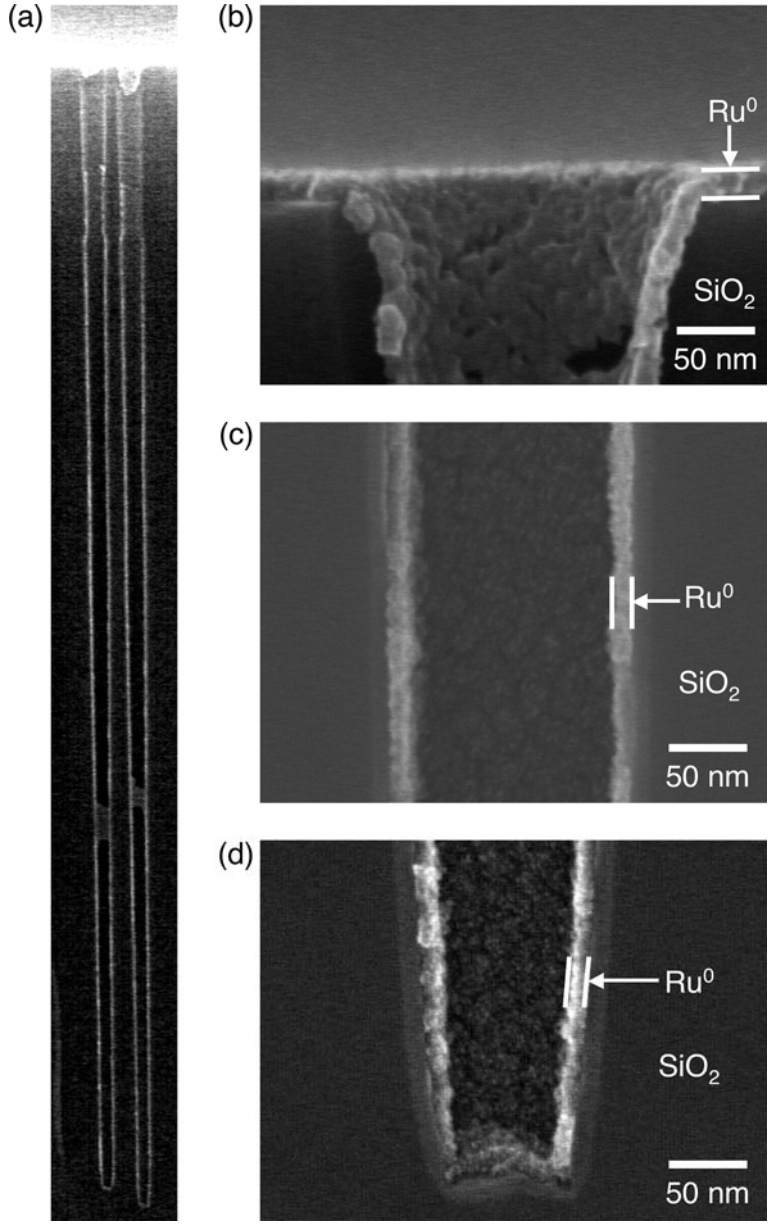

Figure (a) Observation image of the ruthenium film formed inside a pore with a depth of 10 micrometers and an aperture diameter of 250 nanometers (aspect ratio of 40:1) (observations by scanning electron microscope (SEM))

Figure (b) Enlarged image of the top of a pore

Figure (c) Enlarged image of the middle of a pore

Figure (d) Enlarged image of the bottom of a pore

■Tanaka Holdings Co., Ltd. (Holding company of Tanaka Precious Metals)

Headquarters: 22F, Tokyo Building, 2-7-3 Marunouchi, Chiyoda-ku, Tokyo
Representative: Hideya Okamoto, President & CEO
Founded: 1885 Incorporated: 1918 Capital: 500 million yen
Employees in consolidated group: 3,456 (FY2010)
Net sales of consolidated group: 891.0 billion yen (FY2010)
Main businesses of the group:

Manufacture, sales, import and export of precious metals (platinum, gold, silver, and others) and various types of industrial precious metals products. Recycling and refining of precious metals.

Website: http://www.tanaka.co.jp

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Headquarters: 22F, Tokyo Building, 2-7-3 Marunouchi, Chiyoda-ku, Tokyo
Representative: Hideya Okamoto, President & CEO
Founded: 1885 Incorporated: 1918 Capital: 500 million yen
Employees: 1,532 (FY2010)
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Businesses:

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Website: http://pro.tanaka.co.jp

<About the Tanaka Precious Metals>

Established in 1885, the Tanaka Precious Metals has built a diversified range of business activities focused on the use of precious metals. On April 1, 2010, the group was reorganized with Tanaka Holdings Co., Ltd. as the holding company (parent company) of the Tanaka Precious Metals. In addition to strengthening corporate governance, the company aims to improve overall service to customers by ensuring efficient management and dynamic execution of operations. Tanaka Precious Metals is committed, as a specialist corporate entity, to providing a diverse range of products through cooperation among group companies.

Tanaka Precious Metals is in the top class in Japan in terms of the volume of precious metal handled, and for many years the group has developed and stably supplied industrial precious metals, in addition to providing accessories and savings commodities utilizing precious metals. As precious metal professionals, the Group will continue to contribute to enriching people's lives in the future.

The eight core companies in the Tanaka Precious Metals are as follows.

- Tanaka Holdings Co., Ltd. (pure holding company)
- Tanaka Kikinzoku Hanbai K.K.
- Tanaka Denshi Kogyo K.K.
- Tanaka Kikinzoku Jewelry K.K.
- Tanaka Kikinzoku Kogyo K.K.
- Tanaka Kikinzoku International K.K.
- Electroplating Engineers of Japan, Limited
- Tanaka Kikinzoku Business Service K.K.