Ruthenium

One of the platinum group metals, ruthenium is silvery white in colour. The hard and brittle metal was officially discovered in 1844 by professor Karl Karlovich Klaus, who first isolated it from ruthenium oxide. However, it was named 17 years earlier by Jöns Jacob Berzelius and Gottfried Osmann. They were inspecting the remains of platinum ore that were insoluble in aqua regia and named it ruthenium oxide because of the ore's origin in the Ural mountains, Ruthenia being Latin for Russia. According to the International Platinum Group Metal Association (IPA), there are unsubstantiated reports of ruthenium's isolation from as far back as 1807, when a Polish chemist named it vestium.

Ruthenium is found native with other platinum group metals in ores in South Africa, North and South America as well as in Russia. It is extracted from pentlandite in the Sudbury, Ontario, nickel-mining region in Canada and from pyroxinite deposits in South Africa. According to a 2003 US Geological Survey report, the only source of ruthenium in China is the Jinchuan nickel-copper mine deposit in China, which is estimated by UK analysts Roskill to contain 400,000 oz of ruthenium. The rich pgm deposits in South Africa are responsible for most of the ruthenium that is mined today.

The metal with an atomic number of 44 is known for its hardness, electrical conductivity and density. Ruthenium is used as a hardener for platinum and palladium in jewellery. Whereas platinum alone is too soft for jewellery uses, the addition of 5% ruthenium can offer firmness in shaping, according to Jeremy Coombes, director of marketing at Johnson Matthey. The metal retains its hard and brittle nature even at very high temperatures, with a melting point of 2,310°C. Its density is 12.45 g/cm^3.

Its resistance to corrosion has encouraged application in jewellery and electrical applications. According to the IPA, the addition of 0.1% of ruthenium to titanium boosts its corrosion resistance by a hundred times. Good catalytic properties and its stability under varying operating conditions has made it popular in electronic applications, particularly computer hard drives. Adding a thin layer of ruthenium to the magnetic coating of a hard disk increases data storage density substantially.

Ruthenium forms alloys with other platinum group metals and with other metals such as molybdenum. One ruthenium-molybdenum alloy is a superconductor at 10.6K.

PRODUCTION

Major producers of platinum group metals in South Africa, such as Anglo Platinum, Lonmin, Implat, Northern, Aquarius and ARM, produce ruthenium as a by-product of platinum and palladium. As the market for ruthenium is very small, primary production statistics are not traditionally made public, though Johnson Matthey estimates production at between 800,000 oz and 1m oz each year.

Hitachi

Hard drives with perpendicular magnetic storage have a three-atom thick layer of ruthenium between two magnetic layers, allowing for a higher area density and therefore more room for data storage

The recent increases in ruthenium's demand and price have made producers more open with their production levels. Prices before 2006 generally remained below $100/oz, apart from a brief period in 2000-2001. In 2006, new applications for ruthenium increased demand and pushed the price up to nearly $900/oz. The price has since fallen back to around $500/oz.

Anglo Platinum, the leading producer of ruthenium, does not publish individual statistics for the metal, grouping it instead into an "other platinum group metals" category that also includes iridium and osmium. However, earlier this year, outgoing ceo Ralph Havenstein announced that Anglo Platinum expects to produce 500,000 oz/year of ruthenium. This includes ruthenium raw materials bought from other producers and refined on-site.

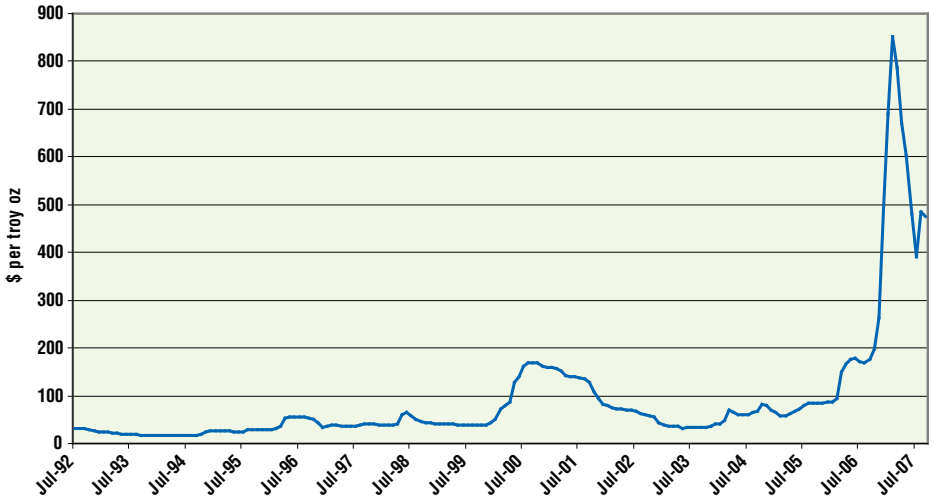
Impala followed Anglo Platinum's lead, forecasting that it would produce 250,000 oz of ruthenium this year. Lonmin expects to produce between 150,000 and 200,000 oz.

Reports that demand is outstripping supply does not seem to concern the market. Demand for ruthenium last year was 1.3m oz, 300,000-500,000 oz more than the year's supply, according to Johnson Matthey. "Although not all primary producers report production or sales figures for these metals, it is clear that some of the ruthenium currently being supplied is from stockpiles built-up over previous years," it explains in its annual pgm report in 2007.

Stockpiling has occurred because of previously relatively low demand. Because ruthenium has been produced as a by-product metal for many years and never mined simply for its own purposes, producers may have had to stockpile the metal and wait to take advantage of potential price rises.

As ruthenium is generally found in pgm-rich ores, it is produced in tandem with the other metals with which it occurs naturally. Miners carry out the first stage of the

Ruthenium prices



Source: Johnson Matthey

process, which is the flotation circuit, producing a cake (or concentrate) that contains all or most of the platinum group metals and often gold too. This cake is then sold to a refiner to process into the individual metals.

Many of the major South African miners have their own integrated refineries; others sell their cake to established refiners such as UK-based Johnson Matthey and Germany's Heraeus. Some primary producers sell concentrate to other producers such as Anglo Platinum, which reports that its refined production of ruthenium, iridium and rhenium from purchased metals in concentrate was 49,400 oz last year.

Heraeus has refined ruthenium for over three decades, growing from a capacity of a few hundred kg per year in the 1970s to several tonnes a year by 2003/2004. Within the past three years, Heraeus has doubled its refining capacity for ruthenium, though it does not publish statistics on how many ounces it refines each year.

The process of isolating ruthenium is a chemical one, and according to the Los Alamos National Laboratory in the USA, the final stage is the hydrogen reduction of ammonium ruthenium chloridate, which leaves a ruthenium powder. The powder is then consolidated by powder metallurgy techniques or by argon-arc welding, the result of which can be plated by electrodeposition or by thermal decomposition methods.

Ruthenium is sold as a powder (also called sponge) or as rod, shot, pellets, or ingots. It is also sold in the form of over a dozen compounds, such as ammonium hexachlororuthenate ($(NH_4)_2RuCl_6$), ruthenium bromide ($RuBr_3$) and ruthenium oxide (RuO_2), according to ESPI Corp, a high-purity metal specialist in Oregon, USA providing small quantities of materials for research. Johnson Matthey sells 19 different forms of ruthenium and ruthenium compounds, including powders and crystals, for industrial markets. Hereaus sells ruthenium as a powder with 99.9% purity. It also sells an electronic grade which is used in computer hard disk application.

Ruthenium demand by application*

Chemical	164	222
Electrochemical	96	137
Electronics	582	874
Other	49	55
Total Demand	**891**	**1,289**

**'000 ounces* *Source: Johnson Matthey*

MARKETS

Consumption of ruthenium increased dramatically last year, owing to the increased demand in new computer electronics applications using vertical memory storage. These hard drives use technology that sandwiches a three-atom-thick layer of ruthenium between two magnetic layers on a disk, allowing for a higher area density and therefore more room for memory storage. Electronics demand increased 78% in 2006 to 874,000 troy oz. In chip resistors and flat-screen display units, where ruthenium is used because of its abrasion-resistance qualities, consumption dropped slightly owing to the metal's increasing price, according to Johnson Matthey.

Other sectors utilising ruthenium are the chemical industries (*see table*). Demand rose partially because of new processes using the metal, says Johnson Matthey, such as acetic acid manufacture and polymer production. Ruthenium plays an important role in chlorine production; it is coated on to titanium, which is used as an anode in the electrolytic process.

Future increases in the usage of ruthenium are expected, says Heraeus, in fuel cells – due to ruthenium's excellent ability to act as a catalyst – and in turbine blades as part of a nickel-base single crystal alloy. Because of the ruthenium alloy's high melting point, gas turbine operating temperatures will be able to rise considerably, and it is hoped that large quantities of fuel can be saved owing to more efficient combustion. ■