

# PALLADIUM

## AUTOCATALYST

**Demand for palladium from the autocatalyst market grew by more than 10 per cent to 3.81 million oz in 2004. Purchases of metal by Japanese and US auto makers rose substantially as use of palladium-based autocatalysts increased, and in both countries the effects of year-on-year changes to inventories also had an impact. Demand in China and the Rest of the World region also expanded, in line with higher light vehicle production and tighter emissions standards. In Europe, however, autocatalyst demand for palladium fell once again as sales of gasoline-powered cars continued to trend downwards.**

## Europe

Western European sales of gasoline cars fell by 6 per cent in 2004 to a little over 7.5 million vehicles, a consequence of the ongoing rise in popularity of diesel cars. Palladium demand from European auto manufacturers contracted by 5 per cent to 1.16 million oz as a result.

At the same time, thrifting of palladium loading levels in autocatalysts continued to negatively affect metal demand. In particular, the increased use of close-coupled catalysts has allowed catalyst manufacturers to reduce palladium use significantly. These catalysts are fitted almost immediately downstream of the engine manifold (rather than under the floor pan) where exhaust gas temperatures are much hotter. This enables close-coupled catalysts to reach their optimum operating temperature very quickly once the engine is started, maximising catalyst efficiency.

The adverse effects of lower gasoline vehicle output and reduced metal loadings on palladium demand far outweighed the continued move away from catalyst systems containing platinum to alternatives based on palladium-rhodium formulations. Furthermore, by the beginning of 2004 larger auto manufacturers were already using palladium catalyst

Palladium Demand: Autocatalyst '000 oz		
	2003	2004
Europe	1,200	1,160
Japan	550	675
North America	1,205	1,445
Rest of the World		
China	95	105
Other	380	425
<b>Total</b>	<b>3,450</b>	<b>3,810</b>
<b>Autocatalyst recovery</b>	<b>(410)</b>	<b>(530)</b>



systems on a majority of their gasoline car production, so with fewer vehicle models making the transition, there was less of an impact on metal demand.

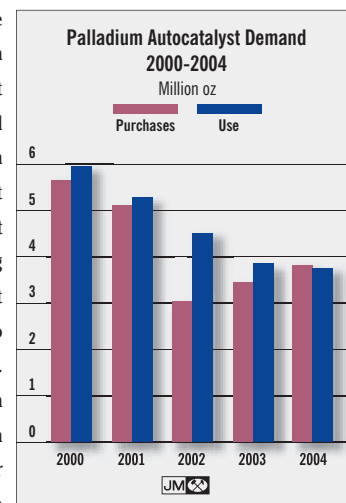
## Japan

Purchases of palladium by the Japanese auto industry reached 675,000 oz in 2004, a year-on-year jump of 23 per cent. The surge in buying was largely the result of increased use of palladium-based autocatalysts, although stock building by some vehicle manufacturers, higher average pgm loading levels and increased light vehicle production also contributed.

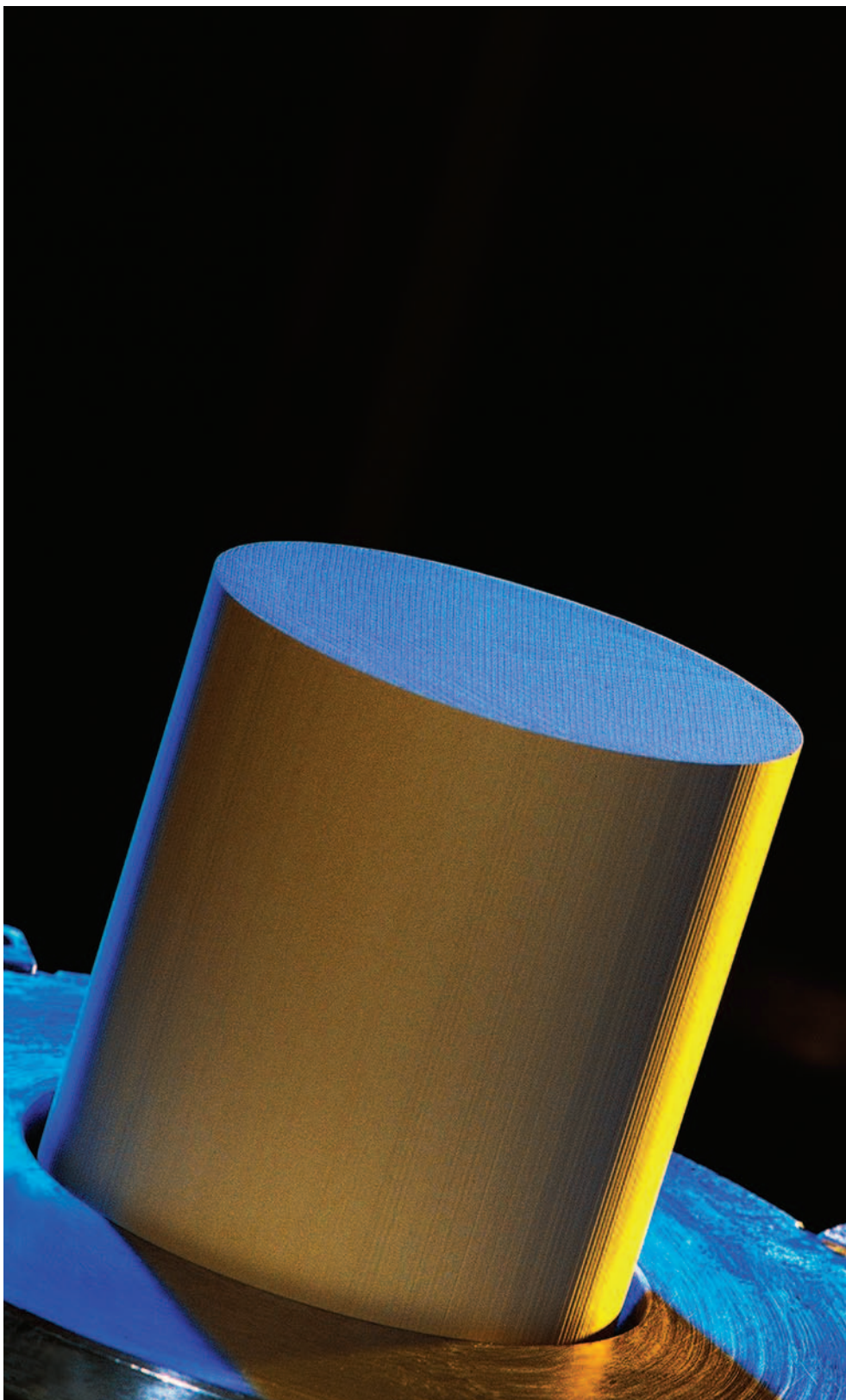
Japanese auto manufacturers have, in general, been relatively conservative with regard to altering their use of pgm in response to changes in the prices of the metals. However, with the premium between the platinum price and that of palladium not only persisting but widening, and tightening emissions legislation pushing the average pgm content of emissions after-treatment systems upwards, an increasing proportion of new Japanese light vehicle models are switching to use of palladium-based catalysts. The effect of this on palladium demand increased markedly in 2004, when a significant number of new vehicle models with palladium-rhodium catalysts entered production.

With their future palladium requirements rising and the price of the metal weakening, some Japanese vehicle manufacturers are believed to have bought palladium to hold as stock in 2004, in addition to their purchases for current vehicle production. This was a contributory factor in the growth in total demand.

A third factor in the increased Japanese demand for palladium in autocatalysts was the ongoing tightening of emissions regulations in the country. A large proportion of new light duty vehicles manufactured in 2004 met the Japanese TLEV (transitional low emissions vehicle) standard, with a significant number certified to the stricter LEV and ULEV (ultra-low emissions vehicle) standards. This had the effect of increasing average pgm loading levels. In addition,



*Autocatalyst demand for palladium was boosted in 2004 as auto manufacturers increasingly moved away from use of catalyst systems containing platinum in favour of those based on palladium.*



many sports utility vehicles and multi-purpose vehicles (people carriers) were reclassified as cars instead of light commercial vehicles in Japan with effect from January 2004. As passenger car emissions limits are generally more stringent than those for light commercial vehicles, this contributed to the rise in overall average palladium loadings.

Finally, although Japanese light vehicle production only expanded by a little over 1 per cent last year, larger cars and SUVs accounted for a greater proportion of total output. These vehicles tend to require a greater volume of catalyst (and therefore pgm) than smaller-engined models.

### North America

Purchases of palladium by the North American auto industry surged by 20 per cent to 1.445 million oz last year. Following substantial use of metal inventories in 2002 and (to a lesser extent) in 2003, auto company stocks of palladium had fallen close to target levels by the beginning of 2004. Little additional metal is believed to have been drawn from stocks during the year and so purchases of metal increased.

In contrast to purchases of the metal, however, the

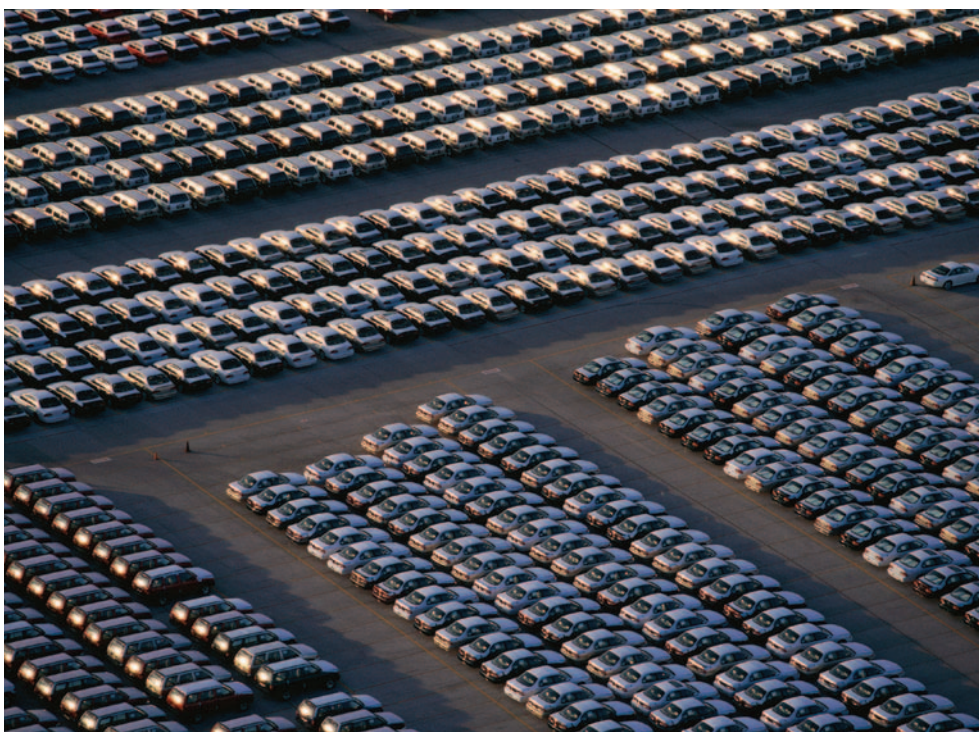
actual use of palladium on catalysts fell by 10 per cent year-on-year. This stemmed from further progress made in reducing the palladium content of autocatalysts, continuing the trend of the last few years. In the five years covering 2000 to 2004, the volume of palladium used on catalysts in North America fell by more than 50 per cent, from well over 3 million oz to less than 1.5 million oz. In 2004 the negative effect of this thrifting continued to outweigh the ongoing shift by US automakers towards greater use of palladium-based gasoline autocatalysts at the expense of catalysts containing platinum.

The reduction in the use of palladium on gasoline autocatalysts was also due in part to a fall of almost 2 per cent in US light vehicle production last year. Although sales of light vehicles held up well (supported by heavy discounting and other financial incentives for consumers) strong competition from imports, notably from Japanese automakers, resulted in total light vehicle production in the USA softening to around 11.6 million units.

### China

Demand for palladium from the Chinese automotive

*With inventories of new vehicles at high levels and imports rising, US light vehicle production fell by close to 2 per cent last year and this had a negative effect on palladium consumption.*



industry increased by more than 10 per cent in 2004 to 105,000 oz. Although the rate of growth in light vehicle output slowed compared with the previous year, production nevertheless increased by around 12 per cent. At the same time the progressive tightening of Chinese emissions legislation contributed to higher autocatalyst demand for palladium.

**Rest of the World**

Autocatalyst demand for palladium in the Rest of the World increased by more than 12 per cent to 425,000 oz in 2004. The majority of the growth in metal demand was due to rising light vehicle production and tightening emissions legislation in Asia.

Indian light vehicle output surged by 29 per cent to over 1.3 million units last year, an increasing proportion of which met Euro II equivalent emissions standards. Light vehicle production in Thailand and Indonesia also grew at double-digit rates, with a rising proportion of new light vehicle models in the latter being fitted with catalytic converters. South Korean production of cars and light trucks also increased in 2004, despite poor domestic sales, on the back of rising exports to Europe and North America.

**Autocatalyst Recovery**

The total volume of palladium recovered from scrapped autocatalysts surged by 29 per cent to an estimated 530,000 oz in 2004. The biggest impact on the volume of metal recovered was the ongoing trend for an increasing number of relatively heavily-loaded palladium-based catalysts to enter the recycling chain in the USA. These catalysts date from the mid-1990s onwards and rising numbers of vehicles from that period are now being scrapped. Consequently, recovery of palladium in North America climbed by 75,000 oz to reach 345,000 oz last year.

In Europe, the proportion of scrapped vehicles fitted with catalytic converters continued to rise in 2004, reflecting their widespread introduction in the region a decade previously. With catalyst collection rates also trending upwards, the volume of palladium recovered jumped by 57 per cent to 110,000 oz. In the mature Japanese market, however, catalyst collection rates have flattened out and palladium recovery from

vehicles scrapped in Japan was stable at around 40,000 oz last year.

**CHEMICAL**

**Demand for palladium in chemical catalyst applications expanded by 15 per cent in 2004 to reach 305,000 oz. Good growth in palladium demand was seen in North America, Asia and the Middle East as new production capacity for bulk chemicals manufactured using palladium catalysts came on stream.**

**Demand for palladium catchment gauze in the nitric acid industry also improved for the second year in succession.**

Investment in new production capacity in the bulk chemicals industry pushed up orders for palladium-based catalysts significantly in 2004. The greatest

impact on palladium demand came from the construction of new purified terephthalic acid (PTA) manufacturing plants in North America, China and South East Asia.

PTA producers made substantial investments in expanding their operations, in order to catch up with rapidly rising demand for the chemical in the manufacture of the plastic resin, polyethylene terephthalate (PET). Demand for PET, which is principally driven by the global packaging industry, continued to grow rapidly in 2004. Demand for palladium-based catalysts in North America was also boosted by the construction last year of substantial new capacity at a major hydrogen peroxide manufacturing plant.

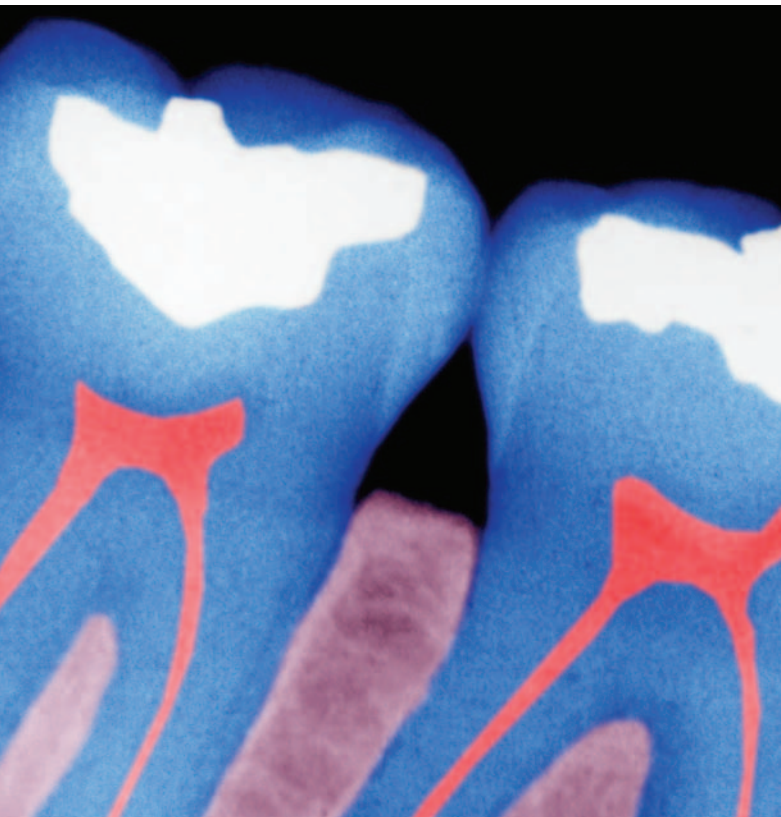
The widening price differential between platinum and palladium began to stimulate greater demand for palladium catchment gauze in the manufacture of nitric acid in 2003, and this trend continued throughout 2004. With the economics of installing catchment gauze becoming more compelling as the platinum price increased, purchases of

	2003	2004
Europe	65	65
Japan	25	25
North America	70	85
Rest of the World	105	130
<b>Total</b>	<b>265</b>	<b>305</b>



	2003	2004
Europe	70	80
Japan	515	520
North America	225	235
Rest of the World	15	15
<b>Total</b>	<b>825</b>	<b>850</b>





Use of palladium in dental alloys continued to recover slowly in 2004.

palladium for gauze manufacture increased, most noticeably in North America.

### DENTAL

Demand for palladium in dental alloys grew by 3 per cent to 850,000 oz in 2004. Japanese and North American demand for alloys containing palladium increased marginally, while use of the metal in Europe improved for the second year in succession, a result of the low and relatively stable palladium price.

Demand for palladium in dental alloys in Japan, by far the largest market, was little changed in 2004, edging up to 520,000 oz. Production of 20 per cent palladium 'kinpala' alloys dipped when the proportion of the cost of treatment covered by the state-backed reimbursement scheme was cut from 80 per cent to 70 per cent in the first half of 2003. The fall in demand, however, was not as substantial as many kinpala producers had feared and production slowly recovered during the second half of 2003 and throughout 2004.

Demand for palladium in dental alloys in North America also increased slightly, reaching 235,000 oz in 2004. Alloys with around 30 per cent palladium remain popular in the region and the comparatively low price of the metal increased the competitiveness of palladium-based alloys compared to high gold alloys.

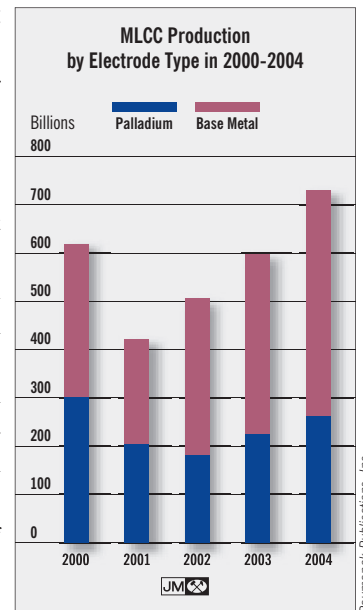
In Europe, palladium-based dental alloys were widely substituted by alternatives, including ceramic products, following the spike in the price of the metal in 2000 and early 2001. However, the relative stability of the palladium price since early 2003 (particularly versus the price of gold) has gradually drawn some demand back. In 2004, use of low-cost silver-palladium alloys in Germany in particular increased, and total European demand improved by 10,000 oz to 80,000 oz.

### ELECTRONICS

Demand for palladium from the electronics industry grew to 955,000 oz in 2004, a rise of 7 per cent compared with the previous year. Use of palladium in all sectors of the market increased as a result of rapid growth in production of electronic equipment. The weak price of palladium also contributed to a strong rise in demand for the metal in plating applications. Most of the growth in demand came from China and elsewhere in Asia, reflecting the continuing concentration of component manufacturing capacity in the region.

Global production of multi-layer ceramic capacitors (MLCC), the largest single electronics application for palladium, increased by almost 22 per cent in 2004 to over 720 billion units. Component output climbed faster than the overall growth in production of electronic goods due to increased use of MLCC in automotive electronics and fast-selling consumer products such as mobile phones with cameras. As a result, the consumption of palladium in MLCC rose for the first time since the late 1990s.

Actual use of palladium in MLCC has lagged behind growth in capacitor production due to thrifting and miniaturisation



Palladium Demand: Electronics '000 oz		
	2003	2004
Europe	85	100
Japan	225	225
North America	215	205
Rest of the World	375	425
<b>Total</b>	<b>900</b>	<b>955</b>



However, the increase in use of the metal was just 1 per cent: the difference between the rate of growth in MLCC output and demand for palladium was due to the continuing miniaturisation of capacitors and further substitution of palladium by nickel.

The effect of substitution on palladium demand remained significant in 2004, although the overall rate of replacement of palladium-based MLCC with nickel alternatives slowed slightly in terms of the numbers of capacitors produced.

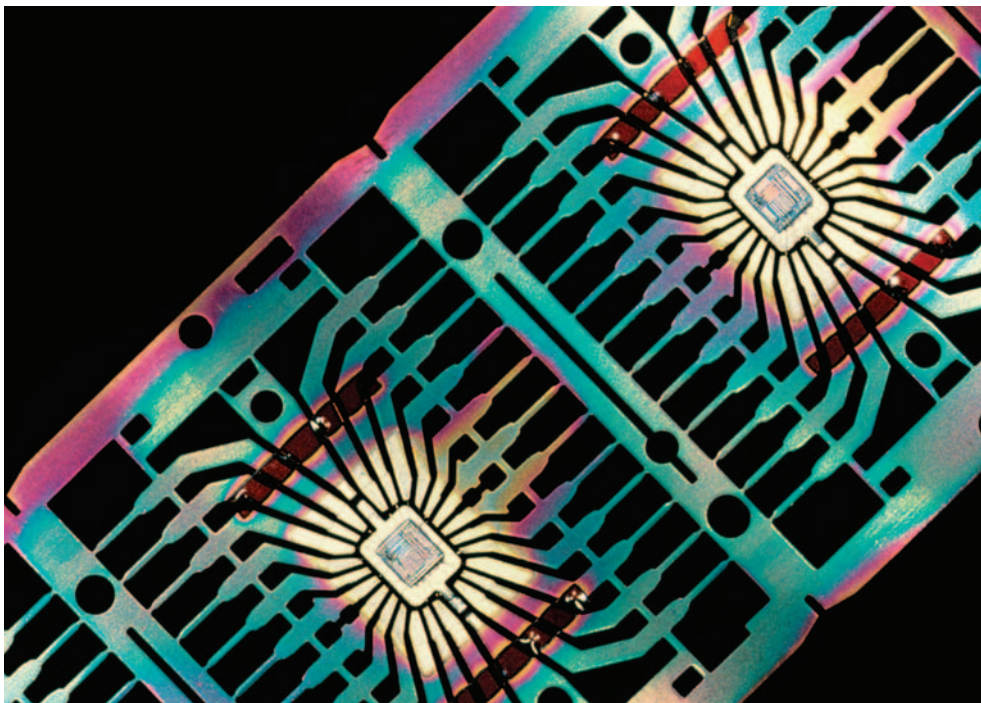
The trend of component miniaturisation also continued to have a detrimental effect on palladium use. The latest generation of MLCC is substantially smaller than the preceding series, and the ongoing decrease in average capacitor size has had a pronounced impact on metal demand. Furthermore, the average palladium content of the thick film pastes used in MLCC manufacture also continued to decline slowly in 2004.

In contrast to the MLCC sector, sales of palladium pastes for use in hybrid integrated circuits (HIC) grew rapidly, increasing by 15 per cent last year. Robust

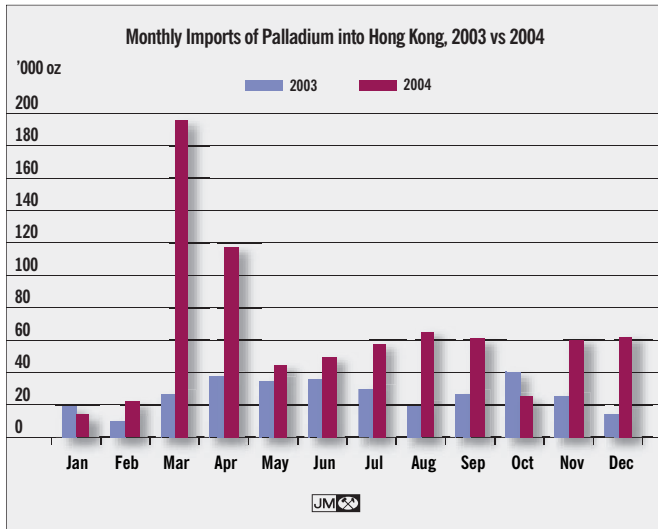
growth in production of HIC was driven by strong demand for the components in automotive electronic applications and the commercialisation of new uses for HIC-based circuitry such as electronic price tags.

Use of palladium in plating applications surged by 25 per cent in 2004. This was a result of both firm growth in demand for connectors and lead frames (in line with rising output of electronic equipment) and the acceleration of programmes to remove lead (Pb) from solders. The weakness of the palladium price encouraged producers of connectors to make greater use of alloys containing palladium in preference to those based on gold. At the same time, the lead frame sector made further progress in switching from tin-lead (Sn-Pb) solders to alternatives using palladium, driven both by demands from manufacturers of consumer electronics for lead-free components and rising regulatory pressure on the industry to substitute hazardous metals with alternatives.

Finally, consumption of palladium in resistor chips and related products increased by 7 per cent last year. Higher production of components such as piezo-actuators to meet orders from the automotive and telecommunications markets led demand for palladium higher. This more than offset the ongoing miniaturisation of resistor components.



*Use of palladium in electronic applications, including hybrid integrated circuits and lead frames (shown left), grew strongly last year.*



Imports of palladium into Hong Kong jumped in early 2004 as the jewellery trade built up stocks of palladium products.

**JEWELLERY**

**Global demand for palladium for the manufacture of jewellery soared from 250,000 oz in 2003 (much of which was used in white gold alloys) to 920,000 oz last year; a result of the rapid introduction of palladium jewellery in China. Purchases of palladium by Chinese jewellery producers surged to 700,000 oz: palladium jewellery is an entirely new product sector and the need to build stocks throughout the jewellery supply chain had a considerable impact on metal demand.**

Purchases of palladium by the Chinese jewellery industry exceeded all expectations in 2004, reaching 700,000 oz. The overwhelming majority of this metal was used to produce palladium jewellery, with only small volumes used in the manufacture of other precious metal jewellery alloys.

The development of the palladium sector was led at first by jewellery manufacturers. During the first quarter of 2004 retail prices of platinum jewellery

	2003	2004
Europe	35	35
Japan	160	155
North America	0	0
Rest of the World	55	730
<b>Total</b>	<b>250</b>	<b>920</b>

failed to keep pace with the rapid rise in the price of platinum, resulting in a sharp reduction in manufacturing margins on platinum jewellery. This prompted several companies to divert a proportion of their capacity towards the production of palladium pieces.

With the initial profit margins

on palladium jewellery at least five times those on platinum, the number of fabricators trialling production of the former quickly increased. Purchases of palladium consequently surged in March and April as manufacturers, wholesalers and retailers established stocks of product ahead of the May Day holiday period.

The introduction of palladium jewellery at the retail end of the market was largely confined to second and third tier cities. Retail sales of palladium jewellery developed unevenly, with some stores initially having to discount prices to stimulate sales of what for both customers and sales staff was an unfamiliar product.

However, by promoting palladium on the basis that it shares a number of attributes with platinum (e.g. its purity, durability, and the fact that it will not tarnish) and by virtue of its comparatively low price, stores were able to tap into a desire for affordable white precious metal jewellery amongst consumers.

With plain jewellery largely priced per gram of metal, the low density of palladium (it is roughly half the density of platinum and is significantly lighter than gold) also enhanced its price competitiveness. In addition, the notion that palladium jewellery had the potential to appreciate in value was frequently part of the sales message, with retailers citing both the recent example of platinum, as well as the rise in the palladium price to over \$1,000 in early 2001.

Fewer retailers in the largest, most affluent metropolitan areas (particularly Beijing and Shanghai) decided to stock palladium jewellery. In these cities considerable effort and expense has been spent on establishing and reinforcing platinum's position as the precious metal jewellery to which consumers aspire; stores are therefore reluctant to allocate display space to an unfamiliar product that could detract from sales of platinum. The lack of promotional information, its 'cheaper' image, and the absence of a palladium contract on the Shanghai Gold Exchange were other deterrents for the leading retailers.

After the flood of palladium buying by manufacturers in March and April 2004 to establish stocks of product, demand for the metal eased but remained substantial: imports of palladium bullion to Hong Kong averaged more than 53,000 oz per month from May through to December (see accompanying graph).

Demand became increasingly driven by retailers who continued to enjoy good margins on palladium sales, not least because (unlike platinum) the metal was not subject to a 5 per cent consumption tax. In contrast, the financial returns on palladium jewellery for manufacturers declined as competition increased; by the end of the year there was little difference between platinum, palladium and white gold in terms of profit margin per gram. Nevertheless, the weak price of palladium meant that it was relatively inexpensive to finance product inventories, whilst the low volatility of the palladium price during the second half of the year further reduced the risk of holding metal.

In summary, palladium jewellery rapidly established a presence in Chinese provincial cities, where it offered an affordable alternative for less affluent consumers seeking pure, white precious metal jewellery. In doing so, palladium took sales from plain platinum, white gold and even traditional yellow gold jewellery, but also helped to increase the total precious metal jewellery market.

Outside China, palladium is used as a component of platinum and white gold jewellery alloys in Japan and is also a common constituent of white gold alloys in Europe (where there are tight limits on the permissible nickel content of jewellery). Demand in Japan demand weakened in 2004 in concert with the drop in platinum jewellery production, whilst demand in Europe was largely stable.

**OTHER**

**Demand for palladium in other applications jumped to 290,000 oz in 2004, up from 140,000 oz the previous year. Consumption of the metal in most minor industrial uses was fairly stable but sales of physical investment products to private investors in North America surged to an estimated 200,000 oz.**

Demand for palladium as a physical investment in North America increased markedly in 2004. Sales of palladium coins and small bars (1 oz and 10 oz) to individual investors climbed rapidly and accounted for 200,000 oz of palladium demand in total.

The widening divergence between the price of palladium and platinum, and the gross

underperformance of palladium compared with the rest of the commodities sector, fuelled a perception that the metal was therefore considerably undervalued. This, coupled with increased marketing and promotion of palladium investment products, resulted in a surge in sales, particularly during the first quarter of the year when the price of the metal rallied from less than \$200 to over \$300.

Much smaller volumes of palladium were used in the production of commemorative coins in China and Europe. The People's Bank of China issued 8,000, half-ounce palladium Panda coins in 2004, the first time the coins had been reproduced since their initial launch in 1989. In Europe, a palladium-gold coin was minted in Slovakia to commemorate the country's accession to the European Union.

In the industrial arena, demand for palladium-based hydrocracking catalysts from the petrochemicals sector edged lower in 2004, reflecting the mature nature of the market. Use of palladium in photographic film also slipped downwards, a result of the wider trend towards digital imaging. However, these reductions in demand were largely offset by small increases in consumption of palladium in catalysts for stationary emissions control applications, gas sensors and hydrogen purification. Total palladium demand from minor industrial applications, therefore, was unchanged at 80,000 oz.

Palladium Demand: Other '000 oz		
	2003	2004
Europe	20	25
Japan	5	10
North America	95	235
Rest of the World	20	20
<b>Total</b>	<b>140</b>	<b>290</b>



*China issued palladium 'Panda' coins in 2004 but by far the greatest demand for investment products was in the USA.*

