Introduction to Workshop 3C: Industrial Applications

Serge Gambs

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It is a pleasure to be here today in Shanghai for this fifth annual LBMA Conference, a conference that has become a leader in the precious metals world. This afternoon we will discuss a very interesting part of our industry, which refers to applications of precious metals in the industry. As you know, the industrial sector is not the main end user of precious metals by far – compared to jewellery – but these applications have become really essential and indispensable in our daily lives. How could we protect our environment without precious metals? How could we be without our PCs and all the appliances that use bonding wires and other precious metal-based components? How could we have mobility, as now cars without exhaust catalysts are no longer being manufactured in most countries around the world?

So we are here this afternoon for a very important session, one that has an important impact on our lives and everyday activities. Our first speaker today will be Jessica Cross, who is well known in the industry for her very in-depth research in the world of precious metals. She is chairperson and chief executive officer of Virtual Metals Research and Consulting, a London-based precious metals company which was founded in 1997. Virtual Metals is sponsored by five leading mining companies and offers proprietary economic and commodity research to facilitate long-term strategic decision-making. In addition to these five companies, Virtual Metals now provides consultancy for 30 other major institutions focused on precious metals.

In a career that spans nearly 20 years, Jessica has worked as a precious metals commodity analyst for major mining houses, including Anglo-American, Consolidated Goldfields, and RTZ. Her precious metals research is extensive and has included work in the authoritative Annual Gold Survey published by GFMS, benchmark research into gold derivatives, as well as detailed work in the platinum group metals. She has a doctorate in financial engineering and today she will give us more information about precious metals in MLCCs.

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Thank you very much, Jessica, for this very thorough analysis of the world of precious metals in MLCCs and your forecasts regarding future offtake of the metals in this industry. No matter how successful and progressive the use of MLCC will be, the consumption of the precious metals is certainly not going to be there. Our next speaker is Mr Ichimitsu Itabashi, research associate from Tanaka Kikinzoku Kogyo K.K.

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Thank you very much, Itabashi-san, for these very interesting details about the world of gold bonding wire at Tanaka. Our next speaker today will be Grant Angwin from Johnson Matthey, replacing Michael Steel, who has not been able to come to Shanghai.

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Thank you very much, Grant. Ladies and gentlemen, do you have any questions that you wish to raise with our speakers today?
Good afternoon. I am honoured to be on this platform and especially delighted to be able to address a topic other than derivatives. In looking at precious metals’ usage in electronics, one deals in terms not of tonnes, nor indeed even of ounces, but of microns. Going from the giant hedge book of the gold market to a nanogramme of gold in a printed circuit board is going from the sublime to the ridiculous, but it’s a useful reminder that there are many different market participants, each with their own objectives and needs.

While all precious metals find a home somewhere in the manufacture of electronic components, for palladium this industry was of prime importance – at least until 2000. In that year, global demand for palladium in electronics peaked at 2.4 million ounces, representing 28% of offtake. Then the price of palladium rallied to $1,100 per ounce and the manufacturers of multi-layered ceramic capacitors – computer chips to the layman – did what any cost-conscious industry would do: they found substitutes. Within 12 months, palladium demand in MLCCs was down to 1.2 million ounces or 16% of overall palladium demand in 2001. This sharp decline was due largely to the substitution of nickel, but it also marked a downturn in global demand for electronic components, and the industry was left with considerable inventories.

But, as Virtual Metals predicted throughout 2003 and indeed this year, the electronics industry has enjoyed strong economic recovery, so much so that manufacturers of the associate components have in many cases battled to keep pace with orders.

Despite this, the outlook for palladium usage in this sector now looks substantially more vulnerable than it did even two years ago. In previous forecasts we assumed that the rate of substitution from palladium to nickel would slow down as the price of palladium returned to what might be considered more reasonable levels. We argued that those that had retooled and made the switch to nickel, namely the manufacturers of MLCCs in the Far East, were already in the forecast equation, and, of the remaining manufacturers in Europe and the USA, the majority would maintain their original fabrication technology, which favoured palladium.

The basis of our argument was that a proportion of this industry remained where the high performance of palladium outweighed any cost advantage of using nickel-based technology. Subsequent developments have proved this assumption overly optimistic in favour of palladium. Moreover, other factors are coming into play, factors which do not augur well for the metal.

Thus our initial assertion – that two thirds of the MLCC manufacturing capacity has substituted irrevocably to nickel – is correct. The top ten manufacturers have made the conversion to nickel and are concentrating their R&D on improving their base metal products.

But what of the remaining one third? Here, too, palladium is under continuous threat from substitution with silver. In other words, palladium is being threatened by both base and precious metal substitutes. The silver substitution is not outright but is more of a gradual trend towards the manufacturers using a palladium alloy that contains an increasing proportion of silver. Discussions with people in the industry reveal that there is a concerted effort to, as one of them put it to me, “work palladium out of the equation completely.”

Whereas a decade ago palladium was favoured in high performance MLCCs (since they remain very stable under a wide temperature range), and the content was 100% palladium, alloys now of more silver to palladium are being favoured and actively developed. Ratios with the proportions...
of 75:25 silver to palladium or even 90:10 silver to palladium are commonly found.

The future for palladium in this remaining residue looks even bleaker. There are now MLCCs using 95:5 silver to palladium alloys at the production stage (reportedly successful), while at the developmental stage there are alloys of no more than 2% palladium, the rest being silver. In answer to the inevitable question, 100% silver alloys do not perform well as there are technical and structural limitations.

Another factor threatening palladium offtake in this sector is continued miniaturisation. In looking at this issue originally, Virtual Metals assumed that miniaturisation can and does occur but eventually reaches a minimum, beyond which performance is lost. The only factor that can then address the issue and continue the process is a technological breakthrough or development which then allows the process of miniaturisation to resume. Yet while this seems to be the case in most other products, it does not seem to be applying to MLCCs. The reason for this, in the case of MLCCs, is that the performance (the capacitance) actually improves markedly with smaller and smaller units of product – quite the opposite to other components. Thus in the case of MLCCs there is a distinct technical advantage to miniaturisation over and above the cost savings. Thus size does count and further trends towards even more miniaturisation must be expected.

A third factor working against palladium is closely associated with miniaturisation, that being the ability on the part of the manufacturers to thrift and constantly reduce the loadings of palladium. This comes about not only because of miniaturisation but also through the application of thinner and thinner layers of palladium to each capacitor. Again, there are the same technical advantages in that thinner applications of palladium achieve better capacitance in the final product. Whereas five years ago the metal coating on an MLCC probably averaged 1 1/2 microns, today 0.8 microns are standard and coatings half this level are being tested.

In terms of loadings, the thickness of palladium precious or base metal paste can vary enormously between MLCC designs and what the customer wants. With respect to palladium, this can be anything from 8mm-27mm per square inch of dielectric board (the initial substructure that then gets chopped up into the individual MLCCs). Assessing the amount of palladium per capacitor is, however, complicated, since in terms of size, MLCCs can vary from one square inch to the size of a pinhead. So attempting to come to an industry average for the purposes of calculating loadings and then forecasting is hazardous, to say the least.

The outlook for the future of MLCCs is, without doubt, robust, though it is looking like palladium will only be there in amounts which continue to reduce dramatically. The growth of MLCCs is coming from two areas. First, there is apparently unquenchable demand for goods like mobile handsets, added to which the motor industry is now fitting as standard equipment MLCC-rich electronic features. But we are also looking at increasing intensity of use. The original mobile handsets which were the size of a brick – and probably weighed as much – contained around 50 MLCCs. Today, thanks to Bluetooth, 3G technology and most recently colour imaging, mobile handsets need about 400 capacitors per handset. Industry observers are quite comfortable with projected demand growth rates for MLCCs of 12% per annum. But if all this substitution away from palladium towards both nickel and silver was triggered by palladium price spikes, surely there must still be some price sensitivities left in this sector? Industry participants and MLCC manufacturers claim that $200 per ounce palladium is too high and at those levels they have no interest in looking to salvage the metal. At $100-$150 per ounce their attitude towards palladium begins to soften and they sound more accommodating. But far more damaging to increased palladium offtake than the absolute price level is the price volatility which, like the motor manufacturers on the issue of exhaust emission control, the MLCC manufacturers conclude “we just cannot stomach.”

With these candid comments from the consumers of precious metals in mind, you have to wonder about the current rhodium price and the long term damage that the price rally will inflict on this already vulnerable metal. Without doubt, short term price spikes are jam for some but poison for many others.

On that note, I thank you for your time this afternoon.
Gold Use in Electronics: Bonding Wire

Ichimitsu Itabashi

Research Associate, Tanaka Kikinzoku Kogyo K.K.

Gold is used in field of electronics manufacturing as bonding wire that connects the IC chip and circuit board. World fabrication of gold bonding wire is about 150 tons in 2004, which represents a threefold increase over the last 10 years.

The reasons for using gold are due to the metal’s basic properties, which include low electrical resistance, ductility and no oxidation. Gold is drawn to a thinness of less than 30 microns in the manufacture of bonding wire.

There are some threats to bonding wire and the wire bonding process from new technological developments in semiconductor manufacturing. However, high-strength gold wire and high-reliability gold alloy wire are useful in the mass production field of electronics manufacturing in the future.

Wire Bonding Process

The integrated circuit (IC) in the wafer process is made on a Si chip, which is cut out from a single crystal Si ingot.

Wire bonding is one of the important steps in the assembly process. After the wafer process, the IC chip is cut into pieces and put onto a circuit board. The wire bonding process makes a gold wire loop and completes the electrical contact between the IC chip and the outer electrode of the circuit board.

After this wire bonding, the circuit board is covered by mould resin to protect it from outer stress and marking is put on the moulded package, then the IC device is complete.

Details of the wire bonding process are shown in Figure 1 and explained as follows.

a) Gold bonding wire goes through a ceramic cylinder tool, called a capillary.

Fig.1 – Wire bonding process
b) A ball is made on a wire tip under a capillary by the discharge from a spark electrode of bonding machine.

c) IC chips on a circuit board are heated to not less than 473 K. A gold ball with a capillary is lowered onto the electrode of an IC chip and an ultrasonic vibration is added, then the gold ball on the wire tip is bonded to the IC chip.

d) After the IC chip bonding, the capillary goes up and moves to the electrode of the circuit board. The wire goes through the capillary and makes a loop between the IC chip and the electrode of the circuit board.

e) On the electrode of the circuit board, the capillary is lowered again and ultrasonic vibration is added. The gold wire is bonded to the electrode of circuit board without making a ball as in IC bonding.

The reason for the use of high purity gold has to do with the basic property needs of the wire bonding process. Bonding wire is an electrical wire, so it requires low electrical resistance. Gold has the third lowest electrical resistance of all metals. Making a ball on a wire tip also requires no oxidation. Gold doesn’t oxidize and is also a very ductile metal, corresponding to the complicated movements of the bonding machine.

**Market Trends**

The market areas for growth are mobile phone equipment and automotive applications.

There are various electrical units and systems in a car. The internal temperature of a car increases very sharply in summer and decreases to very low levels in winter in cold northern regions. Recently, there are increasing cases of electrical units being placed near the engine, which has a very high temperature. Automotive application needs for bonding wire therefore must correspond to the severe environmental conditions.

In 1994, world fabrication of gold bonding wire was about 50 tons. In 2003, it reached nearly 150 tons – representing a threefold increase over the last ten years.

However, there are some threats to bonding wire and the wire bonding process from new technological developments in semiconductor manufacturing.

One of these is flip chip (FC) bonding technology, which has the advantage of low electrical resistance, thus it is applied to the high-speed clock devices of high technology.

Another threat from the most advanced technology is Cu through electrode in a Si chip. This process is able to achieve chip stacking that FC bonding technology couldn’t, since, of course, the electrical resistance is low. Cu through electrode is in development by ASET (Associated of Super-Advanced Electronics Technologies) in Japan.

Wire bonding technology continues to be used widely in the manufacture of low-end products and low-cost applications, but the threat posed by the new technological developments is increasing.
Technical Trends

There is a strong requirement of fine pitch bonding to correspond to high-density composition for mobile equipment manufacturing. The bonding pad becomes a small area to achieve a small-sized package. The electrode pitch on a Si chip has become smaller due to the fine technology of the wafer process.

In order to realise fine pitch bonding, a small ball and a fine wire of less than 20 microns are required. High strength is necessary for bonding wire as a material property.

Fig 2 indicates IC bonding part of 40-micron pitch bonding sample.

A second technical trend is stacked bonding. Si chips are stacked in one device at SiP technology. Stacked bonding requires short and low loop making for lower chip bonding and long and high loop making for upper chip bonding as shown in Figure 3.

Short contact of lower wire and upper wire should not occur, of course for wires next to each other, but also if outer stress is added during the molding process.

Thus high strength is necessary for bonding wire to realise stacked bonding.

The third technical trend is high reliability. When bonding interface in the high temperature storage, Au₅Al₂ appears in the bonding boundary as the first inter-metallic compound (IMC). Au₅Al₂ is easily transformed into Au₄Al. Au₄Al is corroded by mould resin.

The electric resistance of the bonding point is rapidly increased by the Au₄Al corrosion phase – then IC device failure occurs.

High Strength Gold Bonding Wire

Many kinds of gold bonding wire are made to meet the various manufacturing requirements of semiconductor and electrical devices. High strength gold bonding wire’s breaking load is over 150 mN, which means 300 MPa at φ25 micron and 4% elongation. Over 300 MPa of high strength, gold bonding wire’s tensile strength is three times greater than 5N-purity gold.

High strength methods are types, volume and mixing of elements. General gold bonding wire keeps 4N-purity. This drastic change of property by less than 100 wtppm elements is based on field results in high purity metal research.

High Reliability Gold Alloy Bonding Wire

Cross-sections of encapsulated samples at 473 K for each hour comparing gold and a gold alloy including 1% palladium are shown in Figure 4 on the next page.
During temperature storage, an IMC phase appears and grows in the bonding boundary. After 200 hours of storage, the IMC has grown about 3 microns thick. The IMC of 4N-Au is thicker than that of the gold alloy.

After 500 hours of storage, the upper part of the IMC in 4N-Au turns brown. There is no change in the gold alloy sample. After 1,000 hours, all of the IMC in the 4N-Au changes into a dark brown phase. However, only the peripheral region of the IMC in the gold alloy turns brown.

The electrical resistance of the 4N-Au sample rapidly increases after 200 hours, corresponding to the IMC phase’s colour change, which is confirmed in the cross-section observation shown in Figure 4. The electrical resistance of the gold alloy sample doesn’t change over the course of 1,000 hours.

Gold alloy makes a palladium barrier in the bonding boundary and blocks diffusion of Au atoms, so it may be difficult for Au₅Al₂ to transform into Au₄Al. Thus gold alloy bonding wire guarantees high reliability.

**Conclusion**

There are some threats from new technological developments in semiconductor manufacturing to bonding wire and the wire bonding process. However, gold bonding wire will be useful in the mass production of electronics manufacturing in the future. The main trends of bonding wire are in demand due to cost reduction and corresponding to severe environmental conditions.

Fine pitch bonding and stacked package manufacturing can be achieved by using Tanaka gold bonding wire and it is useful in the reduction of costs in electronics manufacturing. And Tanaka gold alloy bonding wire guarantees high reliability requirement.
Autocatalysts in China

Grant Angwin
Sales & Marketing Manager, Johnson Matthey Plc

My task today is to talk to you about the use of autocatalysts in China and, given that this is a precious metals conference, to discuss what that might mean for demand for platinum-group metals.

The first thing to say is that autocatalysts are already being fitted to many cars in China and in 2003, according to Johnson Matthey’s own estimates, about 150,000 ounces of PGMs were used in catalytic converters fitted to cars manufactured in this country. This paper will outline the prospects of auto production through to the end of this decade, consider the emissions, legislation that is – and will be – in place and estimate what scale of PGM might result.

Before we consider the details of autocatalysts, it is important that we consider some auto statistics. I must acknowledge Global Insight Automotive, formerly known as DRI Automotive, as the source of many of the statistics that I will quote.

The chart above indicates just how many vehicles – cars, light commercial vehicles, and heavy duty vehicles – exist on China’s roads at present. In 2003 the total was just under 26 million, but by 2009 it is expected to be more than double this figure, at around 55 million.

This chart shows a forecast for the population in China, together with the prediction for car ownership. Global Insight estimates the number of cars per thousand people in China in 2003 was 6.7. This can be compared with the US Department of Energy estimates of around 550 for Europe, 600 for Japan and 710 for the USA. Plainly the potential for growth in ownership is enormous.
This chart shows annual sales of autos in China from 1999 to date, with a projection to 2009. In the first year, 1999, sales were just 1.9 million, but by last year they had grown to 4.5 million and by 2009 they are expected to be 8.3 million. What has really caught the world’s attention in recent times has been the 60+% growth in the sales of passenger cars in both 2002 and 2003. This is particularly relevant as these are the vehicles most likely to be fitted with auto catalysts in the near term.

The above chart illustrates that the production of cars in China is almost equal to the sales and that imports account for just 4% of domestic sales in China.

The attraction of the Chinese market to the world’s auto manufacturers is clear, as virtually every global OEM (original equipment manufacturer) is present, mainly through Sino-foreign joint ventures. The next table shows the most important of these. Each has been selling at an annual rate of at least 100000 cars in 2003 or 2004.

### Emissions Legislation

Having established that the number of vehicles on the roads in China will increase dramatically by the end of the decade, the next question for our industry is how man of them will be fitted with catalytic converters to reduce the pollution that would otherwise grow to an unacceptable level?

In terms of emission legislation China is following closely the procedures adopted in Europe. In the European Community we are currently at stage 3 – Euro III – in our legislation, with Euro IV scheduled for 2005, and draft proposals already in place for Euro V from 2008. China is some way behind Europe but has been moving fast to catch up in recent years.

Following the European pattern, Euro I was the first standard applied in China. This came into effect in Beijing at the end of 1998, but the lack of unleaded fuel made wider application impossible until 2000 as catalytic converters would have been poisoned by the presence of lead in gasoline.

The tougher Euro II standard has applied in Beijing since August 2002, in Shanghai since January 2003 and nationwide for cars from July 2004. It will be applied to other light-duty vehicles from July 2005. It has also applied to heavy-duty vehicles since September 2003, but for these vehicles the standard can be met without the use of a catalyst.

The next stage will be the Euro III standard. This is expected to apply in Beijing and Shanghai from 2005 or 2006 and nationwide from 2008. As in Europe, tax incentives are being considered for vehicles that meet Euro III in advance of the specified deadlines.

Our latest information is that Euro IV standards can be expected to be applied nationwide from around 2013, or perhaps earlier.

### The Autocatalyst Market in China

The significance of all this legislative activity can clearly be seen when one looks at the number of factories that are being constructed or are planned for the manufacture of autocatalysts.

All the world’s major autocatalyst manufacturers are present in China: Johnson Matthey; Englehard and Delphi have factories here in Shanghai, as does the catalyst support maker Corning. Not far away in Suzhou are Umicore and the support maker NGK. A little further west in Wuxi we have Cataler and a local producer Weifu Leader. In south China the Kunming
Precious Metals Institute is another local manufacturer. Earlier in this presentation I showed a prediction for the number of light-duty cars and vehicles manufactured in China would grow from 4.08 million in 2003 to 7.78 million in 2009 – this is a 91% increase. Our belief is that demand for the PGMs for autocatalysts will grow faster than that, perhaps from 150,000 ounces in 2003 to around 400,000 ounces in 2009 – a 167% increase. The growth will result from a combination of tighter emissions standards and increased output of vehicles.

Some commentators have predicted even higher demand for platinum group metals in catalytic converters in China, but it seems likely that the Chinese market will benefit from the experience in other markets of continuing thrifting of PGMs in autocatalysts relative to their increased effectiveness in reducing pollution.

One thing that might cause demand to be higher than I have predicted would be if it were decided to legislate for the retrofitting of catalytic converters to heavy-duty vehicles in major cities, as happened in Hong Kong in 2003. I have made no allowance for these in the figures just quoted.

In conclusion, it is clear that China is an attractive market for both auto makers and autocatalyst suppliers, and the use of platinum, palladium and rhodium in this application will be a significant extra component in the supply/demand balance in the PGM markets in the future.

Ladies and gentlemen, I thank you for your attention. I will take any questions that I can. If they are specific, I ask that you give me a letter or a note with an e-mail address and I will ask Dr Steel to come back to you. Thank you.
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Questions and Answers

Q – Ed Jette, Stillwater Mining: Grant, the 150,000 ounces growing to 400,000 ounces – is that total PGM consumption?

A – Grant Angwin, Johnson Matthey: That represents total the PGM consumption that Mike is predicting for China. They’re autocatalysts in China.

A – Jessica Cross, Virtual Metals Research and Consulting: If I may just add to what Grant was saying, we agree absolutely with what Grant has said and what they’re seeing in China, but just a quirk. In a sense, the last 18 months’ to two years’ data on car registrations were affected by the SARS virus. It seems as though the Chinese who could afford to go out and buy a car at that stage did, on the basis that they didn’t want to use public transport. Therefore, the last two years’ car sales have been exacerbated by that and we expect it to settle down a little bit. We also anticipate very, very strong growth in car registrations.

Q – Participant: One question maybe to Jessica: where is the platinum going to come from in the future, with such growth rates?

A – Jessica Cross: Well, absolutely. I think that you’ve raised a very, very serious question. We are greatly concerned about that because whichever way you do the supply/demand balance, platinum remains in steep, steep deficit. There is simply not going to be enough metal to go around, particularly if the rand remains strong and you have delays of expansion and new projects from the Bushveldt complex on the Eastern Limb particularly. This is going to become a major problem. I referred to price spikes, and in a sense I was referring to our great concern about what might happen to platinum. We’ve been known to say publicly that we don’t believe we’ve seen the run-up in the platinum price yet. What we see is a structural problem evolving in the market which I think will become apparent in three to four years’ time unless it is addressed. But you’re absolutely correct: there is a problem emerging.

Q – Lewa Pardomuan, Reuters: I just wanted to talk about the deficit in platinum. What sort of deficit are we talking about? Some people in Tokyo thought it would be about 30 to 100 tonnes for this year for platinum. My second question is what sort of price range do you expect for, let’s say, this year? Are we going regain $900 again? Thanks.

A – Jessica Cross: In terms of absolute tonnage, I think this year is slightly more in balance than we’re going to see in future. I think the problem is going to emerge in the next 18 months to three years. We’re looking out at that range. For price forecast, we are looking at anything from 800 upwards, over 1,000 if this is not addressed. I think long term that could be extremely damaging to the market. You’ve seen it in platinum once before; you’ve seen it in rhodium; you’ve seen it twice in palladium; and now we’ve got this problem evolving in platinum as well, which we believe is structural. We’re very, very cautious about it and we are saying quite publicly that we are extremely worried.

Serge Gambs: Would some people in the audience wish to raise questions for Dr Michael Steel? Would you like us to organise these questions to be taken in writing? Let me remind you that, if my memory is correct, the forecast that was published by Johnson Matthey was predicting, this year, for the first time, a surplus in platinum. This was forecasted to be about 155,000 ounces at the end of this year, but this apparently will only be a temporary situation.

Jessica Cross: I wonder if I may formally table a question for Michael, Grant. It’s really the potential success of palladium in diesel catalysts. I think this is technology that could be critical in how these markets evolve and how the imbalance between the two metals is addressed. If this technology – i.e. already announced by Umicore, or possibly some technology announced by Johnson Matthey, Engelhard, or other manufacturers of catalysts – could be the one way that these markets do come back into balance. Obviously, this must technically be a critical issue going forward.

Grant Angwin: Thank you, Jessica. I’ve made a note of that and I’ll ask Mike to call you.
**Serge Gambs:** Could we also organise, Grant, that this information be given to the participants in this room? If you would like to leave your business card with your email address, I am sure we could organise to have this passed on to you also.

**Grant Angwin:** Yes, absolutely.

**Q – Serge Gambs:** Any more questions? John, as a precious metal analyst, may I ask you a question? What is your opinion regarding the future of palladium and platinum, both as far as availability and price wise? I’m sure our audience would like to hear your opinion.

**A – John Reade, UBS AG:** Thanks, and unfortunately I have to apologise that I wasn’t here to listen to all of what was said before, because I was attending the other workshop as well, listening to the platinum jewellery story. So I am not in a position to comment regarding what Jessica said regarding a shortage of platinum in coming years. I would be very interested to hear what she said again, but I won’t bore the group with asking her to do that now.

We’ve taken quite a different view on the outlook for platinum over the next couple of years. Based on our own statistics, which have been confirmed recently by what Johnson Matthey and Impala have said, we’ve seen a decline in Chinese platinum demand this year of something like 20%, and seen no sign in July and August that this is picking up. In fact, it’s remaining at very low levels. Based on the supply/demand analysis that we’ve done, we see the platinum market coming back into surplus this year, in line with what Johnson Matthey said at the start of the year, but also that the surplus will widen in coming years – exacerbated by liquidation from speculative long positions that have been built up in the last couple of years, some of which are on the exchanges and some of which are in the over-the-counter (OTC) market. We forecast that the platinum price will peak somewhere in the fourth quarter of this year. I’ve got a year-end forecast of $840 an ounce, an average price of $725 next year and $600 in 2006, so you can see it is quite a negative outlook for the platinum price.

In the case of palladium, we see the market as in oversupply at the moment and we see that continuing. There is some good news out there in terms of demand; Jessica mentioned before the potential use of palladium in diesel catalysis, and clearly that’s a positive thing. I’ve just been hearing about white gold and even palladium jewellery next door from the Platinum Guild.

While those are positive factors for palladium demand, supply is growing both at a primary level from South Africa and on a secondary level from the recycling of catalysts. I find it almost impossible to play with parameters to get the palladium market to move back into balance. I suspect that the forecasts we have at the moment, which from memory I think are averaging $225 for next year and $200 for 2006, are probably too optimistic. It’s certainly something that we’ll probably be addressing in a report shortly.

**A – Jessica Cross:** John, I agree with what you’re saying about palladium: a surplus market that is probably going to remain in surplus. Bear in mind that you didn’t hear what I was saying that at prices below $200 there could be substitution. Certainly dentistry comes back at below $200; that’s very price sensitive, but also the electronics sector might start showing signs of comeback.

But I believe on your platinum forecasts, we’ve looked very closely at the sensitivity between white gold and platinum in Chinese jewellery. There is without doubt a very intricate relationship not only between the prices, but also the lease rate relationship. I would say at $600 platinum, you’re going to have very, very strong demand of platinum jewellery into China again. Then that starts addressing your imbalance. I’m greatly concerned, as I said previously, before you came in, about projects in the Eastern Limb that are being pushed out on to the backburner. Where you have UG2 ore coming on, this favours palladium for every ounce of platinum. I think that’s another structural imbalance in the market that is emerging very swiftly there. Otherwise, I’d concur. I’m not concerned at all about the balance of platinum this year. It’s going out three years, as I said, where we have cause for concern.

**A – John Reade:** I would agree with all of what you said. I think the point is that, depending on the strength of the South African rand, I think there are a lot of palladium-rich expansions in South Africa that will be in doubt in the medium term. I would say that pretty much everything that’s going to come on line in 2005-06 is under construction and I suspect will be profitable on a cash basis as long as the rand doesn’t stay ridiculously strong. In the long term, I agree that it’s very difficult to forecast what will happen with the PGM market because of all the intricacies involved. I suspect that the next couple of years will see surpluses and in the long term, certainly I can accept your point.
Q – Participant, Shanghai White Platinum and Silver Exchange: I would like to ask Jessica: to what extent do you expect that silver can take the place of palladium, and what would be the volume for industrial use?

A – Jessica Cross: Are you saying in industrial uses?

Q – Participant, Shanghai White Platinum and Silver Exchange: Yes, industrial uses for silver.

A – Jessica Cross: I believe that if the alloys that I was talking about earlier today actually are used successfully, the encroachment into palladium could be quite substantial. If there are high performance sectors which retain the palladium in MLCCs, then the market will maintain its palladium profile. But it’s very difficult at this stage to put any tonnage on it, because we’re still seeing these alloys being tested. It remains to be seen whether they have endurance over a wide range of temperatures. This is the issue. As I said, 100% silver does not give the performance that a palladium/silver alloy does. Obviously, as you go further along the spectrum, the purer the alloy in terms of palladium, the better the performance.

A – John Reade: Yes, absolutely. Just to clarify, although it might have an implication for the palladium price, you wouldn’t think that any of these developments in electronics would have a material impact on the silver price – not the substitution from palladium to silver in MLCCs.

A – Jessica Cross: No, exactly. I wouldn’t expect a price impact at all. It’s really a tonnage. And really, the impact for palladium, where MLCCs and electronic usage were once extremely important, has now been eroded away.

Q – Serge Gambs: If you will allow, I would like to raise a question to one of our speakers. I would like to ask Itabashi-san how he sees the future of five-nines gold in the bonding wire industry as far as volumes are concerned?

A – Ichimitsu Itabashi, Tanaka Kikinzoku Kogyo: I’m sorry but I’m just an engineer. I cannot grasp the tale of the wire bonding market.

Q – Serge Gambs: We understand. The reason I raised the question was because you were presenting some figures showing quite an important upturn in the consumption of gold bonding wires. As a matter of fact, maybe without giving indications of tonnage or things, do you think this progression is going to continue or have you seen recently the demand being more moderate?

A – Jessica Cross: If I can offer my experience in talking to refiners, there certainly seems to be more interest in generating five-nines. That’s one area of value added that they’re certainly looking at. Obviously they wouldn’t be doing it if there weren’t the demand on the electronics side.