Gold & Technology in 2019 & Beyond

LBMA A&R Conference
London, 2019

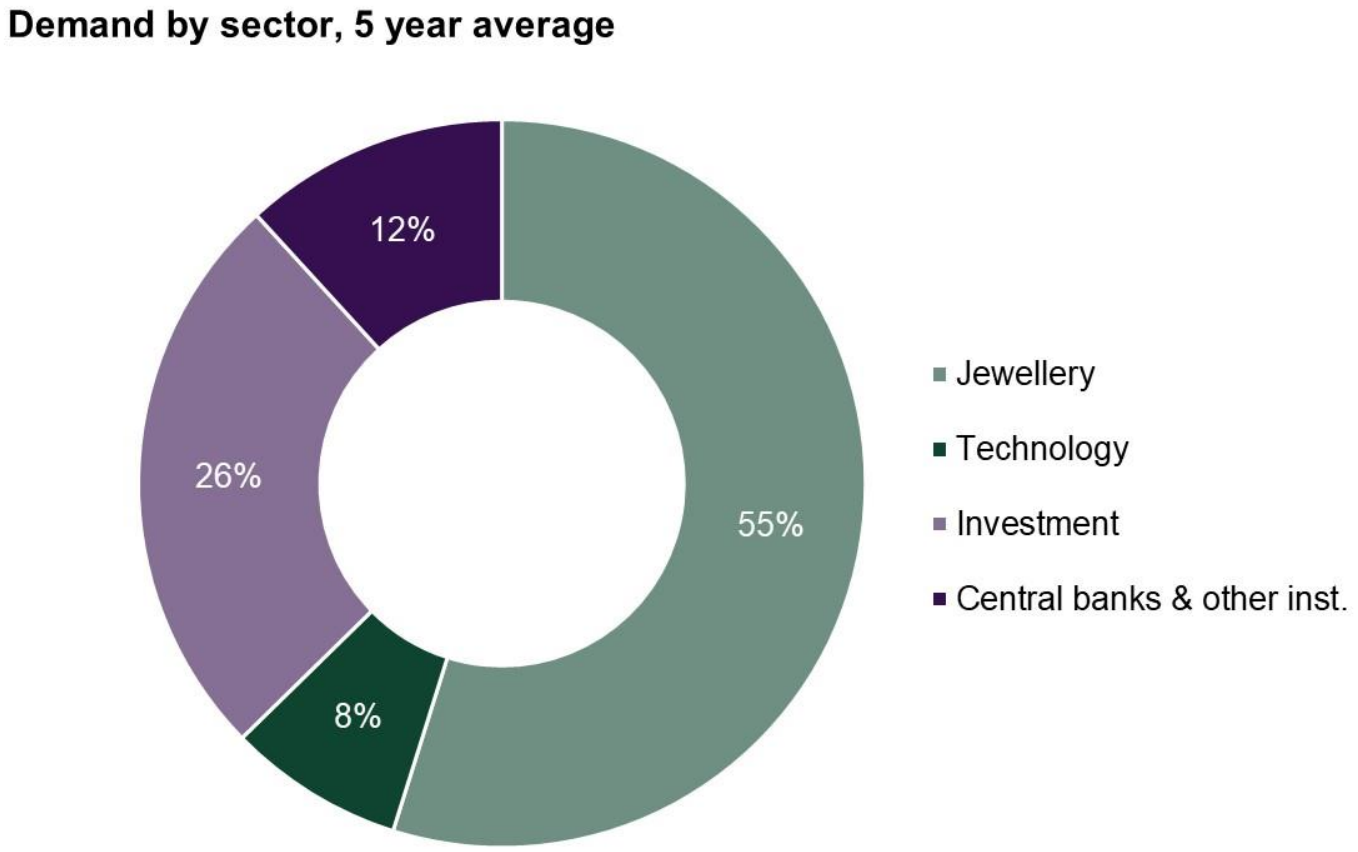
Dr Trevor Keel

Director, Material Value Ltd
Consultant to the World Gold Council

Material Value

WORLD GOLD COUNCIL

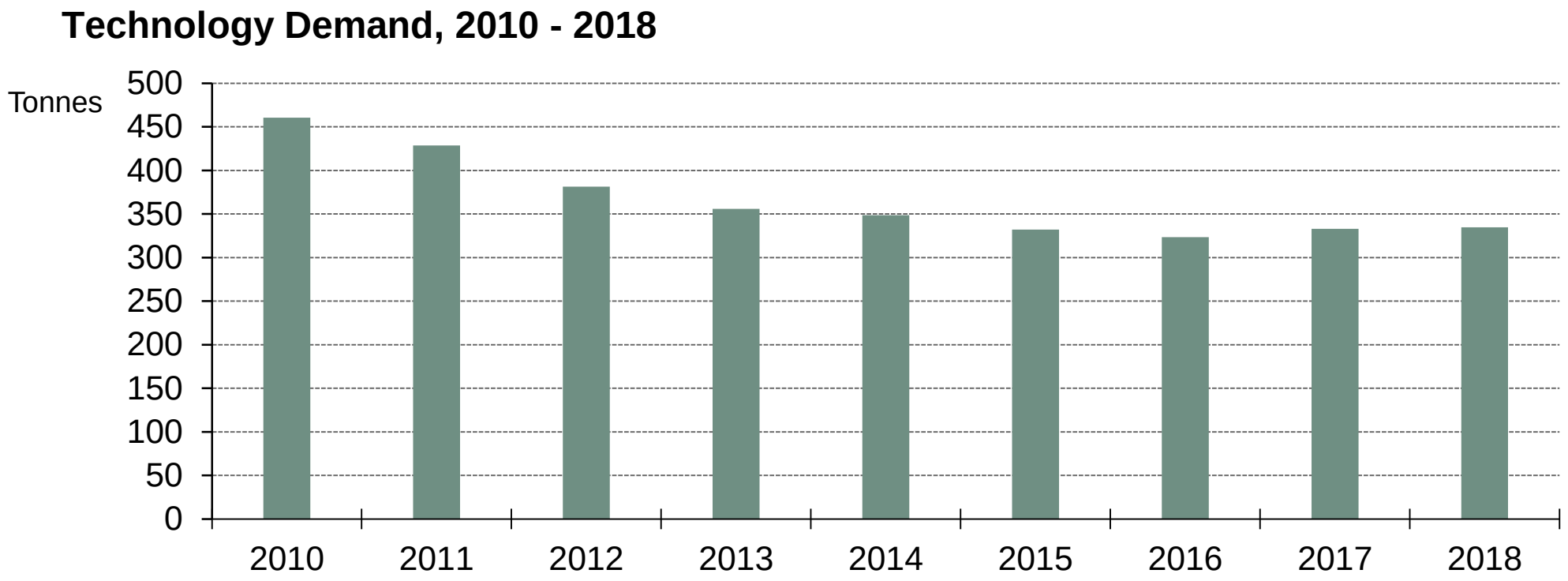
Where does gold go (demand)?



Source: Metals Focus; GFMS, Thomson Reuters; World Gold Council

Material Value

Gold is an important industrial metal

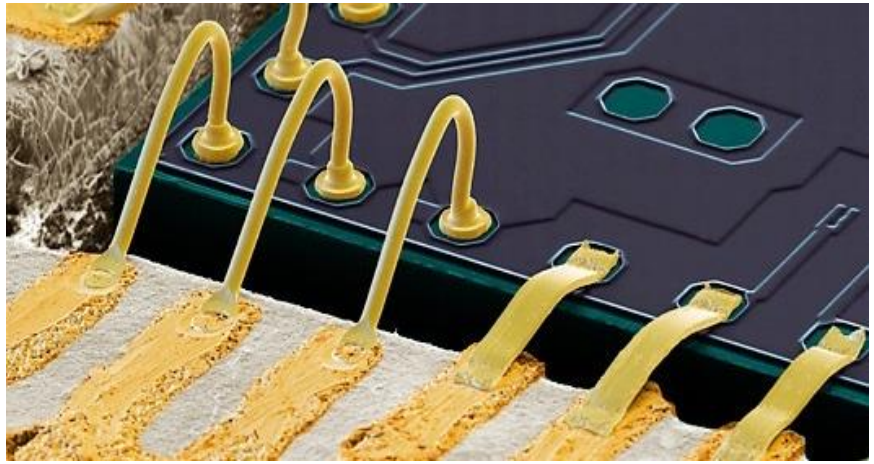


Source: Metals Focus; GFMS, Thomson Reuters; World Gold Council

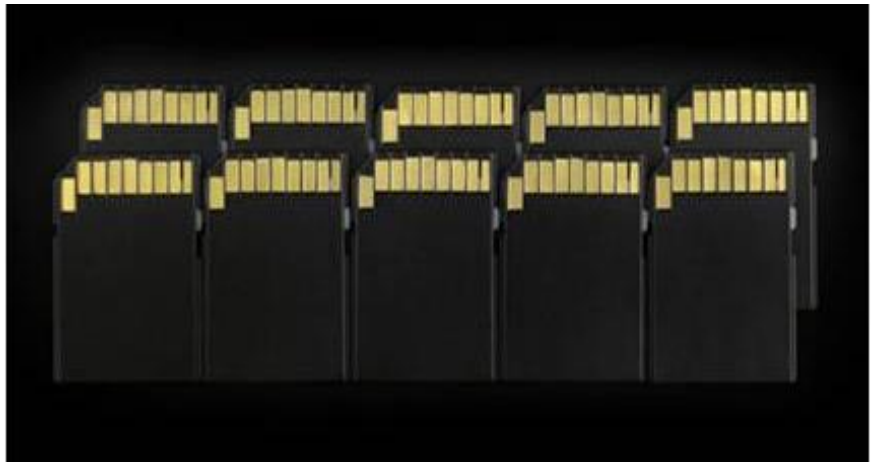
Material Value

Gold & Electronics

- Often the material of choice for contact and connector finishes and bonding wire in chip packaging
- Highly conductive, malleable, corrosion resistant
- Particularly important where reliability requirements are high (automotive, data storage)



Gold bonding wire

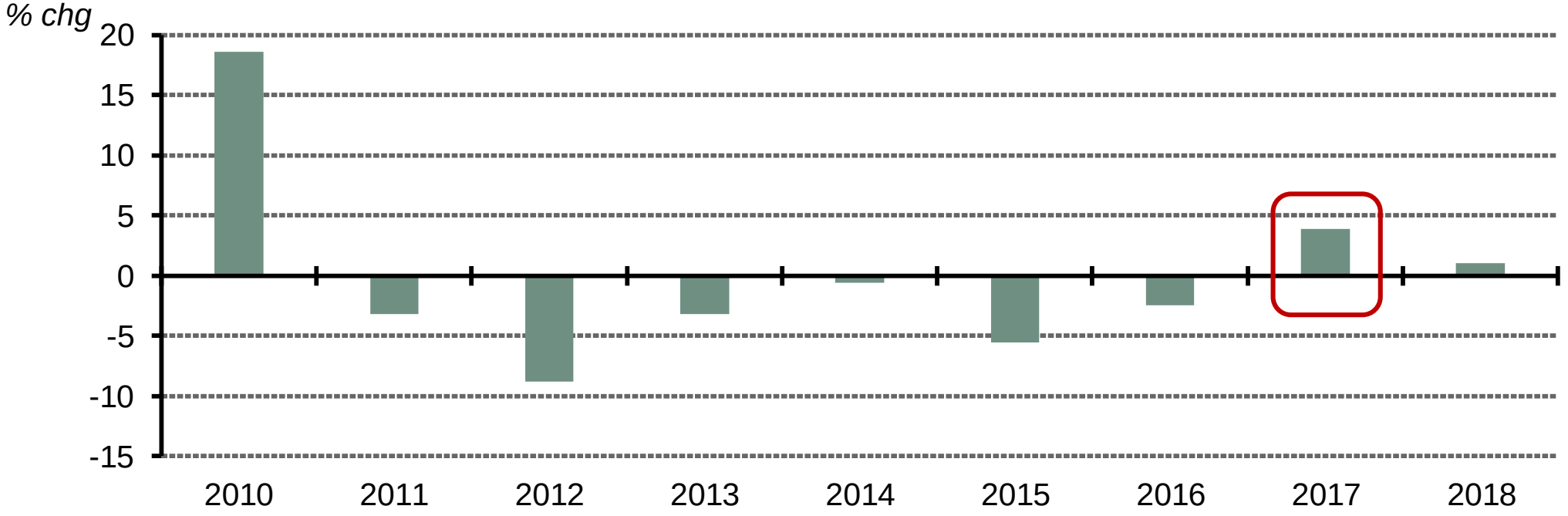


Gold plating

Material Value

Gold & Electronics

2017 saw the first rise in year-on-year electronics demand since 2010



Sources: Metals Focus, Refinitiv GFMS, World Gold Council

Material Value

“Electrification” continues unabated

- Global semiconductor sales saw an all-time high of $469bn in 2018, with a strong long term outlook
- All sectors saw significant growth, with memory demand driving the sector to record highs
- New functionality within consumer electronics drives more complex semiconductors

Material Value

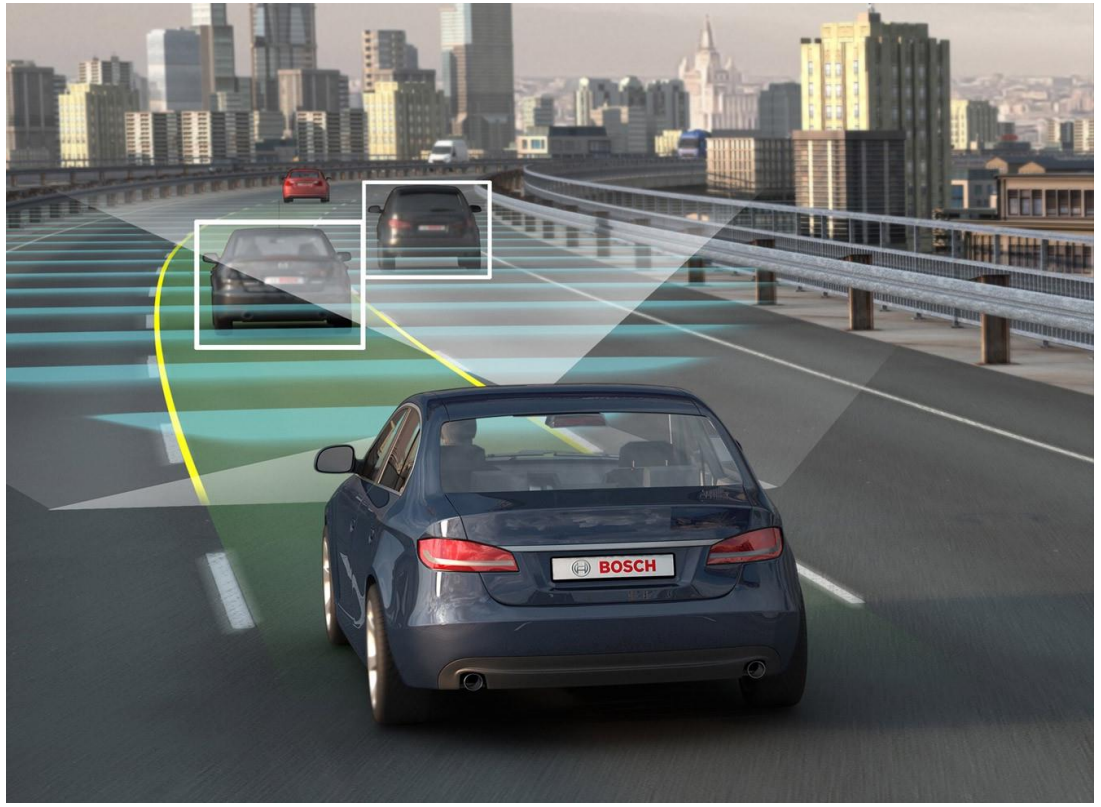
“Electrification” continues unabated

- HEVs and Evs will bring considerable opportunities for the metals industry broadly
- Demand for ADAS, infotainment, powertrain management, safety systems and lighting
- Growth in semiconductor demand:
  - Conventional vehicle - $330
  - HEV - $900
  - EV - $1000+

Material Value

“Electrification” continues unabated

- The development of autonomous vehicles will provide further opportunities
- Considerable electronic infrastructure will be required, both in and ex-vehicle
- Potentially highly disruptive in the coming decades providing key technical and societal issues are addressed



Material Value

Nanotechnology

Gold	• Inert, corrosion resistant, golden • Ideal for electronics, durable coatings, decoration
Nanogold	• Active catalyst, colourful, novel optical properties • Chemical reactions, medicine, clean energy, advanced electronics

Material Value

Catalysis

Catalysis

- Catalysts are true examples of the circular economy in science
- They help to improve the efficiency of a chemical reaction without changing themselves, and can then be recovered and re-used with minimal losses
- Many people are unaware that gold is an excellent catalyst material, and is probably one of the most widely studied catalyst systems in chemical science
- There is a number of gold-based catalysts on the market, with many others in development

Material Value

A new dawn for VCM synthesis – sustainable manufacturing

- Vinyl Chloride Monomer (VCM) is the precursor for Poly Vinyl Chloride (PVC), the world's 3rd most widely produced polymer
- Some routes to VCM require the use of a mercury-based catalyst
- This is a highly polluting and dangerous material, and represents over 20% of the world's demand for mercury on a yearly basis
- JM has now developed and launched an alternative – PRICAT-MFC, a gold-based material designed to eliminate the use of mercury in this process

Material Value

A new dawn for VCM synthesis – sustainable manufacturing

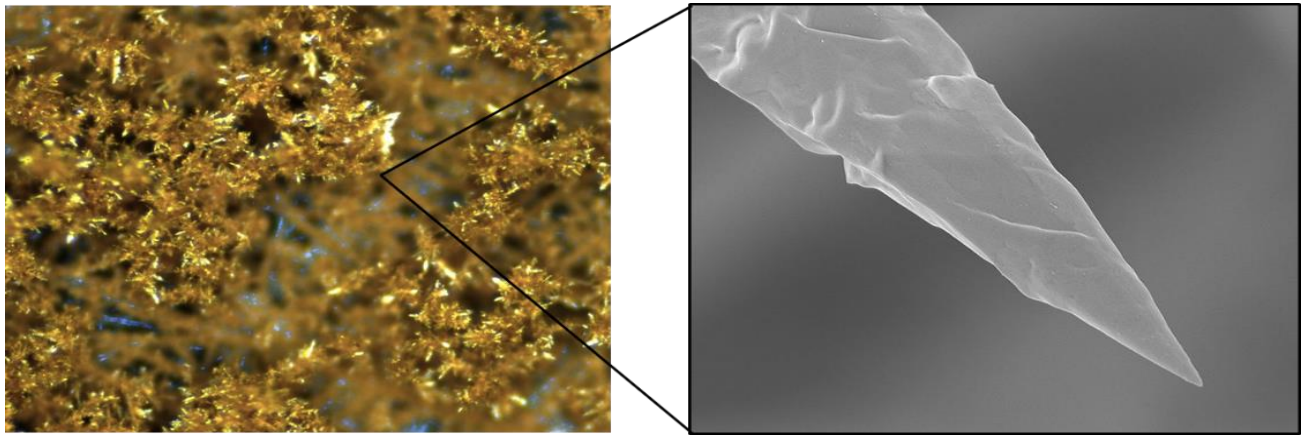
- Manufacturing facility commissioned in Shanghai and opened in 2015
- Evaluation trials underway in full size VCM reactors
- Similar life-cycle cost to mercury catalyst

- **<u>Gold loss is low, and only small part of total life cycle cost</u>**

Material Value

CO_2 Utilisation

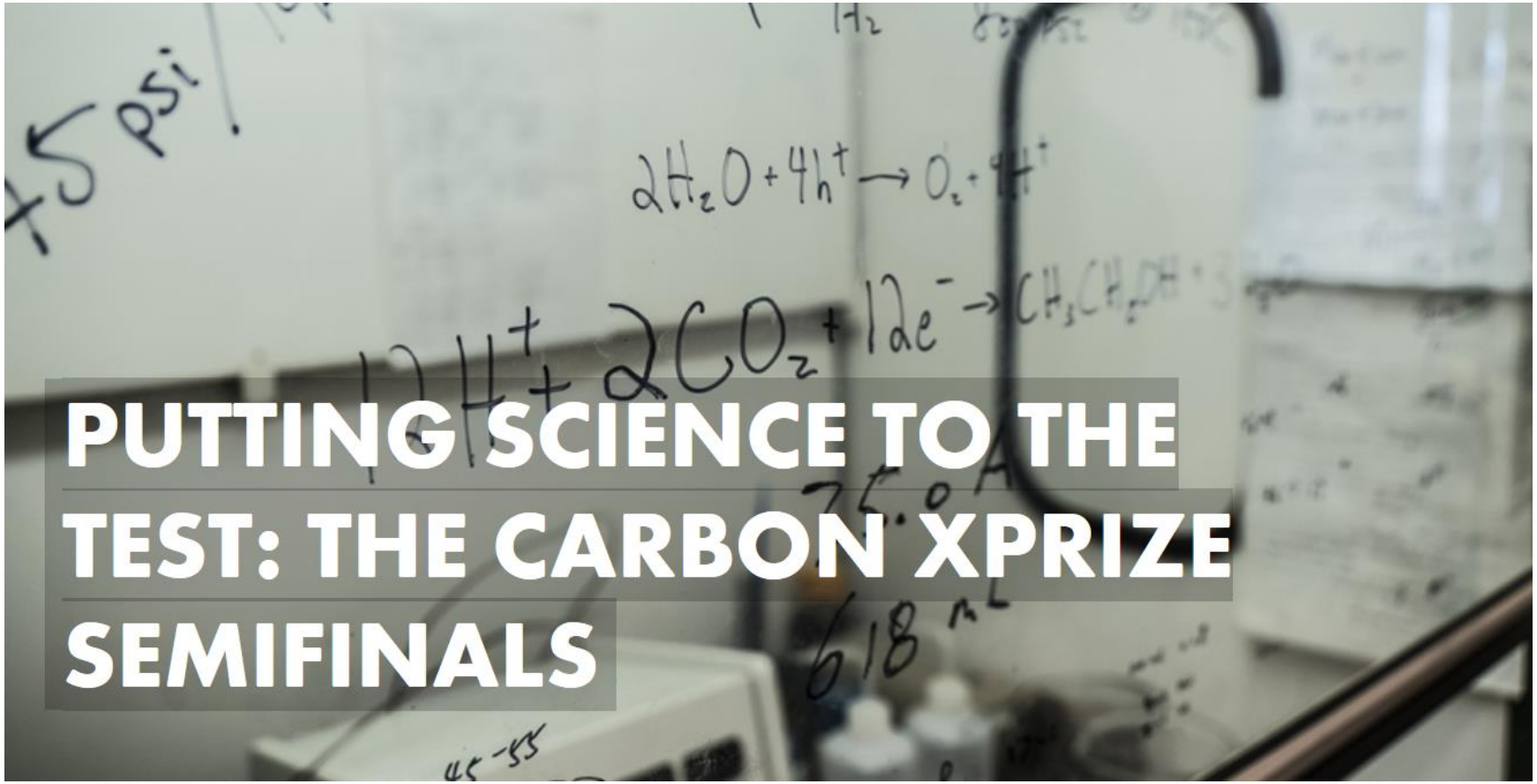
- Recent years have seen intense research on developing new metal-based catalysts that can selectively and efficiently convert CO_2 into fuels with steady operation for hundreds of hours
- Gold is the most active and selective catalyst identified to date for the electrochemical conversion of CO_2 to fuels



Material Value

Nature, *2016*, 537 (7620), 382–386

Metals at the heart of the Carbon XPRIZE

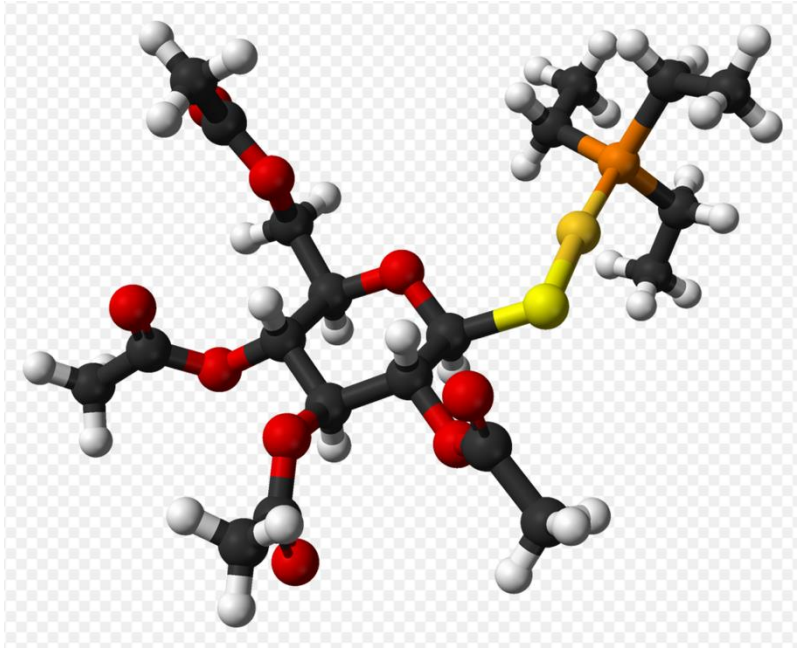


Material Value


Healthcare

Therapeutics

- Auranofin; gold-based drug developed in the 1980s by SKF to treat RA



Gold Nanoparticles Act as Tumor-seeking Missiles

NEWS Nov 09, 2018 | Original story from The University of Texas

Gold 'could be used in cancer treatment'

7 August 2017 Share

Health

Cheap amoebic dysentery drug 'promising'

By James Gallagher
Health and science reporter, BBC News

Material Value

Malaria diagnostics – making every nanoparticle of gold count

- Rapid Diagnostic Tests (RDTs)
  - Readily available
  - Relatively cheap (~$0.50 each)
  - Reliable yes/no diagnosis in 20 minutes
  - No infrastructure or specialist personnel required
  - Over 300 million tests manufactured in 2017, all containing gold
- Gold's most important industrial application!

Material Value

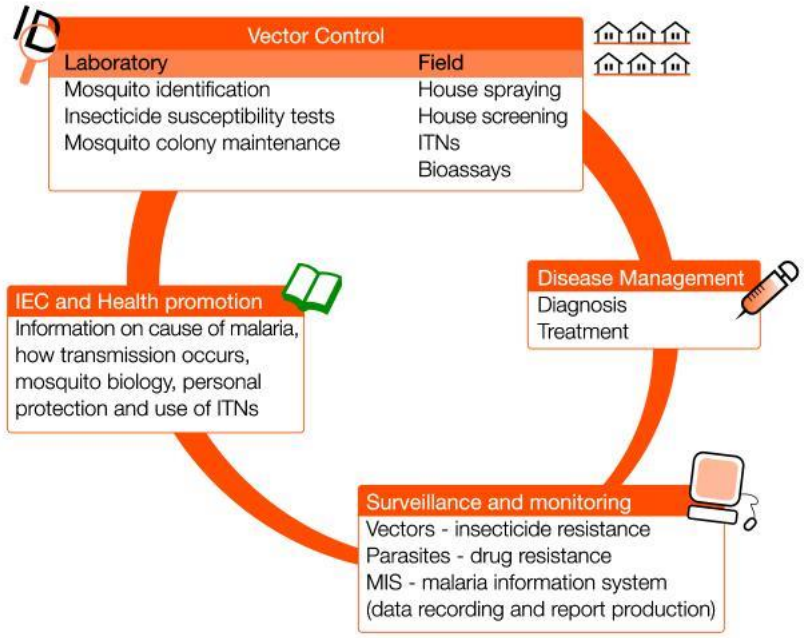
Fighting malaria in Obuasi

Fighting malaria in Obuasi

- In 2005, the Obuasi Mine Hospital (Edwin Cade) recorded on average 6,800 malaria cases each month. Of these, 2,500 were mine employees
- With an average of three days off per patient, an estimated 7,500 man-shifts were lost per month
- This coupled with the slow work rate during recuperation, resulted in a major loss in production
- Cost of medication for malaria treatment was USD 660,000 per annum
- School and work absenteeism was rife

Material Value

Fighting malaria in Obuasi

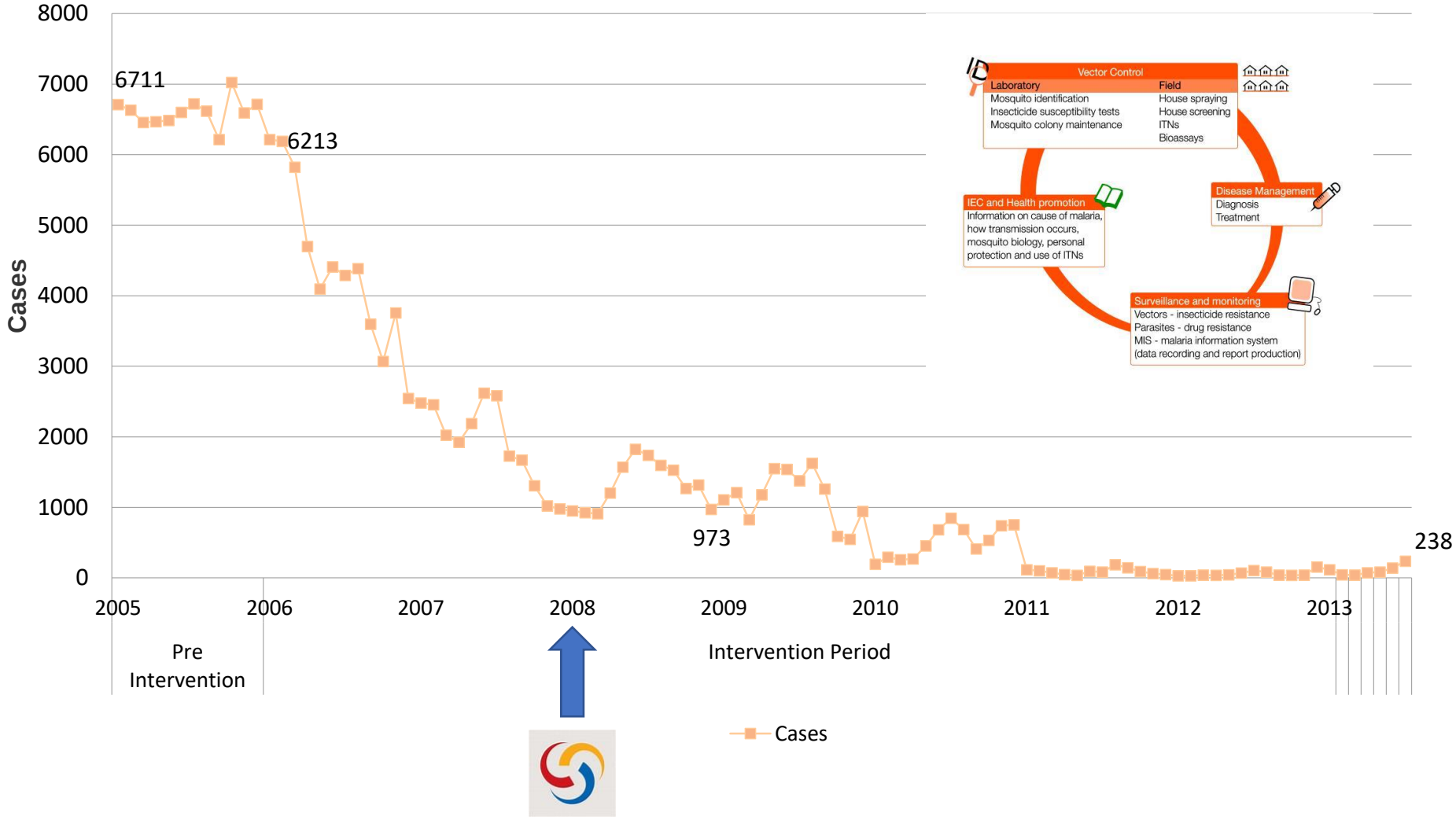


- The decision was taken to implement a complete integrated malaria control programme covering the entire municipality
- Initial Cost: $1.7 million
- Thereafter: $1.5 million per year

- **AIM – To reduce the incidence of malaria by 50% in 2 years**

Material Value

No. of Malaria Cases seen at the Edwin Cade Hospital, Obuasi
(2005-2013)



Material Value

…And beyond

- In 2008, the Global Fund approved a total grant amount of $133million to scale up IRS into 40 districts in Ghana by 2015
- AngloGold Ashanti was selected by the Country Coordinating Mechanism (CCM) as the Principal Recipient of the Grant
- A total of 8 million people will be protected by IRS in the most endemic communities in Ghana

- Over 3800 jobs created nationwide
- Local capacity and strong partnerships built for IRS

Material Value

Global health

Ghana's unlikely marriage of mining and malaria control draws envious glances

Lucy Lamble *in Obuasi*

Mon 4 Jun 2018 07.00 BST

▲ Team leader Bismark Owusu sprays the home of Ama Foaah in Domeabra village with a new form of insecticide designed to control and prevent malaria. Photograph: Cristina Aldehuela/AFP/Getty Images

When a mining firm in Obuasi found malaria was hampering its operations, it joined forces with locals and the government to find a solution. Now others want to emulate their success

Recycling

- Recycled supply was at its peak in 2009 at 42%. 2018 was relatively low, standing at 26%.

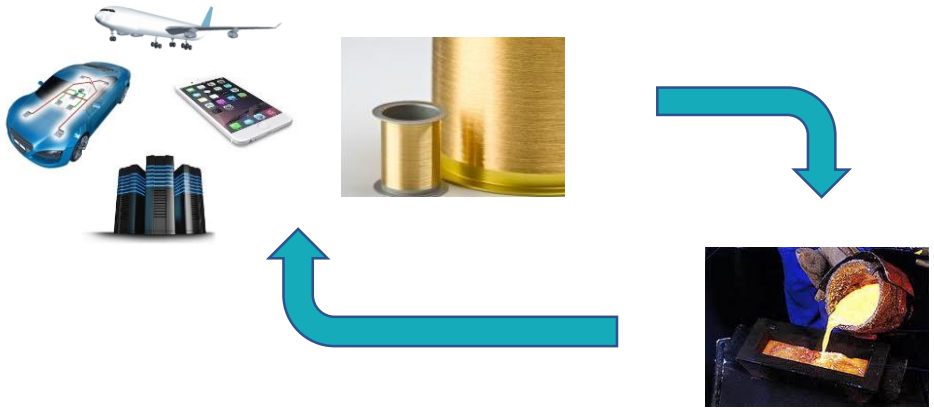
- Many factors contribute to the recycling rate for gold including price and the prevailing economic situation. It is a ‘liquid asset’, ideal for raising cash quickly in times of need. Very responsive compared with mine supply

- Regional / cultural differences – for example Indian consumers far less likely to sell gold jewellery than US / European consumers

Material Value

Recovering gold from end-of-life (EoL) electronics

- In 2010, it was calculated that 1 tonne of scrap circuit boards / cell phones contained between 200-350g of gold.
- Gold, silver and palladium within this scrap represented 93% of it's value.
- However, extracting that material is complex.



Recycling of gold from electronics: Cost-effective use through 'Design for Recycling'

Christian Hagelüken[1] and Christopher W Corti[2]

www.goldbulletin.org

Material Value

Recovering gold from end-of-life (EoL) electronics

- The most valuable materials are ‘hidden’ alongside up to 60 other elements in addition to numerous complex and potentially dangerous chemicals.

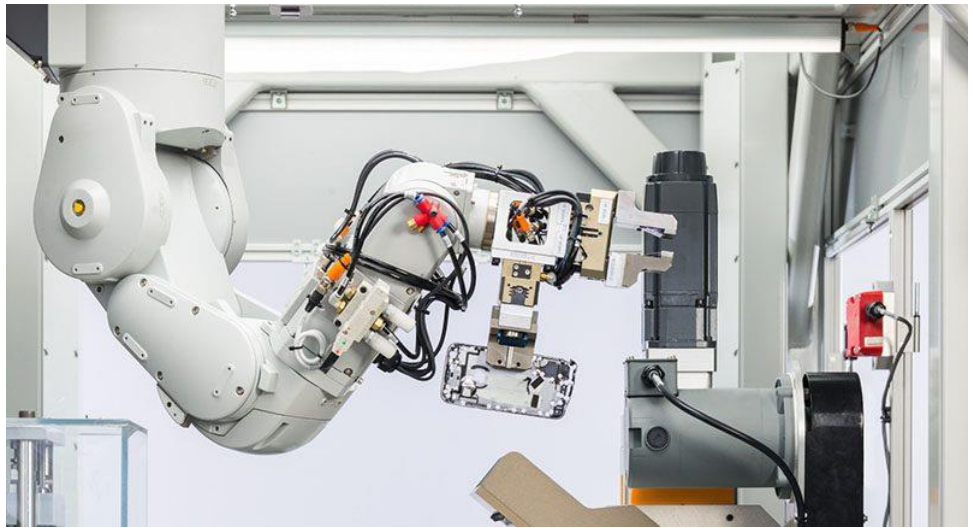
- State of the art recycling plants, primarily in Europe, have designed processes which are so efficient they recover practically 100% of the valuable materials
  - Dedicated recycling chains (collection, dismantling and final processing are all key)

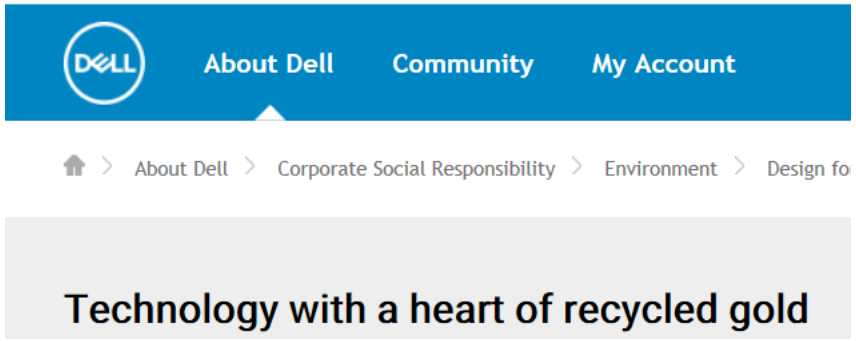
- However, vast quantities of end of life electronics are exported to countries ill-equipped to recycle effectively.
  - Environmental and health impacts
  - Often extremely low processing yields

Material Value

What needs to improve?

- Up levels of collection of EoL consumer goods
  - Numbers game – more handsets containing less precious materials per unit. Collection critical
- Regulated “Design for Recycling”
  - Challenging with regard to high value materials
- Consumer incentivisation
  - New business models required





Material Value

Sustainable Development Goals

Material Value

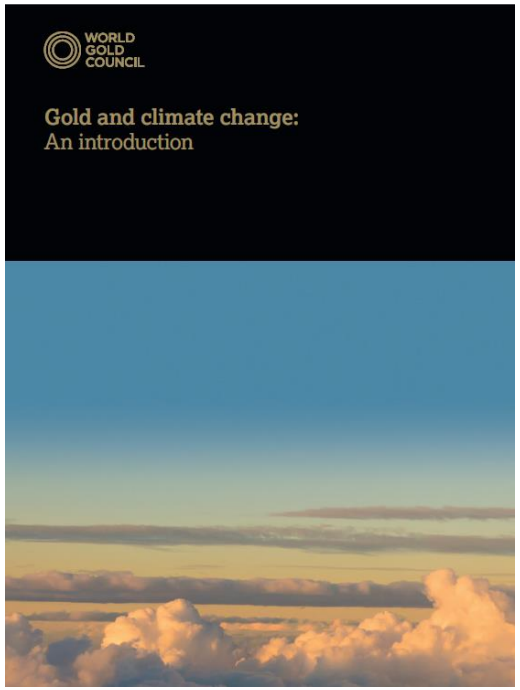
Summary

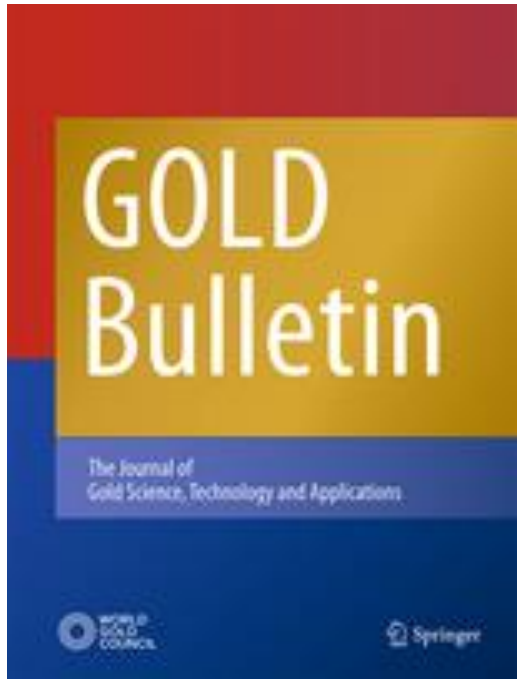
- Gold is a critically important industrial metal with a wide range of applications
- Ongoing electrification will continue to drive demand, particularly in safety-critical applications
- Nanotechnology is opening up new opportunities, particularly with regards to clean technologies and healthcare

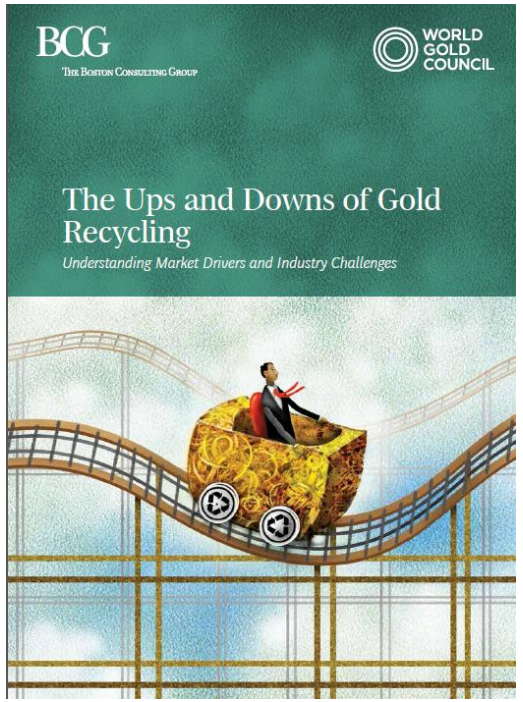
- More broadly, technological developments will continue to be driven from a healthy mix of solid R&D and serendipity. However, metals will **always** be at the heart of new technologies

Material Value

More information and plugs….







Material Value