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Mintek - situated in Johannesburg, South Africa
Mintek operates in the latter stages of the Mining Value Chain

Exploration → Mining → Concentration

Hydrometallurgy & Biotechnology

Pyrometallurgy

Refining → Value Addition

Council for Geo-Sciences (CGS)

Council for Scientific and Industrial Research (CSIR)

MINTEK
A little bit of history…

1934-1939 : The first period – wide variety of investigations
  • Processing of apatite, refractory gold

1939-1945 : The war years – substitutes for materials in short supply
  • Analysis of alloys, preparation of sodium tungstate, de-tinning solutions, processing of strategic minerals, phosphates, ceramics and mercury

1946-1958 : The third period – uranium extraction period
  • Manhattan Project

Early uranium processing test facility 1951, 1952
A little bit of history…

1959-1961: The fourth period – transition
• Interest from AEB – importance of Mintek work on uranium

1961-1976: The fifth period – AEB association
• Association with AEB – importance of Mintek work on uranium

1980-1995: The golden years – paradigm shifting technologies
• Carbon-in-Pulp (CIP)/Carbon-in-Leach (CIL)
• Solvent Extraction (SX) reagents such as Nicksyn™ as well as processes and equipment
• Ion Exchange (IX) materials, Resin-in-Pulp (RIP) and the multistage continuous IX contactor – NIMCIX
• Minataur™ SX based gold refinery
• Leaching - pressure, heap and bio-leaching
• Mechanisms of sulphide leaching
• Electrowinning of base metals
• DC Arc smelting
• Electronic sorting

1995+: Building
• Develop an extensive portfolio of products for the metallurgical industry

Mintek is one of the largest and oldest mineral and metal technology institutes in the world (82 years old in 201). It is a state-owned Science Council, governed by an Act of Parliament, with a board appointed by the Minister of Mineral Resources. It focuses on all aspects of minerals processing and beneficiation, with the exception of iron- and steel making and coal processing. It has a permanent staff of about 750, including 250 engineers and scientists. It undertakes R&D and furnishes commercial testwork and consultancy services to clients worldwide. It has an annual budget of about €50 million: 50% funding from state sources, focused on research, and 50% commercial income, derived from various services to industry (About 800 commercial projects last year).
Mineral industry R&D in South Africa is well funded and active

The minerals industry contributes 10% directly and ~20% indirectly to South African GDP, and research consequently receives significant state support.

**Strategic research drivers**
- Water and energy efficiency
- Downstream value-add beneficiation
- Extension of resource base
- Cleaner mining and processing
- Ultra-deep level mining
- Recycling and “urban mining”

**Research activity**

**Science Councils**
- Council for GeoScience (Exploration)
- Council for Scientific and Industrial Research (Mining research and metal technology)
- Mintek (Mineral processing and metal technology)

**Universities**

**Private sector**
Mintek’s core business

In terms of the Mineral Technology Act no.30 of 1989, Mintek’s mandate is:

1. R&D and Technology Transfer
   - Research & develop efficient mineral processing technologies & value added products & services
   - Improve technical processes and methods to improve mineral production

2. Industry Support
   - Foster the establishment and expansion of industries in the field of minerals and products derived thereof
   - Promote the mineral based economies of rural & marginalised communities

3. Human capital development
   - Promote the mineral based economies of rural & marginalised communities
   - Develop human capital & organizational skills to build world class R&D excellence
1968-2018 Annual Income

- STATE GRANT
- TOTAL INCOME
- OTHER REVENUE
International projects account for half Mintek’s revenue

- Africa, incl SA: 49%
- North America: 21%
- South America: 9%
- Europe: 12%
- Asia: 8%
- Australia: 4%
Mintek’s funding model

- Mintek’s mandate is, effectively, to **develop** and **transfer** to industry technology which will maximise the value of SA’s mineral exploitation

- Technology is **developed** by undertaking research funded by SA government, the local and international private sector and foreign research grants

- Technology is **transferred** to industry by providing test and consulting services, and by sale or licensing of products or technology (Mintek’s “commercial” activities)

- The revenue derived from commercial activities covers approximately 50% of Mintek’s operating costs, with government grants covering the other 50% - a ratio close to optimum

- Mintek makes a small surplus (<5% on turnover) under this model, which is transferred to reserves to cover periodic expenditure on very large projects and infrastructure development

- Current government annual income at level of ~R150m is adequate, but it’s extremely important to have certainty on future funding levels (over 5 year period) to assist planning and ensuring that skills and facilities are appropriate
Points specifically identified in NDP:

- Improved extraction efficiency to extend ore resources
- Improved energy and water efficiency
- Beneficiation to downstream, value-added products

Mintek’s R&D strategy includes these NDP points, and additionally includes:

- Mining, industrial and consumer waste treatment
- Small-scale and artisanal mining
Mintek and Mining Phakisa Synergy

• 6 specific Phakisa interventions are closely aligned with existing Mintek projects:
  
  1. Effective management of water resources
  2. Acid Mine Drainage (AMD) impact mitigation
  3. Fuel Cells as PGM beneficiation opportunity
  4. Local battery manufacture
  5. Local silicon wafer manufacture
  6. Next Generation Mining skill development

• Need to coordinate these activities to derive maximum synergy

• Drawing/building on existing Mintek achievements in these areas could facilitate certain “Quick Hits”
Opportunity to install Fuel Cell at Mintek

- Concept for 1.3MW fuel at Mintek, operating on Egoli gas, providing base load electricity requirement
- Fuel Cell could be used as industrial plant to test locally-developed components

Mintek coordination of DST HySA Catalysis programme

- Mintek will be hosting the HySA project office
HySA Centres of Competence

- Materials and Components
  - UCT, Mintek

- Components and Systems
  - UWC

- Systems and Infrastructure
  - NWU, CSIR

Value Chain
HySA Catalysis Goals

**HySA Goals**

- 25% global fuel cell and hydrogen catalyst demand by 2020
- Low cost hydrogen generation solutions
- Promote equity and inclusion in the economic benefits of SA’s resources

**HySA Catalysis Goals**

- Deliver commercially viable PEMFC prototypes and products in 50W to 5 kW range
- Develop fuel cell supply chain in South Africa with local manufacturing partners
HySA Catalysis does R&D and product development and forms partnerships

Catalyst
- Developed a full range of Pt and Pt-alloy catalyst
- Partnering to scale-up catalyst production

Membrane Electrode Assembly
- MEA for adv. and conventional stacks
- Fabrication methods and production
- Int’l collab.

Fuel Cell Stack
- Adv. and conventional stacks
- Partnering with HySA centres
- Int’l collab.

FC Systems
- Partnering with HySA centres
- Engage with customers
- Engage local supply chain

Portable/Stationary Power Application
- Partner with HySA centres
- Engage local and int’l end-users
- Joint demonstration projects

HySA/Catalysis + Supply Chain + Partners
• A complete set of Pt/C fuel cell catalysts has been produced
• Performance equiv to commercial benchmark – Johnson Matthey’s HiSPEC™
• Scaling to 1 kg / batch
- Equivalent performance to Johnson Matthey commercially available hydrogen (H₂) and CO-tolerant MEAs
- Excellent reproducibility attained in MEA fabrication, instilling confidence in HySA/Catalysis’ MEA manufacturing ability
- 3-layer Catalyst Coated Membrane (CCM) and 5-layer Catalyst Coated Substrate (CCS) preparation methods established
- Active area design fully customizable – demonstrated successful scale-up from 25 to 100 cm² active area with no detrimental effects on performance.
- Currently scaling to 200 cm² to meet a customer’s technical specifications (project sponsored by TIA)
HySA/Catalysis Fuel Cell Projects

The following are a group of pre-commercial projects that will incorporate HySA/Catalysis catalysts, Membrane Electrode Assemblies (MEAs), and stacks:

**Current**

- **Telecom Backup Power** – Technology Innovation Agency (TIA) funded, HySA/Catalysis, local system Integrator, local manufacturer, local cell phone company & international fuel cell company

**Future Projects (confidential)**

- **Rural Schools Power** – DST funded, 3 x HySA centres collaboration, 2.5kW systems
- **Off-grid Renewable H2 and Power Application** – Limpopo government funded (LEDT), 3x HySA centres collaboration, 2.5 kW systems
- **Traffic Signal Power** – Gauteng government funded (GPDRT), 3 x HySA centres collaboration, 1 kW systems
DST’s Energy Storage (ES) Research, Development and Innovation (RDI) Roadmap

• Mintek is a member of the work group that drafted the roadmap for the DST envisioned Energy Storage Programme (awaiting approvals from DST exec)

• The roadmap focuses on Li-based, Na-based and redox flow battery technology development and commercialisation

• Mintek through its minerals processing expertise is well poised to contribute to pre-cursor and electrode materials production development and battery recycling

• Mintek is also positioned to contribute to flow battery development since the tech is very similar to PEM fuel cells
• It is used as a substrate to grow different types of nanowires.

• Examples are Silicon (Si, ) Indium Phosphide I(nP), Indium Nitride (InN), Gallium Nitride (GaN), etc.

• Most of these nanowires are used in device fabrication.

• When used a substrate, its has a direct effect on crystal growth properties of the nanowires.

• Silicon wafer acts as a growth template in growing catalysed nanowires.
Currently at Mintek Si Nanowires grown on Si Wafer

Si nanowires – Ni catalyst
NW diameter: 20-30 nm

Si nanowires - Au catalyst
Size: 20-25 nm
Fabrication Process - Silicon Wafer

Masks → Processing → Processed Wafer → Chips

Wafers → Processing → Processed Wafer
Miniaturisation of Electronic Systems

• Enabling Technologies:
  – System on Chip (SOC)
  – High Density Interconnection technologies
A national facility that is geographically spread across the country and undertakes research, development and innovation activities towards addressing socio-economic challenges facing the country through nanotechnology.
Rapid Test Kits Development

MinDiagnostics™

Research & Development
- Infectious
  - Malaria
  - HIV
- Veterinary
  - RVFV
  - Bovine TB

Cleanroom- Manufacturing
- Products
  - Rapid tests
- Services
  - Contract manufacturing

- Accurate, low-cost, simple to operate and interpret and rapid
- Target Users: Remote areas where there is lack of infrastructure and resources
Water Treatment: Industry and Community Involvement

- Ikusasa Water (Cape Town) – piloting and production
- MTEF National Project at Mintek – Acid Mine Water (AMD) treatment piloting @Sibanye Gold
- Ground water treatment piloting:
  - Gert Sibanda Municipality (Lochiel Village, Mpumalanga)
  - Ngaka Modiri Municipality (Madibogo Village, North West)
- Universities: NWU, UL, VUT – training and further demonstration
Advanced Metals Initiative

End Users

Product Development

Advanced Alloy Development

Advanced Processing Techniques

Ferrous Metals (Fe (Iron), Mn, Ni, Cr, Si, Os, Au)

Foundry Technology
Energy Materials - Rural Communities

- Wind Energy for South African Rural Communities (WESARC)”
- R&D program in collaboration with Virginia Tech (USA), North West University (NWU)-Mafikeng Campus and University of Limpopo (UL), Wits University enabled by Department of Science and Technology (DST) and Air Force Office of Scientific Research (AFOSR)
  - to develop rare-earth modified high performance alloys for multiple applications such as electric motors for wind turbines.
Rare Earth Element (REE) Processing
e- Waste Processing

- 60 million tons per year e-waste is generated globally; about 15% is recycled
- Idea of potential value - EU has 50% of world share of waste recycling industry …
  - 60,000 companies
  - 500,000 employees
  - €24 billion turnover
  - 1.3 million tons dumped in Africa and Asia
- SA produces 340,000 tons annually - 6.6 kg per person annually (US 30, China 5)
- Mintek is developing and providing the technology to incubate industry business opportunities
E-Waste Processing

**Electrical: 50% of total**

30%
- Washing machines, dryers, air conditioners, vacuum cleaners, coffee machines, toasters, irons etc.

20%
- Refrigerators

**Electronic: 50% of total**

15%
- DVD/VCR players, CD players, radios, Hi-Fi sets etc.

15%
- Computers, telephones, fax, printers etc.

10%
- Televisions

10%
- Monitors

An average mobile phone contains more than 45 elements including:

- Lead (Pb)
- Antimony (Sb)
- Arsenic (As)
- Beryllium (Be)
- Platinum (Pt)
- Palladium (Pd)
- Silver (Ag)
- Gold (Au)
- Copper (Cu)
- Cobalt (Co)
- Li-Ion battery

Valuable

Toxic

Source: Umicore
E-Waste Processing

Shredding of printed circuit boards (PCB)

Smelting of PCB in 200kW DC Furnace

Iron and base metal alloy containing precious metals

Hydrometallurgical refining of alloy for different applications, including jewellery
More recent developments ....

- Nickel bioleach technology for Mondo Minerals in Finland
- DC smelting for SA beach sands and Koniambo FeNi
- METRIX® resin-in-pulp for low grade uranium recovery
- ConRoast® smelting technology for high-Cr platinum
- Cyanoprobe® on-line cyanide monitoring equipment
- Minstral® furnace electrode and FloatStar® flotation control
- Heap leaching design data for a very large Chilean copper project
- Milling/flotation process for UG2 platinum ores
Thank You
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