



2018 AFOSR BIOPHYSICS PROGRAM REVIEW

16 -20 APRIL 2018

Dr Makhapa Makhafola



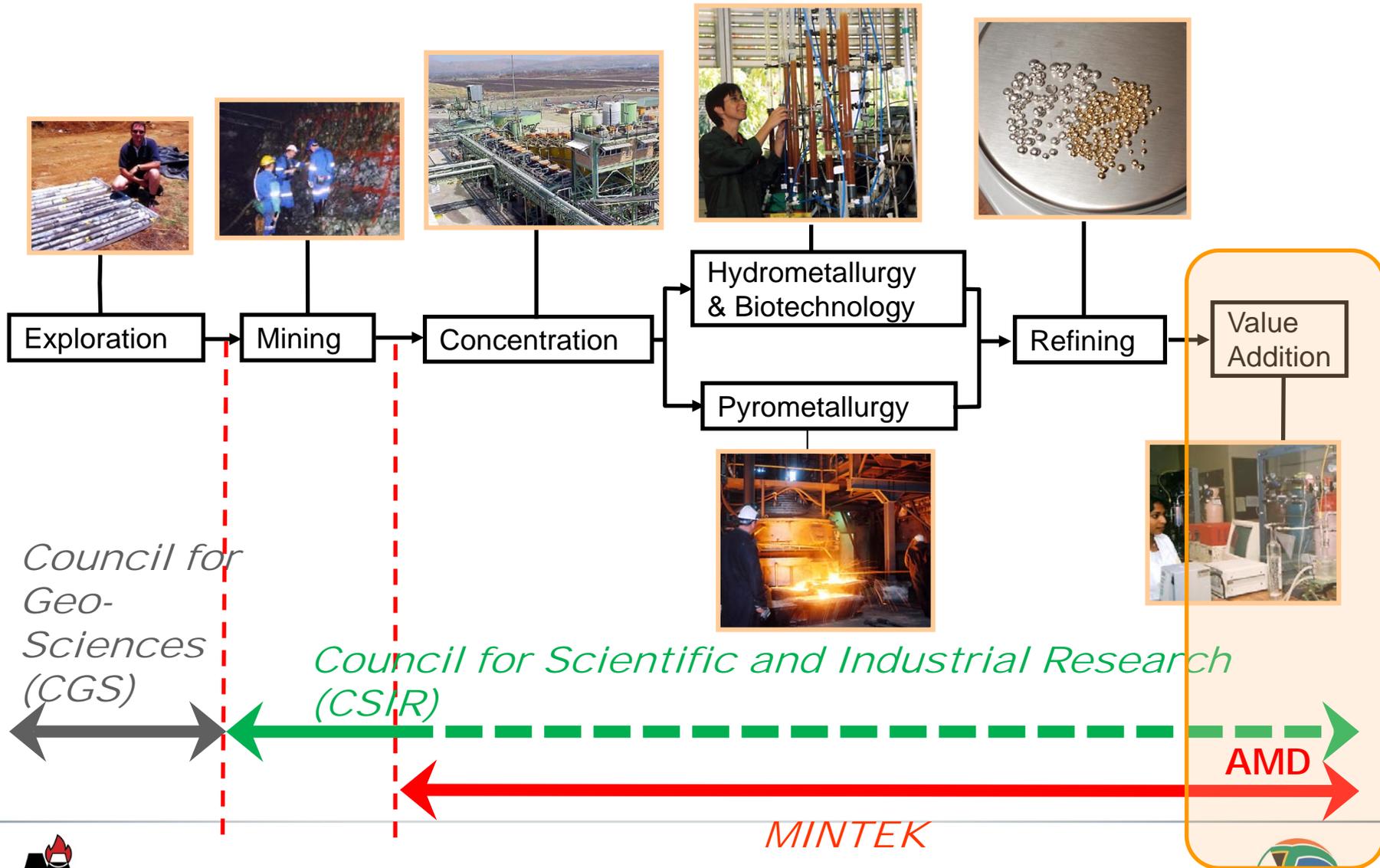
Johannesburg – City of Gold (RSA)



Mintek - situated in Randburg, Johannesburg

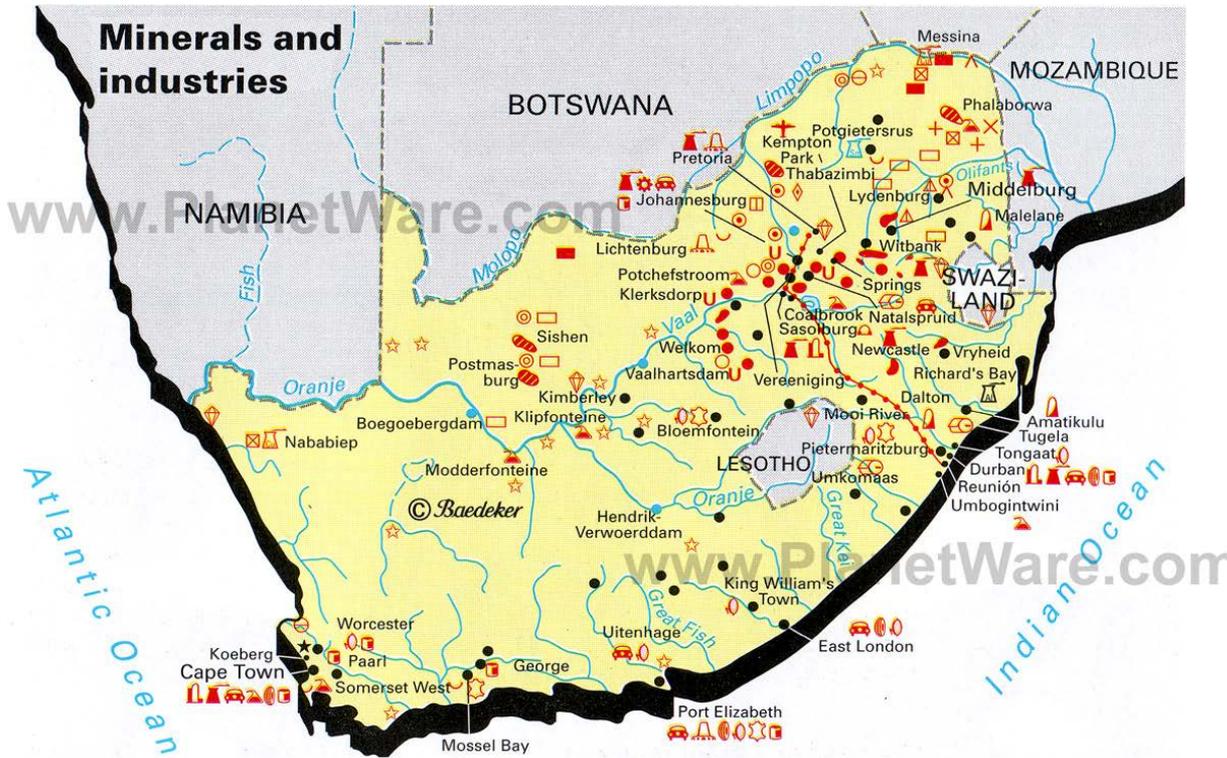


Mintek in the Mineral Value Chain



Mineral Beneficiation

Mineral Beneficiation Approach



- ❖ Value addition
- ❖ Mintek's organisation experienced in mineral processing and beneficiation

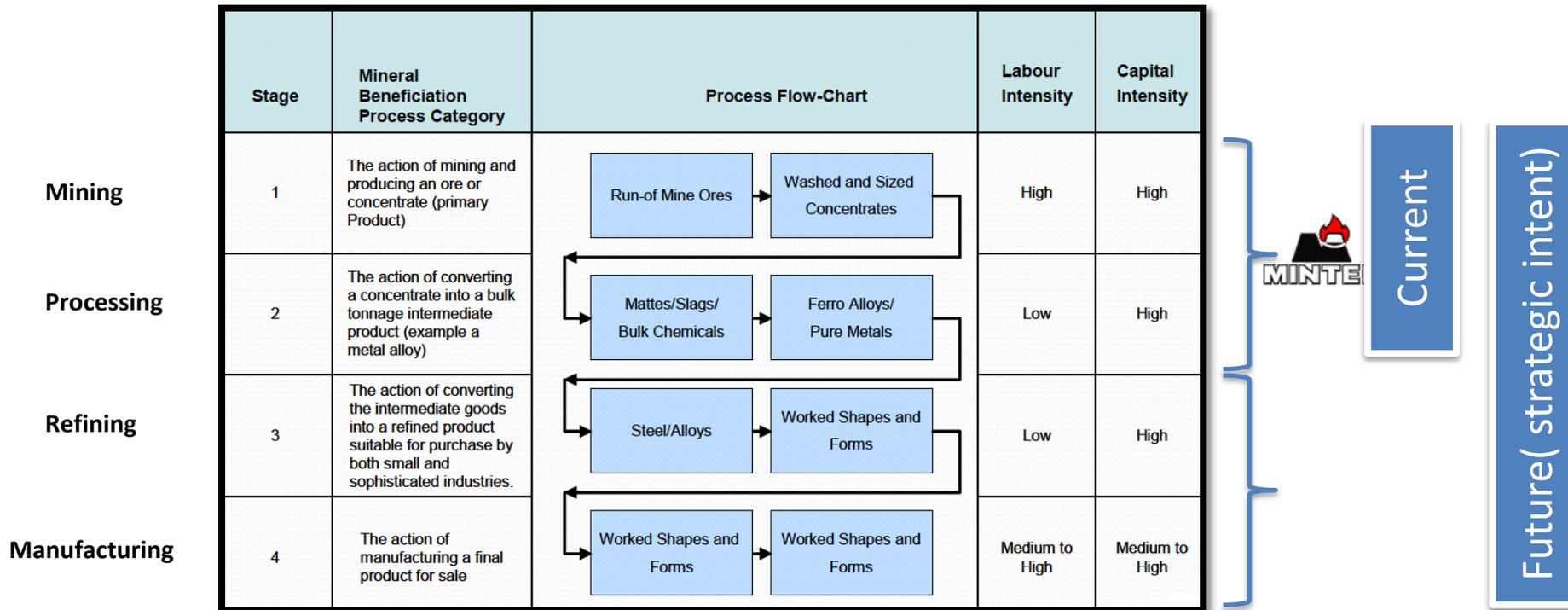
The largest proportion of this gets exported for beneficiation only to import the final products.

In 2011: Total Exports: 7,0 bn USD

Total Imports: 6,5 bn USD

Beneficiation: Scope of Work

Used within the context of economic development to describe the amount of “value” derived from the exploitation of mineral assets which remain in the country and benefits locals including communities (Citi Bank, 2011)



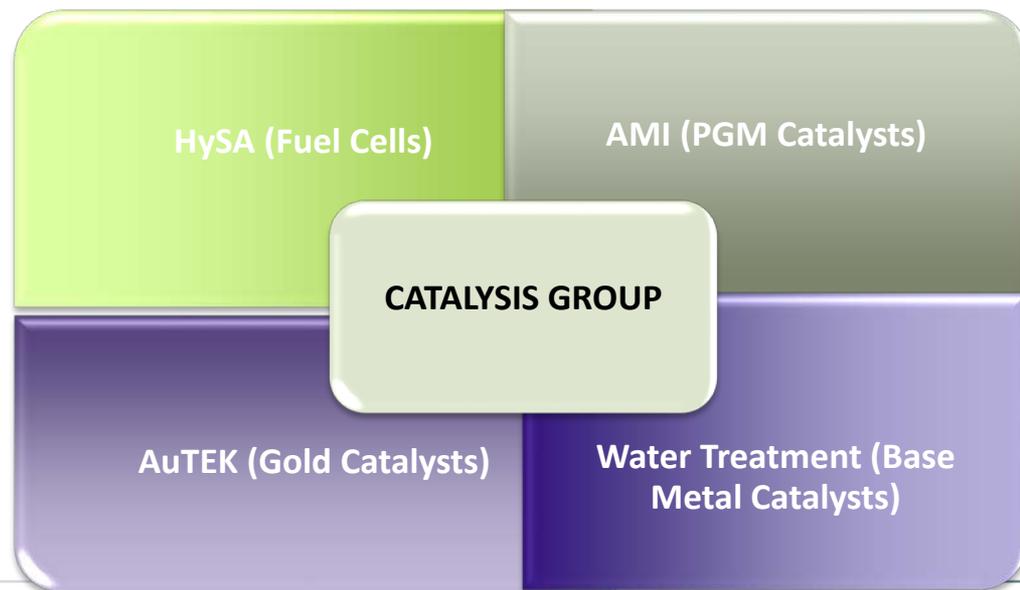
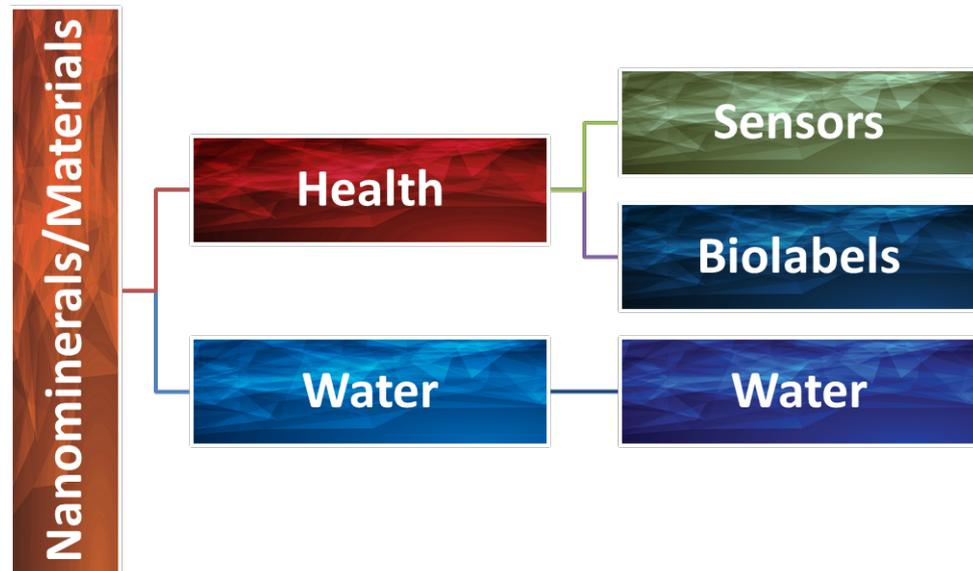
Source: Baartjies, N. “Diversifying a Mineral Based economy”

Advanced Materials Division (AMD) Activities

Physical Metallurgy Group

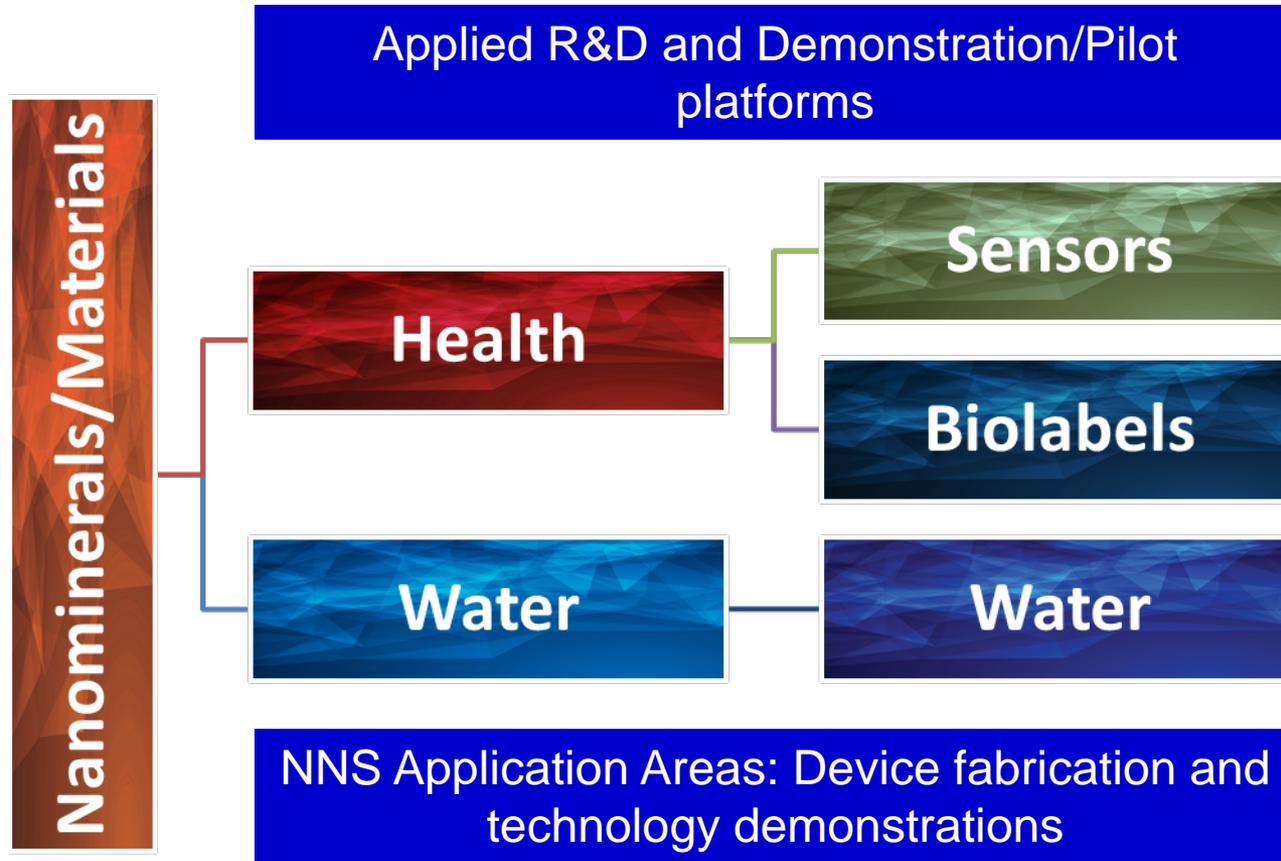
Conducts Materials-related R&D in the areas of Metallurgical Process Development and Improvement, Foundry Technology, Powder Metallurgy, Corrosion and Materials Wear in support of the Mining and Metals-related Industries.

Research and Development



Nanotechnology Innovation Centre (NIC)

Basic Research

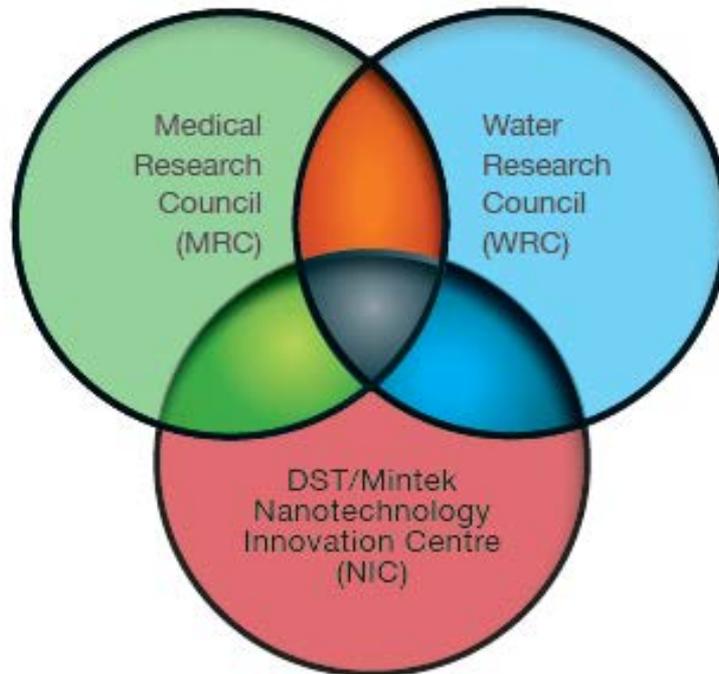


Unlocking new properties and modelling

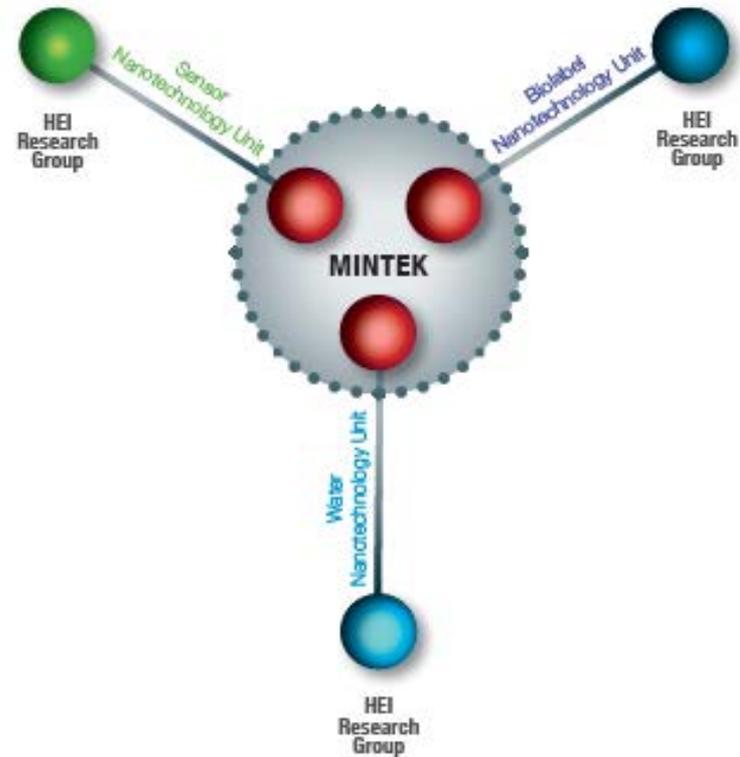
Mintek NIC Governance Structure

MINTEK NANOTECHNOLOGY INNOVATION CENTRE (NIC)

Three Science Councils



Three University Nodes (HEI's)

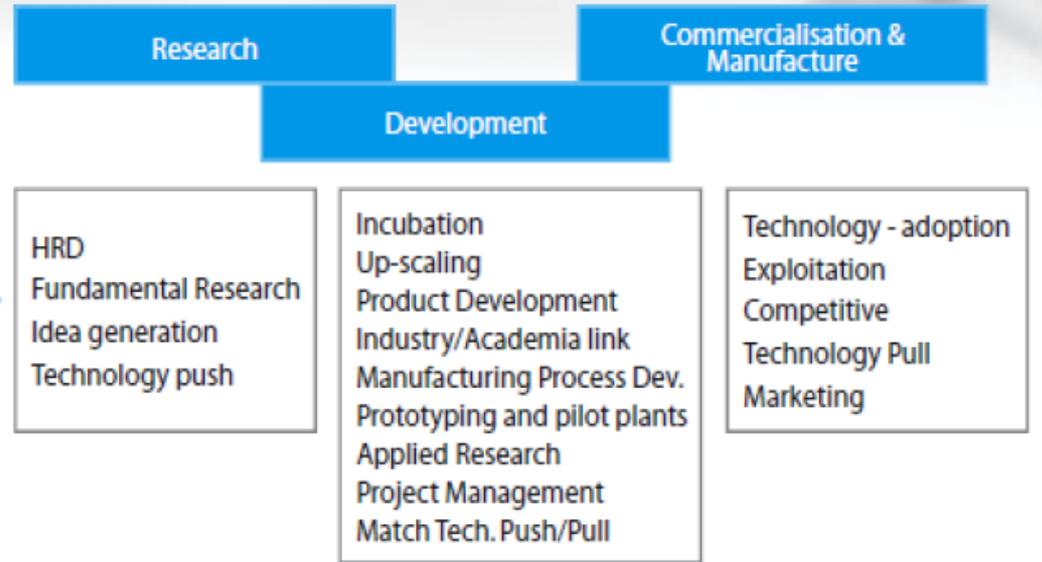
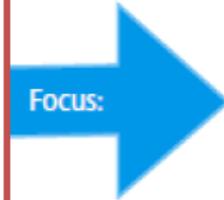


Mintek NIC is Aligned to National Priorities – NNS & NDP

The National Nanotechnology Strategy (NNS) focus areas for South Africa:

- Water
- Energy
- Health
- Chemical and Bio Processing
- Mining and Minerals
- Advanced Materials and Manufacturing.

Focus:



Identified Problem

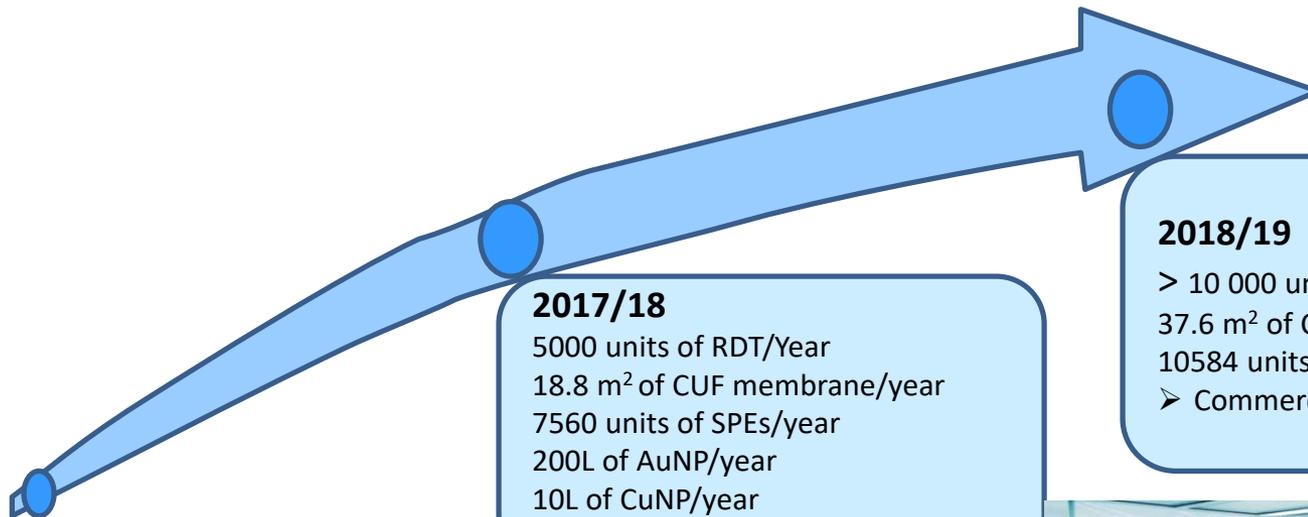
Engaged community

Research

Business plan

Best possible solution

Scale-up of NIC's Products



2016

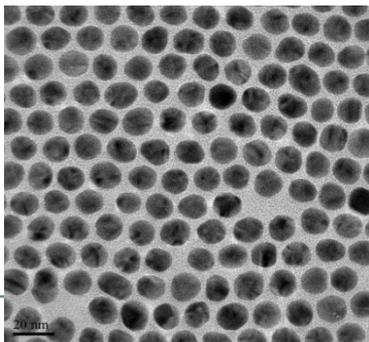
150L of AuNP/Year
5L of CuNP/Year
2000 RDT/Year
3780 units of SPEs/Year
28800 cm² of membrane/yr

2017/18

5000 units of RDT/Year
18.8 m² of CUF membrane/year
7560 units of SPEs/year
200L of AuNP/year
10L of CuNP/year
➤ Pilot line

2018/19

> 10 000 units of RDT/Year
37.6 m² of CUF membrane/year
10584 units of SPEs/year
➤ Commercial manufacturing



Scaling Up of MinDiagnostics® products



Preparation Area



Solution Dispensing

Material Lamination



RDTs for Malaria and HIV



BSL3 Lab- Validation

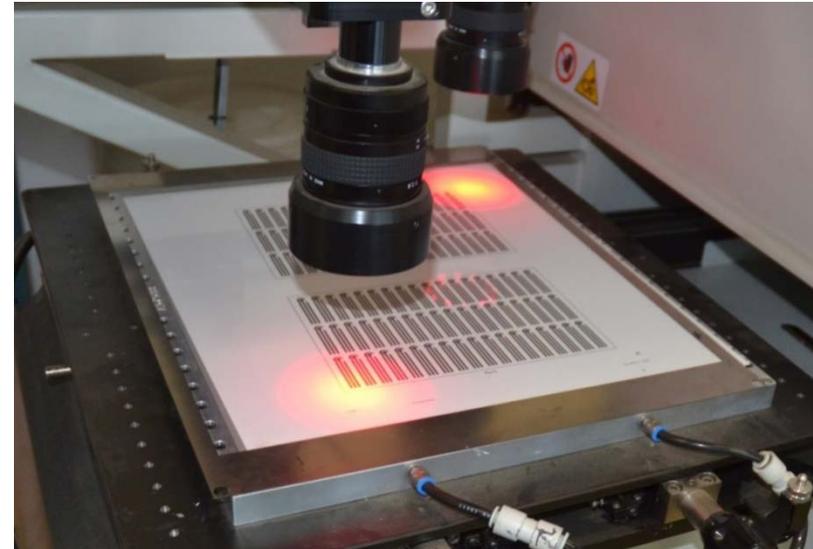


Packaging



Test strip cutting

Scaling Up of NICoSens™ Products



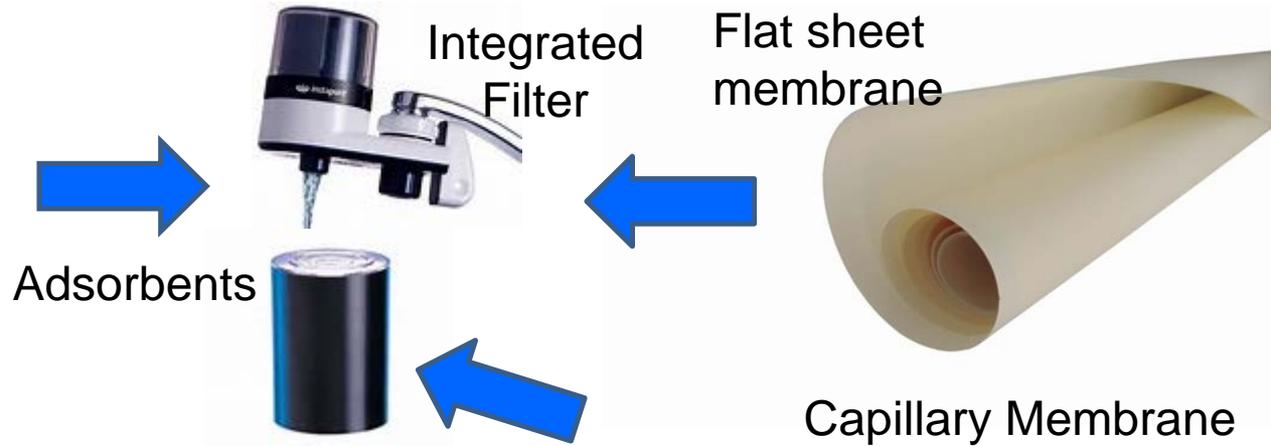
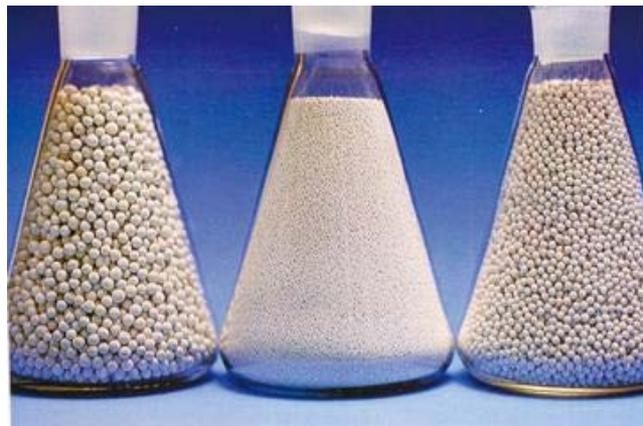
Electrochemical Devices
(Screen Printed Electrodes)



Validation in-house and afield

Glucose Sensor

Scaling Up of NICMembrane™ Products



Module design



Module prototype



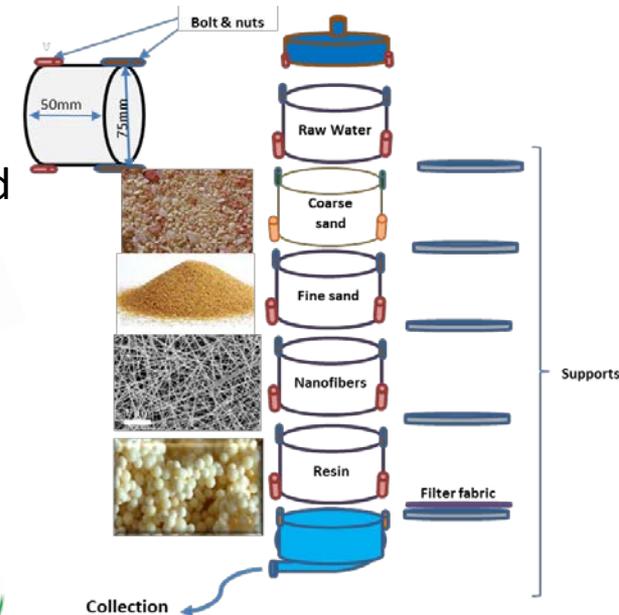
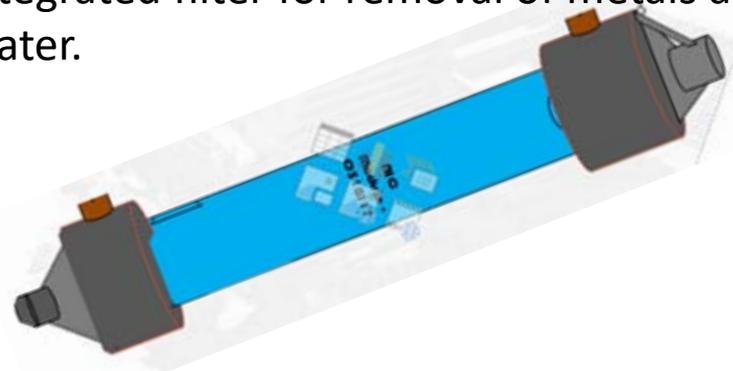
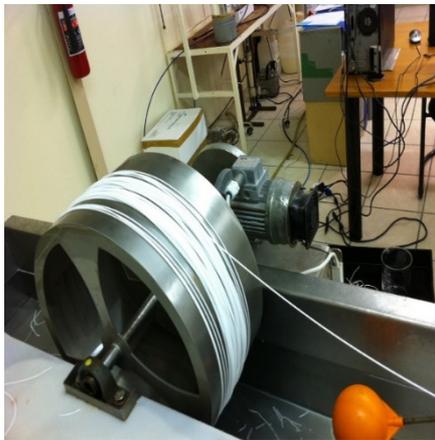
Multiple modules

Scaling Up of NICMembrane™

Towards Commercialisation: Water Purification Membrane Scaled-up Production

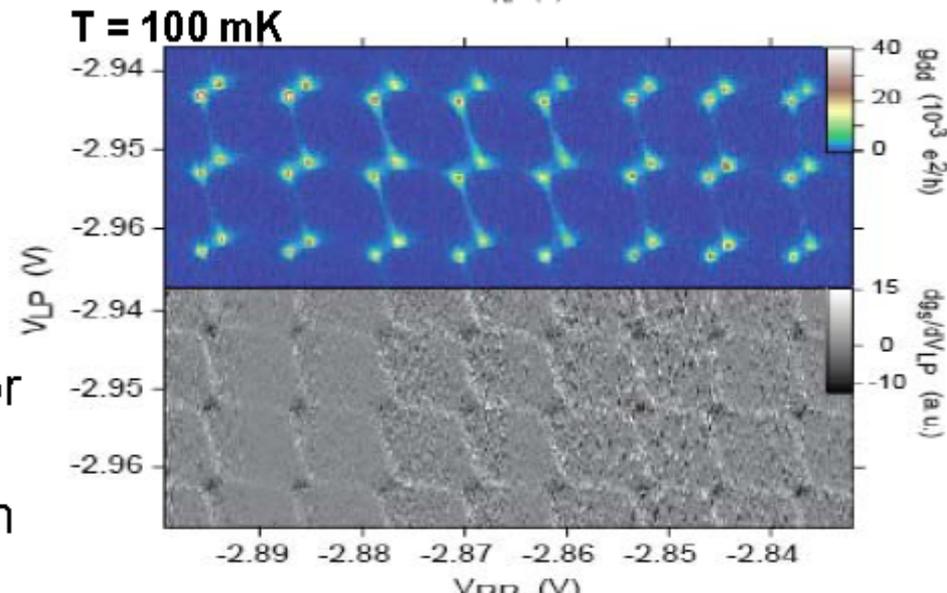
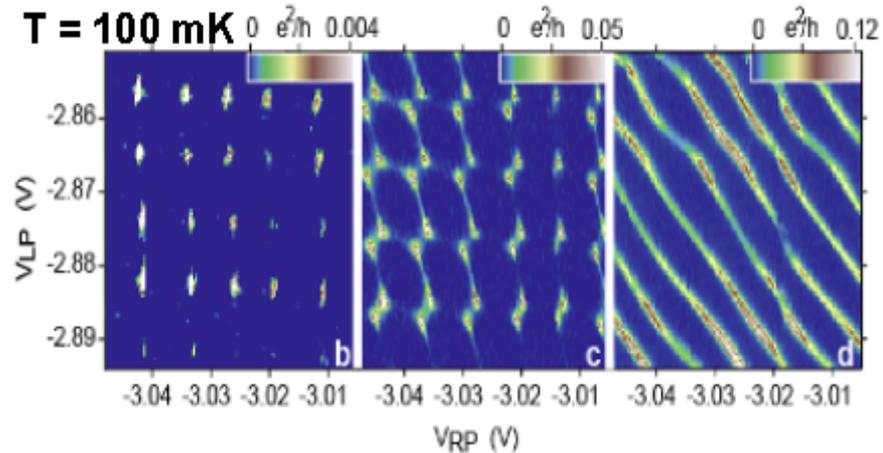
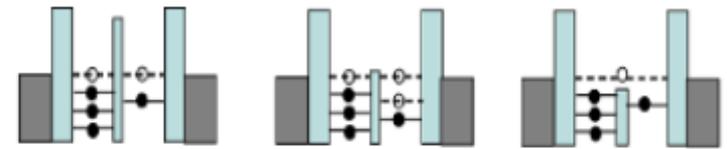
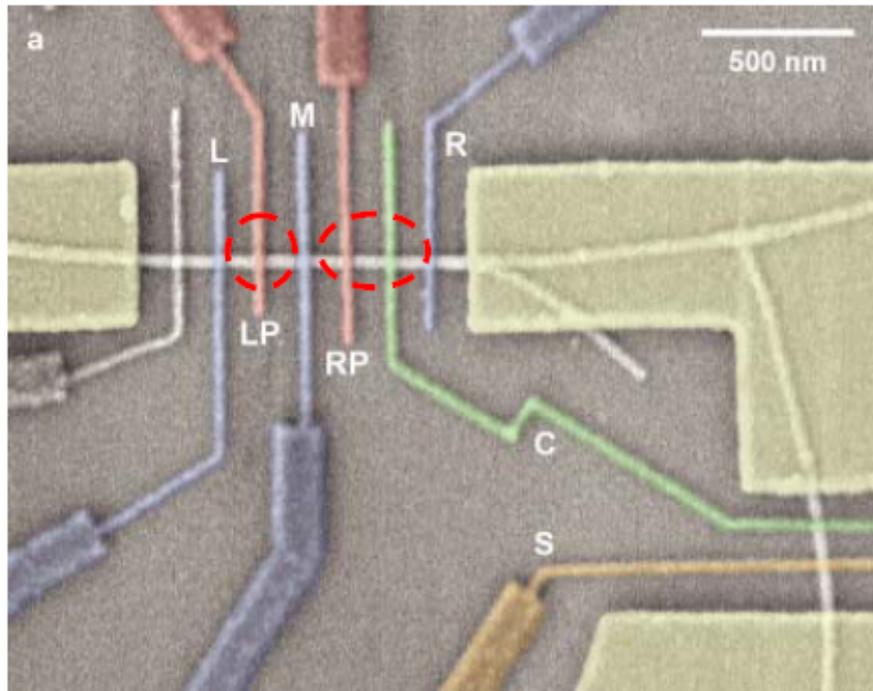
Membrane scaled-up production will commence

- In partnership with the Vaal University of Technology (VUT) Science Park.
- This will allow for customization of a particular membrane module according to the type of water targeted for purification.
- Optimization of the 4m² module.
- Development of an integrated filter for removal of metals and bacteria in drinking water.



Integrated Filter Development

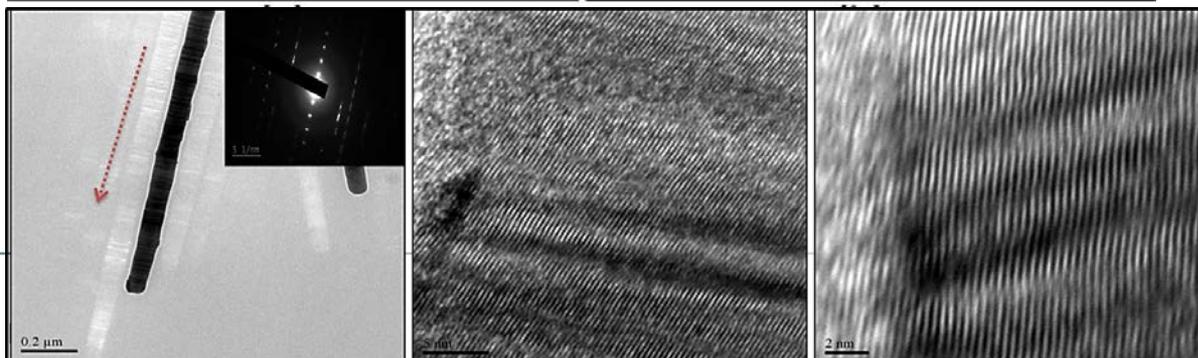
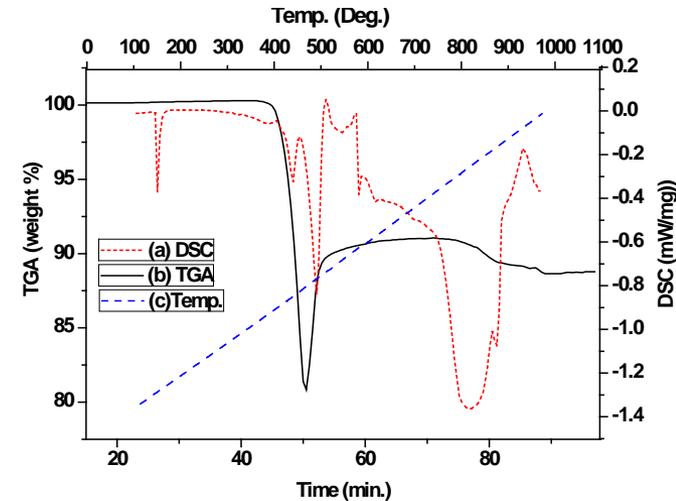
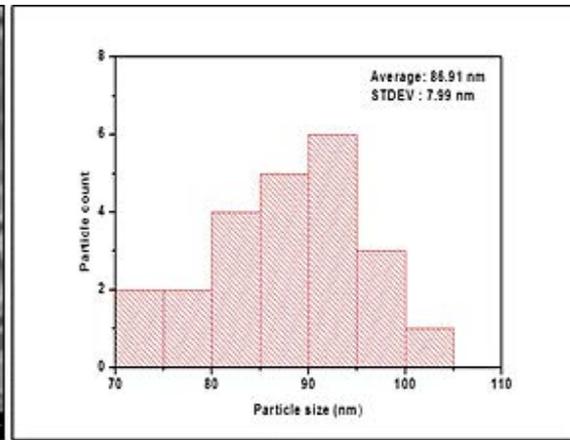
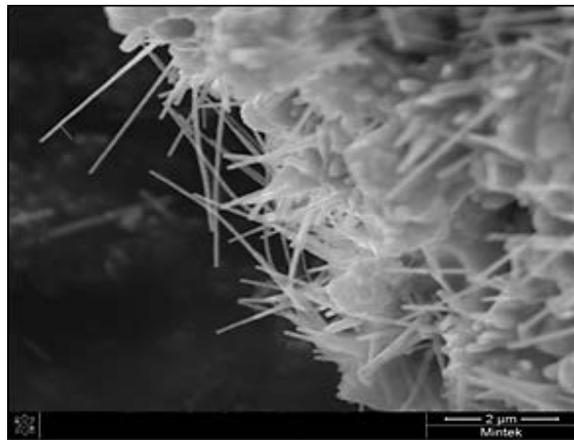
Single Nanowire Device Fabrication



- Fully control of interdot coupling and barrier height by local top gates
- Plunger gates control charge number
- Double dot capacitively coupled to sensor dot on adjacent nanowire
- Charge sensing critical for single-electron double dots and spin control

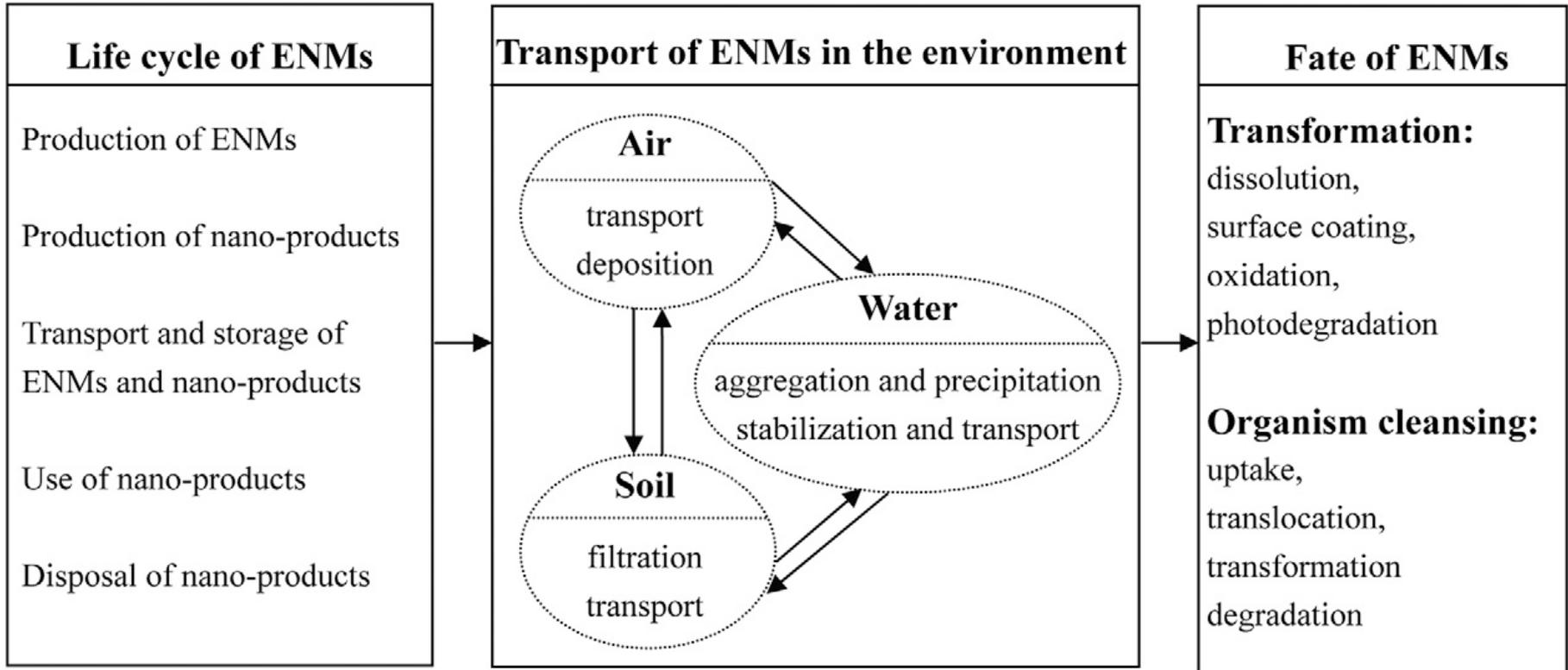
Interfaces, Theory and Modelling

- Understanding of the weak intermolecular interactions at interfaces which do not involve strong chemical bonding
- Interfaces control the growth and structure of materials (e.g., where a structure is grown off a substrate), and control electronic structure and electronic properties in many 'functional devices



Responsible Production of Nanomaterials

Environmental and toxicological evaluation important – basis for nano-enabled devices or technologies



Potential discharge of ENMs in their life cycle and their environmental transport and fate (Lin et al. 2010)

Mintek & UCT: HySA-Catalysis Centres of Competence (CoCs)

Membrane Electrode Assembly (MEA) Development & Scale-up

- Ability to fabricate 3-, 5- and 7- layer MEAs for incorporation into commercial stacks
- Complete flexibility of shape and size of active area and gasket achieved
- Commercial MEA production undertaken by HyPlat
 - already sold >1000 MEAs to industrial customers – accelerate in FY18/19
- Focus going forward:
 - Scale up catalyst production batch size from 1kg to 10kg
 - Produce MEA's for direct methanol fuel cells
 - Fuel cell demonstration projects & sites



HySA/Catalysis (UCT) concept designs for 15 and 30 kW stacks utilizing HySA MEAs

Square Design: 50cm²



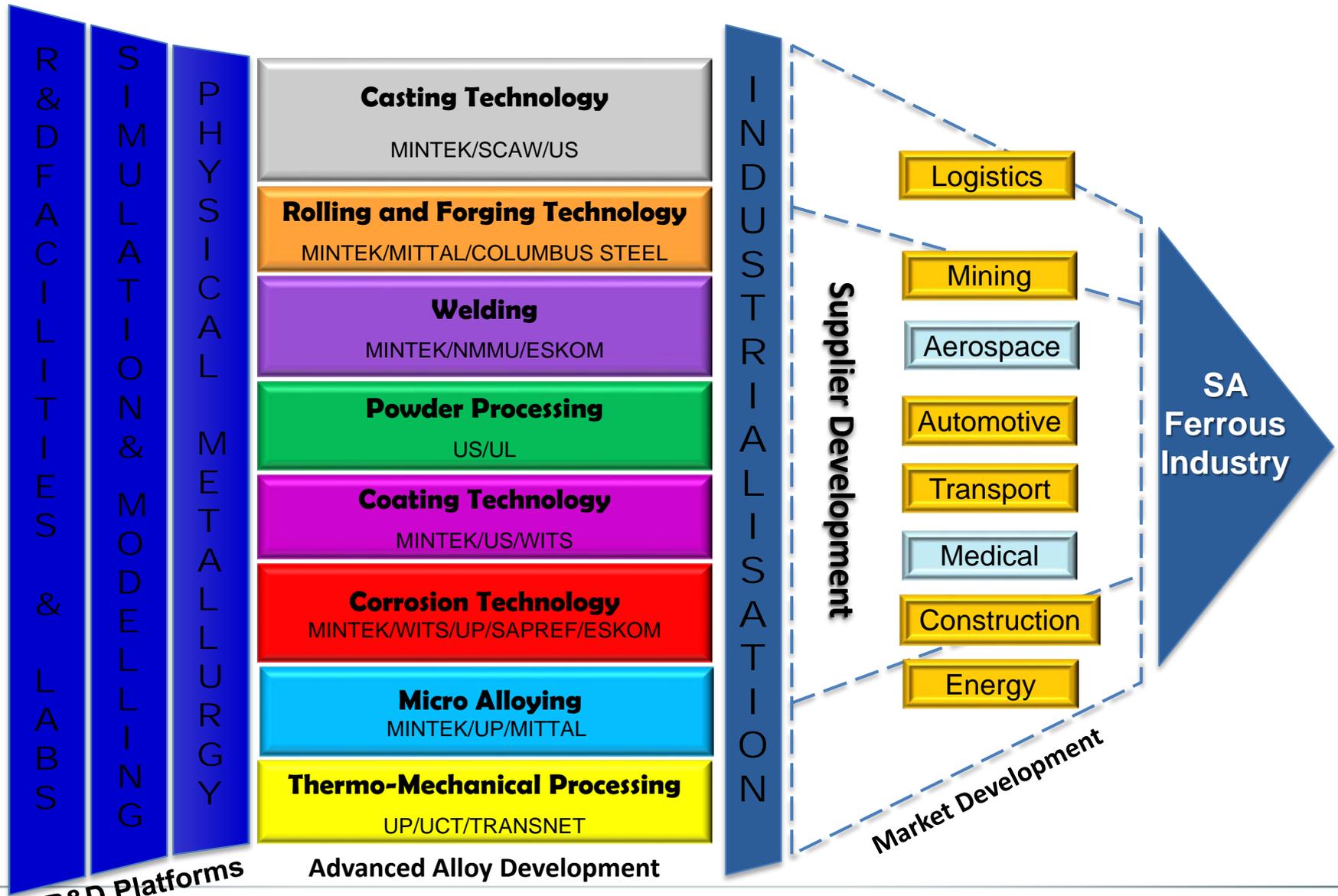
Rectangular Design 205 cm²



Fully gasketed 200 cm²

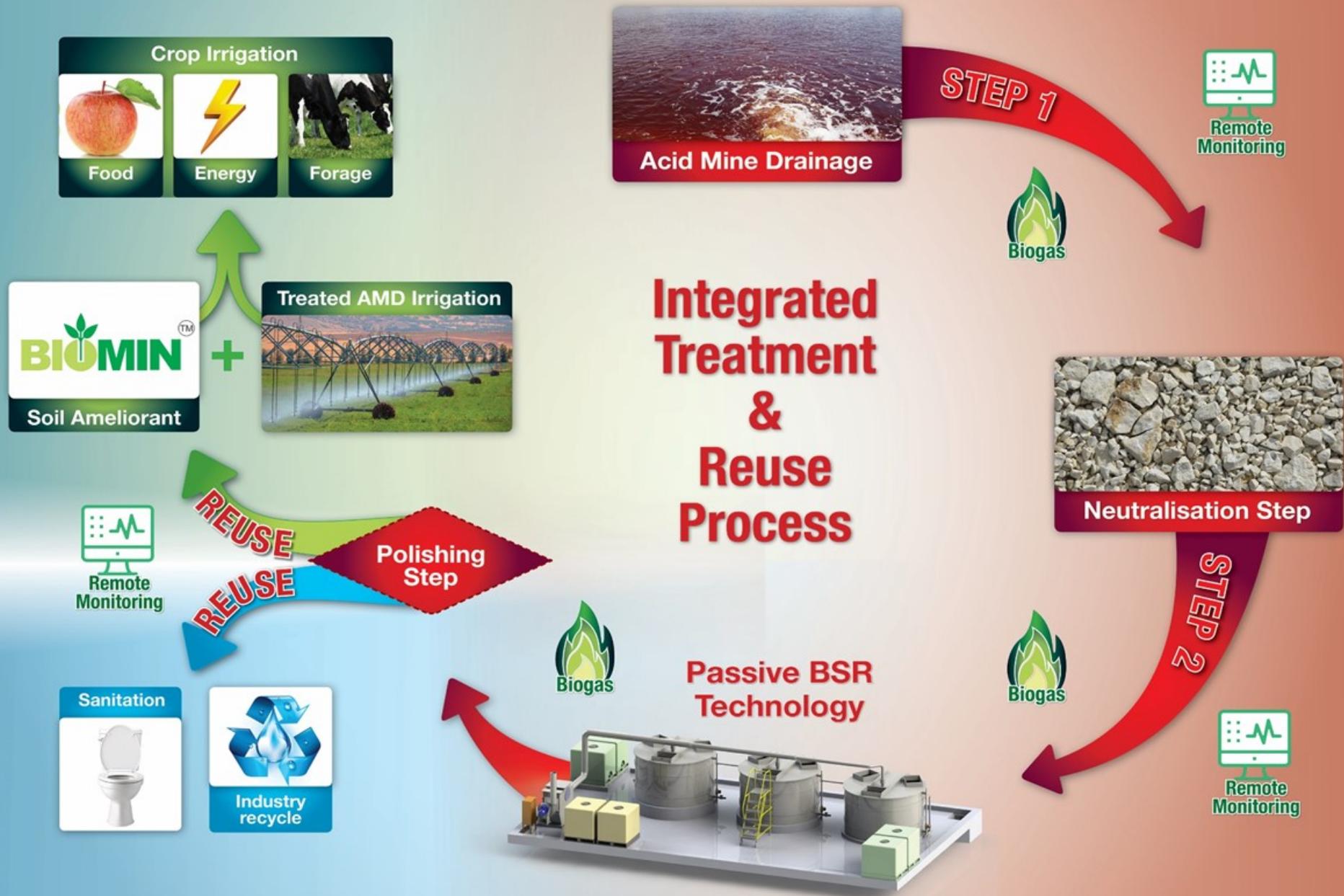


Mintek's Contribution to Steel Industry



Environmental Sustainability

Integrated Treatment and Reuse Concept for Mine Water



Passive Biological Sulphate Removal

Collaborative project with European partners to develop passive systems for treatment of AMD from both the coal and gold mining industries in Europe and South Africa.



South Africa

Discharge levels for sulphates: 200-400ppm



Finland

Discharge levels for sulphate: 1000 ppm



Electronic Waste Treatment

Development and optimization of technologies for treatment of:

- Printed circuit boards.
- Cathode ray tubes.
- Pilot-scale demonstration planned by end of 2020.
- Mintek is having discussions with
 - Electronic Waste Association of South Africa (eWASA),
 - equipment manufacturers and
 - Gauteng Industrial Development Zone (GIDZ) to align activities
- Focus on development of local technologies.
- Mintek preferred technology provider.
- Collaborative proposal submitted for funding.



Support to the Kimberley Process

- Mintek has diamond fingerprinting expertise to trace origins of diamonds.
- Uniquely positioned to provide this capability.
- 1100 Diamonds have been analysed from 7 countries:
 - South Africa, DRC, CAR, Ghana, Tanzania & Botswana
- Fingerprinting of at least 100 diamonds will be conducted during 2018/19.
- Commitment received for supply of ~2500 diamonds from CAR.
- Grow database of analysed diamonds to provide statistical confidence.
- Focus on African conflict diamonds.



Emerging Technologies

Collaborative Research

Africa Collaborative Research



INTERNATIONAL
COUNCIL
FOR SCIENCE



THE COPPERBELT
UNIVERSITY



HSRC
Human Sciences
Research Council

Leading Integrated Research for Agenda 2030 in Africa (LIRA)

- Joint feasibility study.
- Use of renewable energy for use to power decentralized water treatment plants.
- For supply of clean drinking water to growing township communities in African cities.

university
of south africa
UNISA

- Joint instrument acquisition for 3D imaging research.
- Discussions underway on “Artificial Intelligence” theme.



- Development of improved soil ameliorant.
- Analysis of clays for ceramics & pottery.



EU-Collaborative Research



Integrated treatment of low-grade, complex or polymetallic ores.



Boflux (ERA-MIN) - energy and recovery benefits through small additions of boron containing minerals to ferrochromium smelting processes.



Intpart- Exchange programme: excellence in research and education in metal production in Norway, South Africa.

BIOMORE
An Alternative Mining Concept

US - AFSOR – HEIs Collaborations (Progress)

Phase 1 (2014) CONCEPTUALIZATION

- Mintek as member of the DST Delegation
- US Joint Services (DoD)/Africa Technical Exchange Meeting
- Conceptualization of collaboration areas

Phase 2 (2015) TECHNICAL EXCHANGES

- Collaboration/Technical Visit to **Texas A&M University** (AMD)
- Collaboration/Technical Visit to **Virginia Tech University** (AMD)
- AFSOR International Collaborations
- 1st AFOSR International Basic Research Infrastructure Meeting

Phase 3 (2016) TECHNICAL PLATFORMS

- International Forum on Multifunctional Materials in Extreme Environments (IFMMEE 2016) - TAMU
- International Conference on Advanced Manufacturing (ICAM 2016) - VTech
- AFOSR Materials Under Extreme Environments Review 2016 - VA
- USA-Italy-Australia-South Africa Collaboration Consortium on Smart Sensing & Structures (SSS)
- 1st Collaboration: International Institute for Materials for Energy Conversion (IIMEC) School on Computational Materials Science Across Scales - TAMU-FUNDED

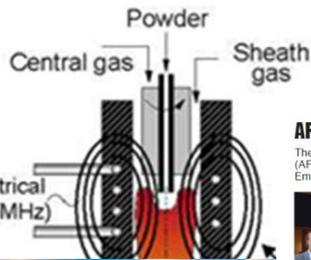
Phase 4 (2017 - 2025) COLLABORATIONS

ACTUAL PROJECTS

- Computational Materials Science (PhD project) – TAMU (**Mr Richard Couperthwaite**)
- Materials for Energy Harvesting (PhD project) – VTech (**Ms Hadio Mantyi**)

INTERNATIONAL CONFERENCE

- International Conference on Advanced Manufacturing (ICAM 2018) - RSA



AFOSR INTERNATIONAL COLLABORATION EFFORT GETS RESULTS

The Air Force Research Laboratory's basic research directorate, the Air Force Office of Scientific Research (AFOSR) hosted the International Basic Research Infrastructure Meeting on 17-19 November 2015 at the Embassy of Italy in Washington, D.C.



Opportunities for Collaboration at the 2018 AFOSR Biophysics Review

- **Dr Gay Hunter** – Smart Sensor Systems.
- **Prof Tiffany Walsh** – Molecular Modeling
- **Dr Saber Hussain** – Nano Toxicology



Thank You
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