



The African Strategy of Fundamental and Applied Physics

Chapter 13.

Condensed Matter and Materials Physics Working Group

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Objectives

- ① To **promote excellence** in all aspects of materials research in Africa.
- ② To ensure that **materials research** contributes significantly, constructively, and sustainably to the **various national strategies** for social equity and poverty alleviation.
- ③ To work closely with governments and state structures to develop **appropriate policy and support** for African materials research and development.
- ④ To build a network of materials researchers which encourages multinational and multi-disciplinary collaboration in **materials research** within Africa and between African Researchers and the rest of the world.
- ⑤ To identify and **foster specific areas of materials research** as appropriate in the different countries Or regions of Africa.
- ⑥ To promote information and resource sharing, exchange and development in materials science by actively engaging **the representatives of the five regions of Africa**.
- ⑦ To encourage downstream materials manufacturing and value-adding activities in all countries in Africa.
- ⑧ To strengthen the facilities and other resources for materials science in the further and higher education sectors.



- 9 To **regularly host meetings, symposia, and conferences** to promote dialogue between materials researchers within Africa and with researchers outside the continent.

Challenge of overlapping schedules for conferences



12th International Conference of the African Materials Research Society
Pre Conference Workshops: 14 – 15th December 2024
Main Conference: 16 – 19th December 2024
Kigali, Rwanda



Chapter 13.

Condensed Matter and Materials Physics Working Group

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Outline

1. Introduction and Motivation
2. Major challenges
3. High-priority future needs
4. Synergies with neighbouring fields
5. Environmental and societal impact.
6. Areas for Improvement in Condensed Matter and Materials Physics

Introduction



- Regarding its huge industrial and security impact, quantum technology has rapidly reached the realms of policymaking.
- The worldwide Condensed Matter Physics (CMP) community is devoting great efforts to study existing material candidates and predict new possible materials.
- Condensed Matter Physics is a highly interdisciplinary field of research attracting more than 46% of the Physicists in the world.

The key question that emerges is: what is Africa's position in the global technological race?"

- Africa is lagging in the global research activities in CMP and advanced materials
- Africa needs to catch up with the worldwide tech race to avoid further marginalization and to take advantage of its natural resources.

Road map strategy



- The outcomes of **several open meetings** and **workshops with researchers from different African countries and the diaspora**, and on the analysis of the **received LOIs** and **responses to surveys**.
- The long-term discussions involved more than **one thousand African** researchers at different career levels: *Heads of research centers, stakeholders, startup founders, permanent researchers, postdoc fellows, Ph.D, Master, and Bachelor students....*



1-the introduction is informative and captures the essence of the field's historical and contemporary significance. However, the link between past achievements in semiconductor research and current goals in quantum technologies could be made more explicit.

2- the call to action is convincing, particularly when it comes to closing the gap in Africa's research into advanced materials and proposing a clear roadmap through the ASFAP working group.

However, the overall impact could be improved by ensuring smoother transitions between topics, such as moving from global trends in quantum technology to Africa's position.

Objectives



Identifying **the challenges forming the greatest barriers** to promote research and innovation in CMP, Advanced Materials, quantum technologies, and related topics.



Identifying the **strategic areas of research** in CMP and MP where Africa should invest to join the global technological race.

Identifying the priority actions to bridge the gaps at the Educational and research levels.

Setting a clear guideline for the **future development of research and innovation** in CMP and MP in Africa within a scientific and economic win-win approach.

Major challenges



Many African countries face challenges in investing adequately in CMP due to limited resources. The main challenges faced by physicists across the continent in the field of CM and MP can be categorized as follows:

Education

- ❑ Unreliable educational background
- ❑ Limited Master and Ph.D programs (*The gender balance is also an issue*)
- ❑ Limited number of qualified researchers/trainers
- ❑ Limited teaching equipment
- ❑ Unemployed Physicists with Ph.D in CMP&MP
- ❑ Career Progression Barriers
- ❑ Brain drain

Major challenges

Education and capacity building

Unreliable educational background

Education is key for African countries to catch up in technology, but many curricula fail to meet international standards, underscoring the need for urgent reform.

- Include examples or data to support statements about the inadequacy of educational standards in Africa.

Unemployed Physicists with Ph.D. in CMP&MP

- Removes over-generalizations, and enhances the logical flow.
- Claims about the quality of research facilities and high learner-teacher ratios need specific examples or statistics for substantiation.

Brain Drain

- The paragraph could benefit from better linking between underinvestment and brain drain. A more explicit explanation of how the lack of funding leads to brain drain would improve logical flow.

Challenges of research infrastructure

- To address the challenges of research infrastructure in Africa, it is essential to put the existing infrastructure landscape into context.





Existing research infrastructure

For experimentalists in CM&MP (synthesis and characterization) In Africa, there are a few hotspots with upgraded instrumentation as :

- Materials, energy, and nanotechnology (COE-MEN)-ARUA (South Africa)
- National Centre for nano-structured Materials (South Africa)
- Ithemba laboratories for accelerator-based science (LABS) (south Africa)
- Centers for imaging and microscopy and nanotechnology (Egypt)
- Foundation for advanced science, innovation, and research (MASCIR) (Morocco)
- Research Center in Semiconductors Technology for Energetic (CRTSE) (Algeria)
- Research and Technology Centre of Energy (CRTEen) (Tunisia)
- Botswana Institute for Technology Research and Innovation (BITRI) (Botswana)
- Centre for Biomedical and Biomaterials Research (CBBR) (Mauritius)
- African Centre of Excellence, Centre of Materials (Uganda)
- African Centre of Excellence, Centre of Materials
- East Africa Institute for Fundamental Research (EAIFR) (Rwanda)
- The African Materials Research Society (AMRS)

The available equipment in AC is old or defective, this is compounded by the fact that there is a shortage of trained technicians for maintenance



Major challenges

While these challenges are substantial, there are notable efforts to overcome them:

Centers of Excellence: Well-equipped hubs like MASCIR (Morocco) and EAIFR (Rwanda) set benchmarks for infrastructure and training programs. South Africa leads with sustained government funding and partnerships in materials science.

Training and Capacity Building: Programs such as the AMRS workshops and other initiatives under organizations like ARUA offer technician training and promote knowledge exchange.

Regional Cooperation: Collaborative frameworks among African institutions (e.g., CRTSE, CRTEn) allow sharing of resources and expertise, helping smaller or under-resourced centers benefit from more advanced facilities.



Major challenges

Maintenance and Repair Challenges

The shortage of trained technicians for equipment maintenance exacerbates the issue. Even when resources are available, the process of getting dysfunctional equipment repaired is frequently cumbersome and entangled in bureaucratic hurdles. *This delays the restoration of critical research activities, further stalling progress.*

Financial Constraints

A lack of funding is a pervasive problem that hinders the acquisition of upgraded instrumentation. African laboratories often struggle to afford state-of-the-art equipment necessary for advancing research capabilities.

Impact on Research Output

The combination of outdated equipment, inadequate maintenance, and funding constraints significantly affects the ability of researchers to produce high-quality work. *These challenges limit opportunities for innovation and collaboration with international research institutions.*

High-priority future needs



Education and capacity building

- A teaching-by-project approach is strongly recommended with input from industry.
- Build up Pan African Master and related Ph.D programs with exchange student programs.
 - ✓ Master in Theoretical & computational CM (career in data science or quantum computing)
 - ✓ Master in Experimental and applied CM&MP (career in industry).
 - ✓ Professional Master's in Materials Physics and Applications Nexus EWF.
 - ✓ Master in quantum technologies (interface between physics, engineering and mathematics)
- Set up an International Centre for Experimental in Africa (ICEPA)
- Enhance teaching activities at Master's and PhD levels by organizing regular schools on specific topics.

High-priority future needs



Research

- Establish **new collaborative** networks between universities, research institutions, and industries within and outside Africa.
- Encourage **public-private partnerships to provide funding.**
- Upgrade existing research infrastructures and create **new facilities equipped with state-of-the-art instrumentation, and facilitate access to advanced experimental and computing tools.**
- Invest in training programs, mentorships, workshops, and international collaborations to enhance the capacity of African researchers in CMP.



Synergies with neighbouring Fields

- CM & MP exhibit numerous synergies with neighboring fields, fostering interdisciplinary collaboration and driving scientific innovation across various domains.
- Collaboration with neighboring disciplines can open access to diverse funding streams and international networks.
- Collaboration between CMP and condensed matter chemistry (CMC) researchers enables us to better understand chemical processes at the molecular level and develop innovative materials with adapted functionalities.

Areas for Improvement in Condensed Matter and Materials Physics

Interdisciplinary Integration

Promote initiatives where condensed matter research directly contributes to sustainability, such as using materials physics to develop next-generation photovoltaics, water filtration membranes, or climate-resilient materials.

Policy and Industrial Integration

Establish regulatory frameworks that balance innovation and safety while fostering collaboration between academia, industry, and government.

Scalability and Industrial Application

Foster collaborations between academia, industry, and governments to streamline the scaling process, emphasizing cost-effective production methods without compromising quality

Public Awareness and Ethical Considerations

Enhance **science communication** efforts to make condensed matter physics more accessible and integrate **life-cycle analysis** for all new materials to ensure ethical and environmental responsibility.