Physics for a sustainable future: the case of the new Master of Materiomics

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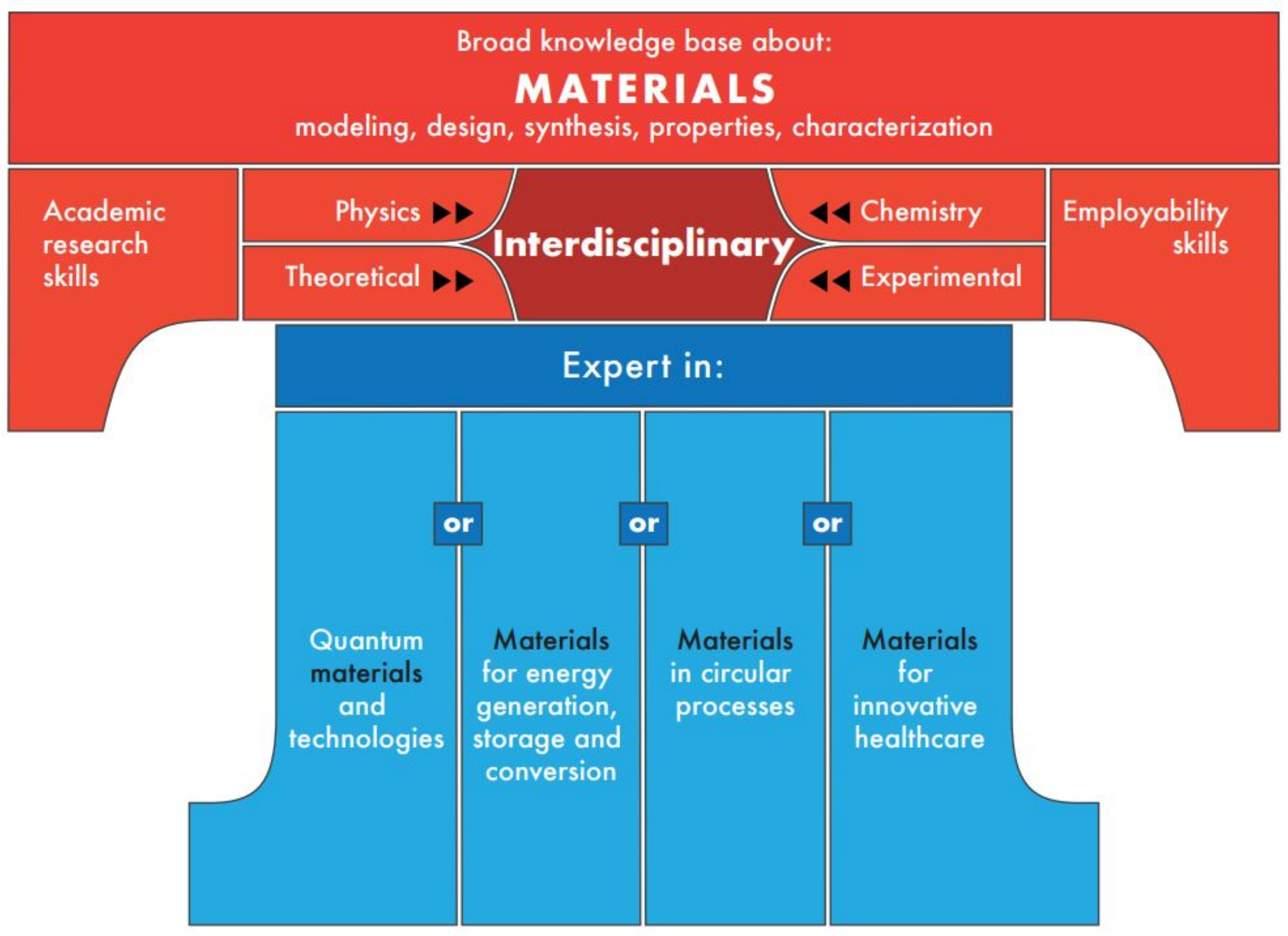
Profile of the Master of Materiomics

In 2022-2023, the Master of Materiomics starts at the Faculty of Sciences (Hasselt University) aimed at students who want to **develop sustainable and innovative materials** at the intersection of physics and chemistry and using both theoretical/computational and experimental approaches, the interdisciplinary T-shaped professional:



Direct access for Flemish students with the following bachelor degree:

- **Academic bachelor in physics**
- **Academic bachelor in physics and astronomy**
- Academic bachelor in chemistry
- Academic bachelor in biochemistry and biotechnology
- Academic bachelor in bioscience engineering
- Academic bachelor in engineering sciences

Four specializations: Materials for...

Quantum

This pillar immerses students in **state-of-the-art emerging technologies** that can force **breakthroughs in cybersecurity, computing power, metrology, the sensitivity of detection instruments for medical diagnostics**, and much more. Students research the technology used in high-tech quantum sensors, for e.g. NMR instruments or magnetic field sensors for space, which are much more sensitive than classical sensors. These materials are also interesting for **future quantum computers**, which perform calculations much faster and can play a major role in, among other things, the encryption, security and transmission of data. Students in this pillar are trained in these and other groundbreaking topics by experts from the **UHasselt Institute for Materials Research**.

Energy

In the Energy pillar, in-depth training is provided in **the development and characterization of innovative, high-performance materials for sustainable energy generation/storage and the reduction of CO_2 emissions**. Students learn more about topics such as improving photovoltaic energy conversion, thermochromic glazing materials that can switch between heat transmission/blocking, designing battery materials for short and long term, green hydrogen via water splitting ... They will find answers to questions such as 'How can we increase the efficiency of new generation solar cells?' or 'How can we convert CO_2 into usable fuels, using sunlight?' Reducing CO_2 emissions, but certainly also capturing, converting and making CO_2 useful (CCU) are technological innovations in which masters in Materiomics can play an important role.

Circularity

In the pillar Circular Processes , the focus is on the study and development of **functional material solutions that constitute the core of a circular economy**. This is based on the rethinking of functional materials, based on quantitative data such as life cycle analysis. Much attention is paid to **searching alternatives for materials or technologies that are not sustainable, to the reusability of materials and to the fully sustainable use of residual materials**. Students are trained to reinvent materials and systems by taking into account sustainable recoverability afterwards. Students in this pillar learn more about sustainable material applications, such as finding alternatives to the lithium ion battery, upcycling residual flows into activated carbon or reusing plastic waste from oceans via new polymerization processes.

Health

In this pillar students acquire an in-depth understanding of advanced materials for the **pharmaceutical industry** and the broader healthcare industry, and the link is made with **biochemistry**. Topics in this pillar are e.g. the development of materials that replace and repair damaged tissue after a heart attack, new insights and applications in organic electronics (e.g. biosensors to monitor the sugar level of diabetes patients), the design and modeling of materials that bring them where they are needed and thus reduce the side effects of, for example, chemotherapy, the use of biological processes in the design of materials,...

Breakthrough materials development for a sustainable future

Context of the Master of Materiomics

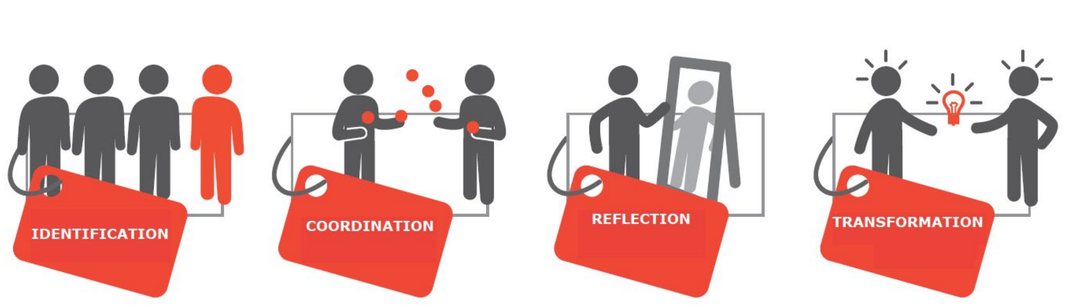
At this very moment, **society faces complex and intertwined grand challenges**, e.g., climate change, pandemics, innovative and safe communication technologies, the energy transition, changing industrial processes, innovative space research and finite resources that are becoming depleted. In response to these challenges, there is a high demand for scientists who are ready for an **internationally-oriented and interdisciplinary research environment and labour market**. One of the core fields in this respect is materials development and research, as some solutions to the above mentioned complex societal issues may lie in the **development of new technologies, of which breakthrough materials development is an important component**.

Goal of the master’s program Materiomics

The goal is to train interdisciplinary T-shaped professionals (see Figure above), i.e., **experts in their field (e.g., physics) who are able to build bridges between the different perspectives involved in materials research and development**. The term 'Materiomics' refers to the holistic study of processes, structures and properties of materials from an exact scientific fundamental, systematic perspective through all relevant scales, from atomic to macroscopic, into the synthesis and functionality. Masters of Materiomics have a solid, broad knowledge base in which the modeling, design, synthesis, properties, and characterization of materials play a central role. Materials are studied from an interdisciplinary perspective, building bridges not only between physics and chemistry, but also between experimental and theoretical methods: **Students are taught to approach materials from different perspectives and learn to communicate across disciplinary boundaries with experts in chemistry etc.**, with due attention to academic research skills and soft skills which prepare them for their professional careers. In addition to a broad knowledge base, students acquire in-depth knowledge and skills in one of the 4 areas of specialization.

Training interdisciplinary physics experts

To obtain these goals, interdisciplinary competences are required: **students need to cross boundaries** between physics and chemistry, as well as between experimental and theoretical/computational methods. Interdisciplinarity is gradually introduced throughout the curriculum, building on the **four learning mechanisms** from boundary crossing theory [1, 2], i.e. **identification, coordination, reflection and transformation**. More specifically, students are introduced to the different perspectives and approaches, to making connections between different perspectives, synthesizing them (e.g. through assignments, group work...), and applying all this to new, complex material problems (e.g. through a hands-on project, the internship and master's thesis). In this way, we aim to ultimately train experts in physics capable of addressing complex material issues from a holistic approach in multi- and interdisciplinary teams with the necessary attention for aspects such as sustainability, availability of raw materials, recyclability and cost.



References

[1] S. F. Akkerman and A. Bakker, “Boundary crossing and boundary objects,” Review of Educational Research, vol. 81, pp. 132-169, 2011.
[2] M. Kluijtmans, “Leren verbinden: het opleiden van bruggenbouwers [Learning to connect: educating bridge builders],” in her inaugural lecture Education to connect science and professional practice, Utrecht University: Faculty of Medicine, 2019.

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