# **ANNUAL REPORT 2016**



Advanced Research Center Chemical Building Blocks Consortium

# NWO REPORT 2019

Advanced Research Center **Chemical Building Blocks Consortium** 

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## LIST OF ABBREVIATIONS

EB	Executive Board
EZ	Ministry of Economic Affairs (www.government.nl/ministries/ministry-of- economic-affairs)
FMS	Research Center for Functional Molecular Systems (www.fmsresearch.nl)
MCEC	Netherlands Center for Multiscale Catalytic Energy Conversion (www.mcec-researchcenter.nl)
NWO	Netherlands Organisation for Scientific Research (www.nwo.nl/over-nwo/organisatie/nwo- onderdelen/cw/ARC+CBBC )
OCW	Ministry of Education, Culture and Science (www.government.nl/ministries/ministry-of- education-culture-and-science)
PD	Postdoc
PI	Principal Investigator
SAB	Scientific Advisory Board
SB	Supervisory Board
TU/e	Eindhoven University of Technology
UU	Utrecht University
RUG	University of Groningen



## FOREWORD

On behalf of the Executive Board, I proudly present to you this first annual report of the Advanced Research Center Chemical Building Blocks Consortium or ARC CBBC.

ARC CBBC brings the best of the Netherlands' academia and industry together to find groundbreaking and truly innovative solutions to one of society's global challenges: sustainability.

ARC CBBC is a virtual research center that connects academia and industry with 'University hubs' in Eindhoven, Groningen and Utrecht as well as three industrial partners, Shell, AkzoNobel and BASF, that play a key role in the energy sector in the Netherlands and abroad. The first academic members, 39 in total, were selected after careful consideration by a Scientific Advisory Board composed of highly esteemed international scientists. We laid the foundations for the first three multidisciplinary, deeply focused research programs, the so-called flagship programs, by organising community events. Over the coming year, we wish to build on these foundations by e.g. following up on our community events and setting up scientific collaboration and knowledge exchange.

The center eventually aims to become a National Center for Innovation in the field of chemistry, physics, materials science and engineering, based on strategic and long-term publicprivate partnerships. This annual report provides an overview of the first steps taken towards this goal, as well as our intentions in moving the research community and the collaboration between our academic and industrial partners forward.

Enjoy reading about ARC CBBC's recent accomplishments.

Prof. Bert Weckhuysen Scientific Director AkzoNobel ( Amsterdam) Shell (Amsterdam)

BASF (De Meern)

Utrecht University

Eindhoven University of Technology



## **INTRODUCTION**

The ongoing demand for energy and materials requires sustainable solutions that will benefit the entire globe. The supply of raw materials is finite, and the ever-increasing need for new functionalities for both existing and new energy sources has yet to be met.

ARC CBBC, the Advanced Research Center Chemical Building Blocks Consortium, is a new joint research center, officially launched in May 2016. This national research center brings together scientific excellence and leading companies in the industry as well as facilitating room for scientific and technological breakthroughs with regard to its three main themes: Energy Carriers, Functional Materials & Specialties, and Coatings.

The center aims to become a National Center for Innovation in the field of chemistry, physics, materials science and engineering, based on strategic, long-term, public-private partnerships. It continues to build on the expertise and talent present within the so-called Gravitation programs involved: the Netherlands Research Center for Multiscale Catalytic Energy Conversion (MCEC) and the Research Center for Functional Molecular Systems (FMS). As Bert Weckhuysen, one of the main initiators and now the Scientific Director of the research center, said at the start:

"With this initiative, we want to connect the industrial and academic strengths available in the Netherlands to work on global societal challenges as part of a long-term collaboration."

The majority of ARC CBBC's first year consisted of investing in solid foundations. Our first 39 research members were selected, twelve members of the Scientific Advisory Board were appointed, the first (pre-)proposals for the bilateral and multilateral projects were set up, and several community events were organised that enabled the discussion and highlighting of these project concepts among our scientific members and our industrial partners' experts.

This all led to foundations we can confidently build on. This, ARC CBBC's first annual report, aims to provide an overview of how these foundations came about, list the research themes and the technological clusters underlying our research program, introduce ourselves to the community and show how we intend to build upon this foundation towards a successful, sustainable future, both for our research center and society.

# THE STORY OF ARC CBBC

The Advanced Research Center Chemical Building Blocks Consortium (ARC CBBC) was founded in May 2016 by AkzoNobel, BASF, Shell, Utrecht University, Eindhoven University of Technology, University of Groningen, the Ministry of Economic Affairs, Top Sector Chemistry, and the Netherlands Organisation for Scientific Research.

ARC CBBC aims to contribute to the complex societal challenges associated with the growing demand for the finite supply of raw materials and the everincreasing demand for sustainable solutions and materials, using green chemistry, smart materials and renewable energy and thereby including new and smart functionalities. Societal and environmental challenges like these require scientific and technological breakthroughs aimed at resource diversification, smarter chemical processes and advanced functional materials. As a national research center, ARC CBBC brings together the industrial and academic strengths available in the Netherlands in the

#### **FIGURE 1: FOUNDING PARTNERS**



fields of catalysis, synthesis and advanced organic, inorganic and hybrid materials as well as macromolecular chemistry and process technology. ARC CBBC's industrial partners are prominent both in production as well as research & innovation. ARC CBBC's academic partners (UU, TU/e and RUG) unite three technological clusters in so-called University hubs:

<b>*</b> / s	niversity of roningen
Utre	cht University
TU/e	Technische Universiteit <b>Eindhoven</b> University of Technology

Homogeneous catalysis, materials and synthesis (RUG) Heterogeneous catalysis, materials and synthesis (UU)

Process technology, materials and chemical engineering (TU/e)

#### **MEMBERSHIP**

After ARC CBBC's official launch in May 2016, researchers from all Dutch universities and knowledge institutes were invited to apply for ARC CBBC membership. This resulted in 159 applications from both new and experienced researchers. The Executive Board (EB) selected the first 39 members based on an assessment and recommendations from the Scientific Advisory Board (SAB), that considered the applicant's scientific background and experience as well as their potential contribution to the research center in terms of their expertise.

#### MULTIDISCIPLINARY FLAGSHIP PROGRAMS

Following the meetings between ARC CBBC's Program Directors and Innovation Directors, the community meetings and scientific discussions with members, and based on the SAB's advice, the EB decided on the themes for the first three flagship programs:

- Small Molecule Activation (Hans Kuipers, TU/e and Adrie Huesman, Shell)
- Fundamentals of Catalysis (Bert Weckhuysen, UU and Robert Terörde, BASF)
- Coatings & Functional Materials (Ben Feringa, RUG and Andre van Linden, AkzoNobel) Each program is a multidisciplinary collaboration between academia and industry consisting of approximately 5-10 PhD/PD positions.

So far, ARC CBBC's Program Directors have confirmed the allocation of funding to the following bilateral projects after review by the SAB with regard to scientific quality and innovation potential:

- Cobalt-free curing of alkyds and of vinylester-styrene coatings
- Polyester synthesis using novel and efficient esterification catalysts
- Perovskite crystallization for stable and large scale printable solar cells

#### STRONG SCIENTIFIC ADVISORY BOARD

The Scientific Advisory Board (SAB) was installed in October 2016. The SAB's main tasks are to provide ARC CBBC's Executive Board of with substantiated recommendations on a) the selection of academic members, b) the overall scientific quality and innovation potential of research project proposals and c) project progress based on evaluation.

#### FIGURE 2: SCIENTIFIC ADVISORY BOARD MEMBERS



LEIBNIZ-INSTITUT FÜR KATALYSE, GERMANY









TANJA CUK JOHN DENNIS UNIVERSITY OF CALIFORNIA AT BERKELEY, CAMBRIDGE, UK CA, USA











FERDI SCHÜTH MAX-PLANCK-INSTITUT FÜR KOHLENFORSCHUNG, GERMANY

INSTITUTE OF TECHNOLOGY, USA

7 December 2015 **Official** announcement of **ARC CBBC** 

Minister Henk Kamp (Ministry of Economic Affairs) officially announces ARC CBBC as a new national research center during a ceremony at the Shell Technology Center Amsterdam.



#### 10 May 2016 **Official launch of ARC CBBC**

During a half day program, organised at the Veerensmederij in Amersfoort, the main initiators explain how the research center aims to play a leading role in research into issues such as the circular economy, sustainable chemical processes and clean energy. The three research themes Energy Carriers, **Functional Materials & Specialties** and Coatings are also discussed.



#### October 2016 Installation of **Scientific Advisory Board (SAB)**

The twelve names of outstanding, independent international academic experts, each a leader in their own field, are confirmed.



UNIVERSITY OF CAMBRIDGE, UK

UNIVERSITY OF SURREY,

GUY MARIN GHENT UNIVERSITY, BELGIUM



ARC CBBC ANNUAL REPORT 2016

# SCIENCE

ARC CBBC builds on the expertise and knowledge accumulated in the Research Center for Functional Molecular Systems (FMS) and the Netherlands Research Center for Multiscale Catalytic Energy Conversion (MCEC). FMS and MCEC are Gravitation programs. These powerful, long-term research incentives by the Ministry of Education, Culture and Science (OCW) and the Netherlands Organisation for Scientific Research (NWO) foster top tier fundamental research.

Chemists, chemical engineers, physicists and material scientists can deliver key solutions to the growing demand for circularity. More than any other discipline, the chemical sector is able to produce novel products by linking new building blocks from the molecular level upwards, thereby creating new materials with improved or novel properties. The chemical and energy sector has the tools as well as the knowledge -

#### FIGURE 3: THE GRAVITATION PROGRAM'S INITIAL PIS



E.W. Meijer (TU/e), B.L. Feringa (RUG), R.A.J. Janssen (TU/e), R.J.M. Nolte (RU), J.C.M. van Hest (RU), S. Otto (RUG)

B.M. Weckhuysen (UU), A. van den Berg (UT), A. van Blaaderen (UU), J.A.M. Kuipers (TU/e), D. Lohse (UT), R.A. van Santen (TU/e) it is the designated sector to take on this global challenge to supply the world with sustainable, smart solutions. ARC CBBC focuses on the necessary scientific and technological breakthroughs to synthesise both new and existing chemical building blocks as part of a strong collaboration between industry and knowledge institutes by exchanging state-of-the-art knowhow and ideas as well as using advanced research tools. It is expected to play a leading role in research into issues such as the circular economy, sustainable chemical processes and clean energy.

## **THREE TECHNOLOGICAL CLUSTERS**

ARC CBBC envisions approaching the challenges identified within the three fields of application employing three technological clusters:

- Homogeneous catalysis, materials and synthesis (Program Director: Ben Feringa, RUG)
- Heterogeneous catalysis, materials and synthesis (Program Director: Bert Weckhuysen, UU)
- Process technology, materials and chemical engineering (Program Director: Hans Kuipers, TU/e)

The three technological clusters all contribute to ARC CBBC's three fields of application, the main research themes:

- Energy Carriers
- Functional Materials & Specialties
- Coatings

Academic scientists will work in close collaboration with the chemical industry on each of these themes. Each theme is led by an Innovation Director appointed by one of the Full Private Partners (see Page 8).

#### FIGURE 4: CBBC'S TECHNOLOGY CLUSTERS AND APPLICATION FIELDS



Flexibility in energy supply, from various renewable and non-renewable carbon resources, will guarantee steady fuel and energy supply in the long term. ARC CBBC's

approach to this research theme includes - but is not limited to - liquefying gas as a transitional energy carrier, direct methane and light alkane activation, storage of renewable electrical energy in chemical bonds (e.g. the synthesis of ammonia, methanol and methane using water and/or CO<sub>2</sub> as a resource), methanol as an alternative energy carrier, and the deployment of the most abundant feedstock, CO<sub>2</sub>, as a building block. Innovation Director: Adrie Huesman



Functional materials play a crucial role in the transition towards a circular economy and should contribute to e.g. increased comfort. Functional materials are functional

in the sense that they respond to the environment, are durable, recyclable with little energy expenditure and are affordable. Research at ARC CBBC is aimed at contributing to, for example, durable structures, biomass and waste product upgrading, new insulation materials, advanced commodity chemicals with enhanced recycling properties, improved processability and lower ecological footprints as well as smart properties including memory, self-healing and self-cleaning properties as well as shape-memory; photo, redox, mechanical, and thermoresponsiveness. It also includes catalyst materials and their advanced synthesis. Such innovations can only be ARC CBBC TIMELINE

#### October 2016 -January 2017 **ARC CBBC Program Directors meet Innovation Directors**

The initial ideas for multidisciplinary flagship programs are discussed at several meetings held in Amsterdam (Shell), De Meern (BASF) and Deventer (AkzoNobel).

#### 23 November 2016 First selection of ARC CBBC members

Based on both an assessment and the SAB's recommendations, the Executive Board (EB) selects the first 39 ARC CBBC members from the 159 applicants.



#### 6-8 December 2016 ARC CBBC at CHAINS

Alongside having a stand to inform the scientific community and other interested parties about its activities, ARC CBBC also organises a separate Q&A session for members and potential future members, as well as a chemical quiz chaired by Ben Feringa.



#### **FIGURE 5: PROGRAM LINES**

sustainable in the long term if research efforts include the recovery of rare-earth metals and new systems that rely on abundant metals. Innovation Director: Robert Terörde

Coatings will play an important role in the smart and circular economy of the future. Sustainable coatings with advanced properties will play a pivotal role in the maintenance of local environments with respect to e.g. heat, humidity, hygiene and sunlight. Breakthroughs are needed both in the green production of the coatings themselves as well as new properties embedded in the coatings. Research into this theme focuses on the green production of coatings, embedding smart (i.e. catalytic, photo and redox) properties into coatings and, by doing so, integrating the coating into its surroundings. This includes a focus on properties such as chemical inertness, UV resistance, anti-smog, anti-microbial or self-cleaning finalities, corrosion resistance and electricity generation using solar coatings. Innovation Director: Andre van Linden

## BILATERAL AND MULTILATERAL PROJECTS

Joint projects between academic researchers and industrial partners will be formulated around at least one of the abovementioned main themes. The program will thereby distinguish a bilateral and a multilateral part.

A bilateral project concerns a cooperation in which one of the Full Private Partners participates with one or more of the selected academic researchers. Only the partners directly involved in a particular project will have access to the results obtained. These projects entail one or more PhD/PD positions each.

A multilateral project or a so-called flagship program is larger in scope and scale and allows the Full Private Partners as well as Associate Private Partners to collaborate with a group of selected academic researchers to expand their knowledge base to be able to achieve true breakthroughs. Projects of this type address long-term joint interests aimed at

#### **TWO PROGRAM LINES**



FIGURE 6: VISUAL OF PROCESS FOR ARC CBBC PROJECT SELECTION. IN THE BILATERAL PART 'COMPANY' REFERS TO A FULL PRIVATE PARTNER. BOTH FULL PRIVATE PARTNERS AND ASSOCIATE PARTNERS PARTICIPATE IN THE MULTILATERAL PART.



providing new knowledge and increased understanding with long-term application perspectives. All the partners have access to the results. These projects entail five to ten PhD/PD positions each.

Several proposal rounds will be organised for multilateral and bilateral projects. The first round is currently open to both types of project and the latter are expected to be effective in late 2017 or early 2018. All the projects are peer-reviewed by our SAB to ensure outstanding quality, novelty, strong collaboration with industry as well as the potential for economic and societal impact.

The first three bilateral projects are ready to start:

## COBALT-FREE CURING OF ALKYDS AND OF VINYLESTER-STYRENE COATINGS

Many coatings dry via chemical crosslinking reactions, which are catalysed by transition metal complexes. The toxicity of some of these metals is under review currently. In this project, we will search for alternative catalysts based on transition metals that avoid potential toxicity. Project Leader: Wesley Browne (University of Groningen) Project Manager: Jitte Flapper (AkzoNobel Coatings)

## POLYESTER SYNTHESIS USING NOVEL AND EFFICIENT ESTERIFICATION CATALYSTS

Aim of this project is to develop new catalysts for polyester syntheses with an attractive environmental and economic profile. These catalysts will lead to more eco-friendly processes and will broaden the scope of raw materials (including renewable-based raw materials) that can be used in polyester syntheses. Project Leader: Adri Minnaard (University of Groningen) Project Manager: Keimpe van den Berg (AkzoNobel Coatings)

## PEROVSKITE CRYSTALLIZATION FOR STABLE AND LARGE SCALE PRINTABLE SOLAR CELLS

This project aims at obtaining fundamental insights in the processes that govern perovskite thin film formation and crystallization for photovoltaic applications. Crystallite size, crystallite orientation, surface coverage, surface roughness and interaction with the receiving surface are crucial parameters that determine the solar cell performance. One of the principal issues in perovskites currently revolves around stability.

# RC CBBC TIMELINE

#### 20 December 2016 Selection of the first three flagship programs

Following the meetings between the Program and Innovation Directors, the EB decides on Small Molecule Activation, Fundamentals of Catalysis and Coatings & Functional Materials as the themes for the first three flagship programs.

## 17 February 2017 First ARC CBBC

community event

The research center got off to a flying start at the University Hall Utrecht, when partners and members meet for the first time to discuss their plans and ambitions regarding the flagship program themes of Small Molecule Activation and Fundamentals of Catalysis.

#### 16 March 2017 Second ARC CBBC community event

The flagship program theme Coatings & Functional Materials is discussed in-depth at this separate community event at the Sikkens Experience Center in Sassenheim, hosted by AkzoNobel.



#### 12-13 April 2017 Scientific Advisory Board meeting

The SAB meets in Utrecht to discuss (and provide ARC CBBC's partners with valuable input about) the first round of bilateral project proposals (ten in total) and the three flagship program preproposals.



#### 18 April 2017 Public Associate Partners confirmed

The EB confirms the accession of six Public Associate Partners to the research center:

- Delft University of Technology
- Leiden University
- Radboud University Nijmegen
- University of Amsterdam
- University of Twente
- VU Amsterdam
- Wageningen University & Research



#### 21 June 2017 Third ARC CBBC Community event

This meeting, held at Utrecht Science Park, aims to take the next step towards the creation of the three flagship programs Small Molecule Activation, Fundamentals of Catalysis and Coatings & Functional Materials. In a plenary session, three possible ideas for future (multilateral) projects are presented and discussed. The significant strides made in recent time provide the opportunity to comfortably think of large-scale deployment. Scale-up of printing technology to GWp/a scale, necessary to impact global energy systems, requires intimate knowledge on the crystallization processes and their dependence on process conditions. Using a range of in-situ spectroscopic and X-ray diffraction techniques the mechanisms and kinetics of crystallization of organometal perovskite layers will be investigated in real time during film formation. This will provide guidelines to develop large scale and fast roll-toroll printing processes for this promising new energy technology.

Project Leader: René Janssen (Eindhoven University of Technology)

Project Manager: Sipke Wadman (Shell)



# **GROWING NETWORKS**

ARC CBBC strives to create an active, wellconnected community; a multidisciplinary network based on sharing information and insights concerning fundamental research and technology development between various scientific disciplines and industrial partners. As a national research center, it unites strong academic and industrial partners in the Netherlands, thereby boosting the knowledge infrastructure with regard to chemical building blocks. The center consists of three main locations or University hubs that unite the three technological clusters (see Page 11). In addition, ARC CBBC is open to all excellent researchers at Dutch universities and knowledge institutes. They are selected after an open invitation procedure, followed by an assessment of scientific excellence by the SAB and the EB's final decision. A distinction is made between new researchers and more experienced scientists.

ARC CBBC also relies on the strong, well-organised chemical industry and energy sector in the Netherlands. ARC CBBC's industrial partners have prominent production, research and innovation activities in the Netherlands and the surrounding regions.

#### FIGURE 7: MEMBERS SELECTION PROCESS



"By combining the best people in different scientific fields, the consortium will spark cooperation between disciplines that, although related, often do not cooperate. That will lead to a new level of innovation. [...] By involving industry on this level, you can make sure you are focusing on really important questions." Matthias Beller, chair of the ARC CBBC's Scientific Advisory Board In addition to the co-founding companies, ARC CBBC offers a collaboration platform for companies of all sizes - from innovative SMEs to major multinationals to achieve its full innovation potential. SMEs can become Associate Private Partners and play an important role in moving ARC CBBC innovations forward to the next phase. To this end, ARC CBBC also collaborates with the SME support agency InnovatieLink with regard to two priority sectors: Chemistry and Energy. An SME membership will, for example, give SME staff access to ARC CBBC courses and schools, as well as opportunities for academic internships and industrial doctorates.

#### GRAVITATION PROGRAMS FMS AND MCEC

ARC CBBC builds upon two Gravitation program research centers (see Page 10): Functional Molecular Systems (FMS) and Multiscale Catalytic Energy Conversion (MCEC). MCEC aims to radically change catalytic energy conversion processes to produce our future fuels and chemicals by adopting a unique integrated approach covering all relevant length scales: from the chemical reactor all the way to the active site. FMS' goal is to design and synthesize chemical architectures with novel functions and properties thanks to full control over the molecules in dynamic complex systems.

More than half the ARC CBBC members are also MCEC or FMS members. Both programs are active in the field of highly interdisciplinary, pioneering research. And both aim to educate a new generation of talented scientists with the expert guidance of renowned researchers, thereby establishing long-term collaborations in a uniquely composed scientific setting. Thanks to staff members participating in both ARC CBBC and the Gravitation programs, a strong link has been forged ensuring that promising results from the fundamental research programs can be further developed within the ARC CBBC program. This crossfertilization will be stimulated by joint activities such as meetings and workshops. Courses and schools will be open for researchers from both programs as well.

#### ASSOCIATE PUBLIC PARTNERS

Delft University of Technology Leiden University Radboud University Nijmegen University of Amsterdam University of Twente VU Amsterdam

Wageningen University & Research

"Expanding the frontiers in science and technology is a lot more effective when done in a collaborative manner. ARC CBBC is a unique research center, which connects academia, industry and governmental bodies. By doing so, fundamental science is naturally linked with applied research and innovation; conducted by the very best scientists the Netherlands has to offer. This research center aims to have a distinctive international impact to a more sustainable future for the generations to come."

MARJAN OUDEMAN - President of the Executive Board of Utrecht University (til 30 June 2017), Chair of the ARC CBBC Supervisory Board

# GOVERNANCE



ARC CBBC is led by the Executive Board (EB), Chairman Ben Feringa (RUG) and Scientific Director Bert Weckhuysen (UU). The center is supported by the ARC CBBC support office. The EB meets five to six times a year and is responsible for the overall management of the research program, while the Supervisory Board (SB) - consisting of representatives from the participating public and private partners as well as the principal stakeholders NWO, Top Sector Chemistry and the Ministry of Economic Affairs – monitors the program's progress, safeguards the national character of the research center and advises the EB concerning long-term strategy. The SB meets twice a year. In October 2016, the Scientific Advisory Board (SAB) was installed. The SAB's main tasks are to provide the EB of ARC with substantiated recommendations on a) the selection of academic members, b) the overall scientific quality and innovation potential of research project proposals and c) the progress of the projects based on an evaluation. The SAB meets at least once a year, but can be consulted throughout the year if necessary.

# **FINANCES**

ARC CBBC was officially launched in May 2016 on the basis of the consortium agreement, which includes the working principles, general structure as well as the financial commitments and intellectual property arrangements agreed by the founding partners AkzoNobel, BASF, Shell, Utrecht University, Eindhoven University of Technology and the University of Groningen. The research center received additional financial support from the Ministry of Economic Affairs, the Top Sector Chemistry and the Netherlands Organisation for Scientific Research.

The initial budget is based on a ten-year commitment including both in-cash and in-kind contributions.

#### TOTAL BUDGET (AMOUNTS X 1000€)

	IN-CASH	IN-KIND
Full Private Partners	25,000	
Full Public Partners	15,000	22,500
Government (NWO, EZ & TKI)	43,500	

The financial support from the various partners is allocated to research, educational and general management activities. The founding industrial partners contribute in-cash, while the founding universities contribute both in-cash and in-kind. They have engaged to build a University hub, which comprises both lab facilities as well as academic and technical staff to be involved in the ARC CBBC's research activities.

#### **FIGURE 8: PROJECT FINANCING**



#### **INVESTMENT IN RESEARCH AND EDUCATION**

- The appointment of PhDs and post-doctoral fellows (PDs), including a material budget and personal education budget for each appointed person
- Investments in new research set-ups and equipment (small and large equipment)
- The appointment of tenure track assistant professors at each University hub
- → The appointment of scientific support staff (technicians) at each University hub

## INVESTMENT IN MANAGEMENT AND GENERAL ACTIVITIES

- → Running the ARC CBBC support office
- → Setting up the talent program and education activities
- → Organising meetings, workshops and summer or winter schools for the ARC CBBC community and experts related to the research center
- Investing in knowledge utilisation and outreach activities

# **POINTS OF ACTION**

Over the coming year, the EB and the ARC CBBC support office will focus on setting up the following activities:

FOLLOW-UP COMMUNITY EVENTS to discuss and finalise the first three flagship programs, focusing on Small Molecule Activation, Fundamentals of Catalysis and Coatings & Functional Materials in order to be able to create a strong multidisciplinary team of PhDs and PDs. This is expected to take place between October and December of 2017.

**FOLLOW-UP COMMUNITY EVENTS** to discuss new flagship programs initiated during the community event in June 2017.

**REINFORCE INTERNAL AND EXTERNAL COMMUNICATION**, and identify outreach activities.

#### **APPROACH POTENTIAL PRIVATE ASSOCIATE PARTNERS**

to collaborate with the research center and set up SME collaborations with InnovatieLink's help.

SET UP SCIENTIFIC COLLABORATION AND KNOWLEDGE

**EXCHANGE** between the Gravitation programs MCEC, FMS and ARC CBBC for the benefit of members and the scientific development of PhDs and PDs.

#### **CREATE (MORE) NATIONAL AND INTERNATIONAL**

**VISIBILITY** in order to attract new members as well as talented PhD and PD researchers from various backgrounds and countries. ARC CBBC will organise separate activities at, for example, CHAINS 2017, the Utrecht Sustainability Conference 2018 and NCCC 2018.

#### **DESIGN A DEDICATED EDUCATION PROGRAM WITHIN THE ARC CBBC ACADEMY.** ARC CBBC is a center for scientific talent, knowledge and innovation that aims to include the following in its program:

- → Summer or winter schools to train PhDs and PDs in multidisciplinary approaches and scientific development
- → Scientific courses and workshops to train R&D staff and in the research center involved members
- → Strengthen the personal development of PhDs and PDs, including scientific writing, project planning, ethical and research integrity as well as career orientation
- → Complementary skill workshops, for example on leadership and entrepreneurship in close collaboration with industrial partners
- → Exploring the options for student and staff exchange
- → Exploring the options for and additional value of setting up online training modules and MOOCs

# AWARDS AND RECOGNITIONS

## Ben Feringa wins the 2016 Nobel Prize for chemistry



"Bernard Feringa was the first person to develop a molecular motor; in 1999 he got a molecular rotor blade to spin continually in the same direction. Using molecular motors, he has rotated a glass cylinder that is 10,000 times bigger than the motor and also designed a nanocar." (www.nobelprize.org)

Ben Feringa decorated Commander of the Netherlands Lion

Ben Feringa wins the 2016 Tetrahedron Prize and Royal Society of Chemistry Centenary Prize

Bert Meijer awarded Nagoya Gold Medal

Bert Weckhuysen receives Robert B. Anderson Award and Tanabe Prize for acid-base catalysis

Sijbren Otto awarded ERC Advanced Grants

Detlef Lohse awarded ERC Advanced Grants

Volker Hessel receives the Flow Chemistry Award

Krijn de Jong receives the François Gault Lectureship Award

Syuzanna Harutyunyan receives the Homogeneous Catalysis Award by the Royal Society of Chemistry

Detlef Lohse receives the 2017 Fluid Dynamics Prize

#### VALUE TO THE DUTCH KNOWLEDGE INFRASTRUCTURE

ARC CBBC addresses many of the major challenges identified in the Top Sector Chemistry with two of its roadmaps. The roadmap Chemical Conversion, Process Technology & Synthesis identifies as its main challenges: increased energy efficiency, improved raw materials efficiency, as well as processes that limit waste and closing the materials loop. The various tasks identified by this roadmap all demand an integrated approach to process technology, catalysis and synthesis, and it is this integration that lies at the heart of ARC CBBC. The roadmap Chemistry of Advanced Materials identifies 'doing more with less' as its main challenge: less weight or material, yet with improved strength, performance or functionality ultimately leading to a smaller footprint for materials production. The tasks that have been identified by the roadmap are related with the application fields targeted by ARC CBBC.

Within the Top Sector Energy, ARC CBBC contributes to, among other things, the innovation theme Energy savings in industry. Other crossovers between ARC CBBC and the Top Sector Energy involve solar fuels, gas as a transitional fuel, biomass valorisation and the electrification of chemical processes.

Finally, ARC CBBC contributes to two of the four program lines of the cross-sectoral program Biobased Economy: chemocatalytic conversion of biomass and solar energy capturing.

In addition, ARC CBBC contributes to the Dutch National Research Agenda 'routes' Circular Economy and Resource Efficiency, Smart Liveable Cities, Energy and Materials.

# **BOARDS & MEMBERS**

#### **EXECUTIVE BOARD (EB)**

Prof. Bert Weckhuysen, Scientific Director (Utrecht University)

Prof. Ben Feringa, Chair (University of Groningen)

Prof. Hans Kuipers (Eindhoven University of Technology)

**Prof. Floris Rutjes** (Radboud University Nijmegen and scientific observer NWO)

Ir. Adrie Huesman (Shell)

Ir. André van Linden (AkzoNobel Decorative Paints)

Dr. Marcel Schreuder Goedheijt (AkzoNobel Specialty Chemicals)

Dr. Robert Terörde (BASF)

Drs. Mark Schmets (Liaison NWO)

#### SUPERVISORY BOARD (SB)

LLM. Marjan Oudeman, Chair (Utrecht University)

Prof. Jasper Knoester (University of Groningen) \*

Ir. Jan Mengelers (Eindhoven University of Technology)

**Prof. Stan Gielen** (Netherlands Organisation for Scientific Research, NWO)

Prof. Emmo Meijer (Top Sector Chemistry) \*\*

Drs. Jasper Wesseling (Ministry of Economic Affairs)

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