LES CERAMIQUES DERIVEES DE PRECURSEURS

1. Polymer Derived Ceramics
2. Atomic Layer Deposition

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Precursors Derived Ceramics - Contexte international

Mot clé : ceramic, période 1995 – 2015
➔ 175.500 résultats

CHINA	21 %
USA	16 %
JAPAN	11 %
GERMANY	7,5 %
INDIA	5 %
FRANCE	4,7 %
SOUTH KOREA	4,7 %
ENGLAND	4,5 %
RUSSIA	3,5 %
SPAIN	3,3 %

Mots clés : ceramic + precursor, période 1995 – 2015
➔ 11.000 résultats

CHINA	21 %
USA	15 %
GERMANY	10 %
JAPAN	9,2 %
INDIA	7,6 %
FRANCE	6,5 %
SOUTH KOREA	4,5 %
BRAZIL	4,4 %
SPAIN	4,3 %
ENGLAND	3,9 %

1er français : 13ème auteur
2ème français : 21ème auteur

Precursors Derived Ceramics - Contexte international

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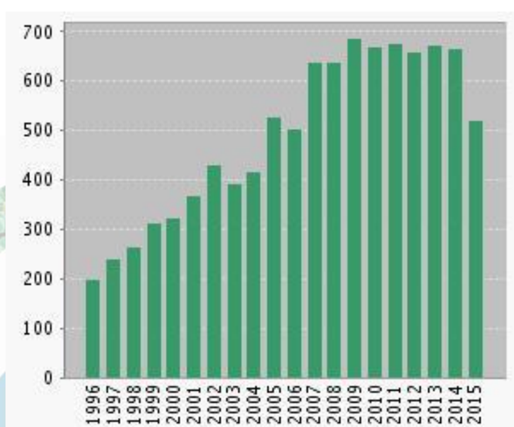
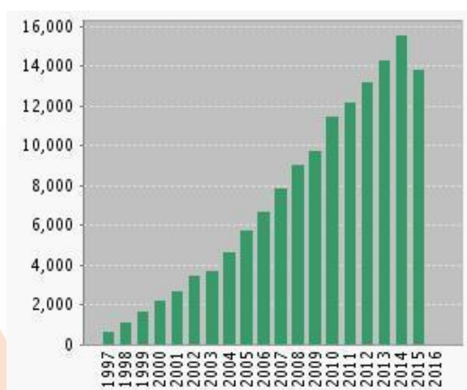


nombre



Citations ➔ h = 118

1er français : 13ème auteur
2ème français : 21ème auteur

Precursors Derived Ceramics - Contexte international

Mot clé : ceramic + precursor, période 1995 – 2015 + Europe

➔ 3.800 résultats

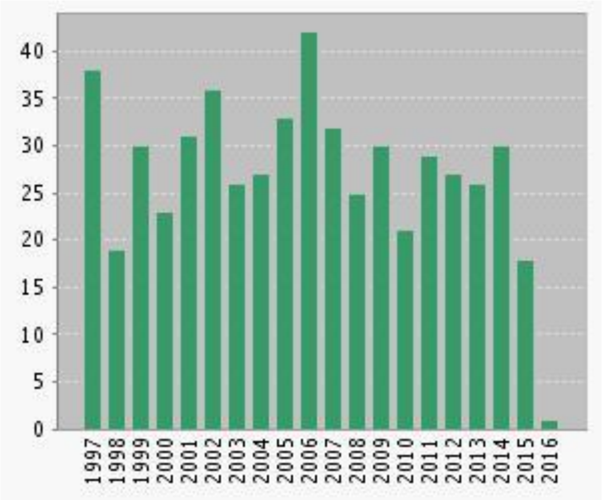
GERMANY	27,1 %
FRANCE	18,2 %
SPAIN	12,0 %
ENGLAND	11,04 %
ITALY	9,3 %
POLAND	4,2 %
ROMANIA	3,8 %
PORTUGAL	2,9 %
SWITZERLAND	2,7 %

GERMANY	1000
FRANCE	600
SPAIN	440
ENGLAND	400
ITALY	340
POLAND	160
ROMANIA	148

Precursors Derived Ceramics - Contexte national

Mot clé : ceramic + precursor, **période – 2015 + France**

➔ ~ 700 résultats



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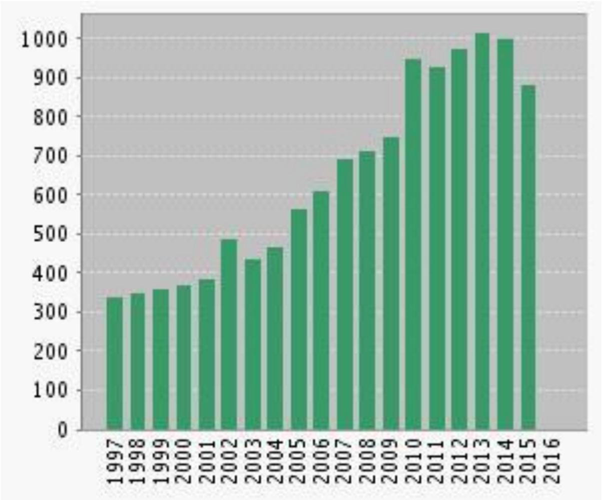
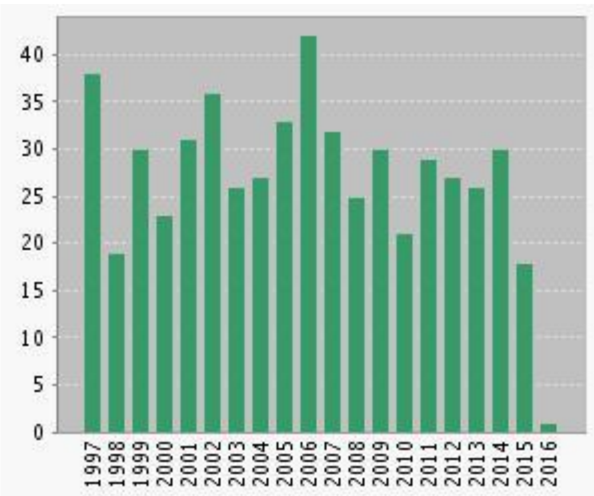


Citations ➔ h = 53

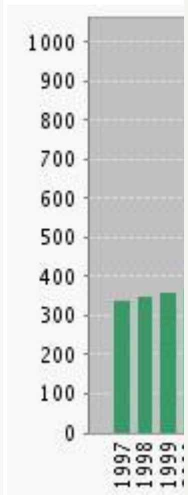
Precursors Derived Ceramics - Contexte national

Mot clé : ceramic + precursor, période – 2015 + France

➔ ~700 résultats



nombre



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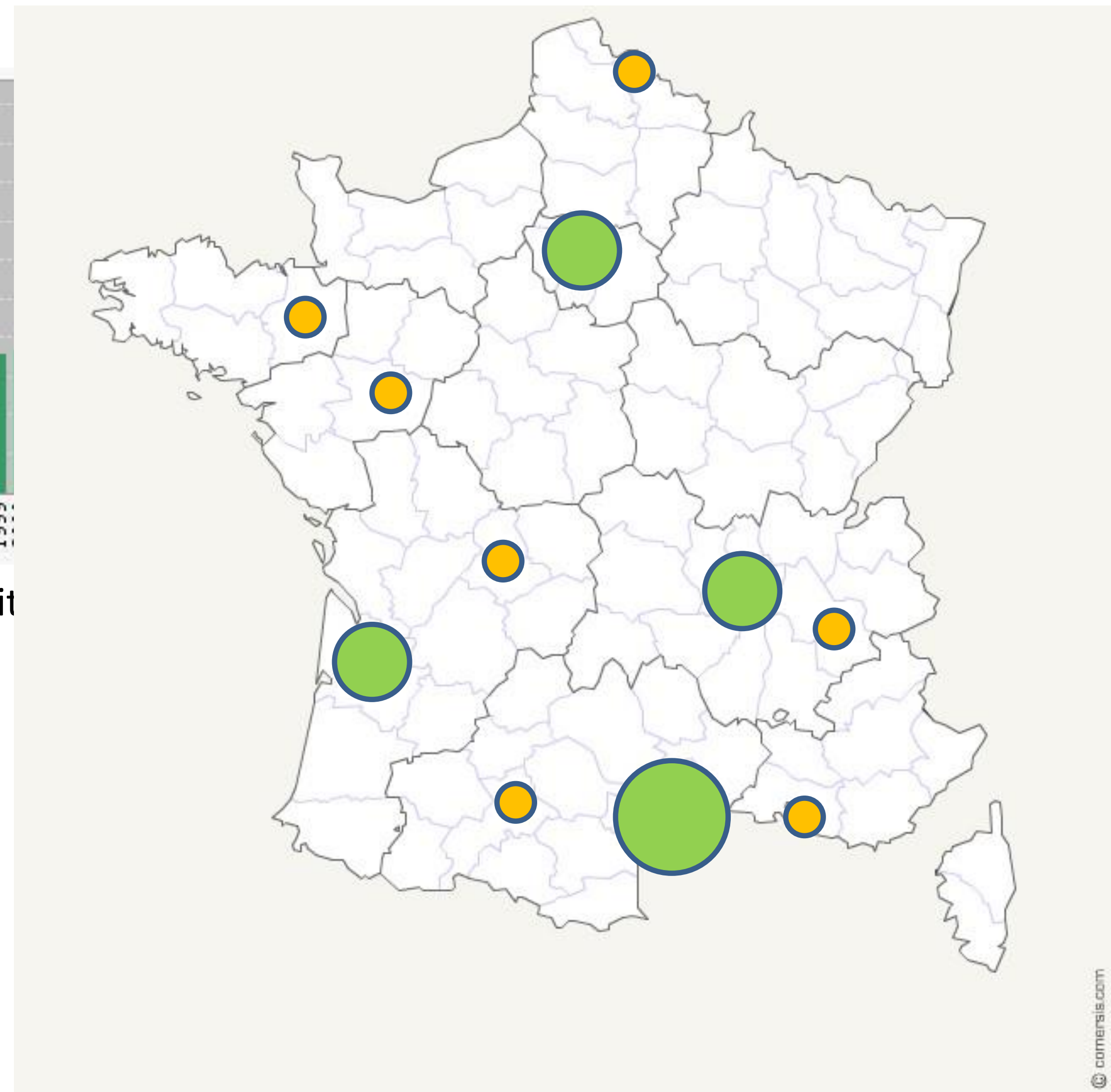

25 premiers > 2%
(adresse)

Precursors Derived Ceramics – Historique/International

- Bildung siliciumorganischer Verbindungen. V. Die Thermische Zersetzung von **$Si(CH_3)_4$ und $Si(C_2H_5)_4$**. G. Fritz and B. Raabe, *Z. Anorg. Allg. Chem.*, 286, 149–67. **1956**.
- The Preparation of **Phosphorus-Nitrogen** Compounds as Non-Porous Solids. F. W. Ainger and J. M. Herbert, pp. 168–82 in *Special Ceramics*, Edited by P. Popper. Academic press, New York, **1960**.
- Inorganic Polymers and Ceramics. G. Chantrell and P. Popper; pp. 87–103 in *Special Ceramics*, Edited by P. Popper. Academic Press, New York, **1965**.
- Continuous **Silicon Carbide Fiber** of High Tensile Strength”. S. Yajima, J. Hayashi and M. Imori, *Chem. Lett.*, 4 [9] 931–4 (**1975**).
- Development of High Tensile Strength **Silicon Carbide Fibre** Using an Organosilicon Polymer Precursor’’. S. Yajima, Y. Hasegawa, K. Okamura and I. Matsuzawa, *Nature* (London), 273, 525–7 (**1978**).
- High-purity Polycrystalline Ceramics From Organometallic Precursors. K. S. Mazdiyasni. *American Ceramic Society Bulletin* Volume: 60 Issue: 3 (**1981**) p. 350-350. ISSN: 0002-7812.
- Polymethylchlorosilane and its Derivatives as **Precursors to Silicon-Carbide Ceramic Fibers** and Shapes. R. H. Baney, J. H. Gaul, T. K. Hilty. *American Ceramic Society Bulletin.* Volume: 60 Issue: 3 Pages: 374-374 Published: **1981**

1950-1981 : 7 références dont ~4 dans le domaine des fibres SiC à hautes performances thermomécaniques

Precursors Derived Ceramics – Historique/National

Physica B 158 (1989) 229–230
North-Holland, Amsterdam

STUDY OF THE POLYMER TO CERAMIC EVOLUTION INDUCED BY PYROLYSIS OF ORGANIC PRECURSOR.

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**LURE, Bâtiment 209D, U.P.S., 91405-ORSAY (France)*
°Laboratoire de Chimie du Solide, Université de Bordeaux I, 33405-TALENCE (France)

Abstract: The structure of a precursor: the polycarbosilane, has been followed during pyrolysis up to 1600°C. A continuous evolution is observed, leading to a nucleation of SiC clusters followed at higher temperature by a growth of the SiC crystalline phase. The structure keeps the memory of the precursor up to 1400°C.

Composites Science and Technology **37** (1990) 7–19

Pyrolysis of Polysilazanes: Relationship between Precursor Architecture and Ceramic Microstructure

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Ecole Nationale Supérieure de Céramiques Industrielles,
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(Received 19 July 1988; revised version received 15 November 1988; accepted 14 June 1989)

ABSTRACT

The pyrolysis of polysilazanes to silicon carbo-nitride has been studied on account of their potential as precursors for ceramic matrices. First, a

A New Way to SiC Ceramic Precursors by Catalytic Preparation of Preceramic Polymers**

By *Bruno Boury*, *Leslie Carpenter*, and *Robert J. P. Corriu**

The preparation of ceramic materials by organometallic processes has opened a new chapter in chemical research. In

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Unité Mixte CNRS/RP/USTL
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Place Eugène Bataillon, F-34095 Montpellier Cédex 5 (France)

[**] This work was supported by CNRS and Rhône-Poulenc Company.

Angew. Chem. Int. Ed. Engl. 29 (1990) No. 7

New Poly(carbosilane) Models. 4. Derivatization of Linear Poly[(methylchlorosilylene)methylene]: Application to the Synthesis of Functional Poly(carbosilanes) Possessing a Poly[(methylsilylene)methylene] Backbone

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Received February 21, 1990. Revised Manuscript Received December 20, 1990

Precursors Derived Ceramics – Historique/National

260 Chem. Mater. 1993, 5, 260–279

Reviews

Preceramic Polymer Routes to Silicon Carbide

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Received October 12, 1992. Revised Manuscript Received December 21, 1992

Chem. Rev. 1995, 95, 1443–1477 1443

Comprehensive Chemistry of Polycarbosilanes, Polysilazanes, and Polycarbosilazanes as Precursors of Ceramics

Marc Birot, Jean-Paul Pillot, and Jacques Dunoguès*

Laboratoire de Chimie Organique et Organométallique, U.R.A. CNRS 35, Université Bordeaux I, 351 cours de la Libération, F-33405 Talence Cédex, France

Received November 10, 1994 (Revised Manuscript Received May 11, 1995)

Contents

I. General Introduction

Among the high-performance non-oxide ceramics, silicon carbide (SiC) and nitride (Si_3N_4) offer unique

Chem. Mater. 1995, 7, 299–303

Boron Nitride Matrices and Coatings Obtained from Tris(methylamino)borane. Application to the Protection of Graphite against Oxidation

B. Bonnetot,* F. Guilhon, J. C. Viala, and H. Mongeot

Laboratoire de Physico-chimie Minérale Ib, CNRS 116, U.C.B. LYON I, 43, Bd du 11 Novembre 1918, 69622 Villeurbanne Cedex, France

Received July 18, 1994. Revised Manuscript Received November 21, 1994®

J. Mater. Chem., 1999, 9, 757–761

JOURNAL OF Materials CHEMISTRY

Conversion of $B(NHCH_3)_3$ into boron nitride and polyborazine fibres and tubular BN structures derived therefrom

David Cornu,*[a] Philippe Miele,[a] René Faure,[b] Bernard Bonnetot,[a] Henri Mongeot[a] and Jean Bouix[a]

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Chem. Mater. 2001, *13*, 1700–1707

FULL PAPER

Chemically Derived BN Ceramics: Extensive ^{11}B and ^{15}N Solid-State NMR Study of a Preceramic Polyborazilene

Christel Gervais,† Jocelyne Maquet,† Florence Babonneau,*,† Christophe Duriez,‡ Eric Framery,‡ Michel Vaultier,‡ Pierre Florian,§ and Dominique Massiot§

Chimie de la Matière Condensée, Université Pierre et Marie Curie/CNRS, Paris, France, Synthèses et électrosynthèses organiques, Université Rennes I, Rennes, France, and CRMHT, CNRS, Orléans, France

Received December 11, 2000. Revised Manuscript Received February 8, 2001

ADVANCED FUNCTIONAL MATERIALS

Adv. Funct. Mater. 2002, *12*, No. 3, March

Boron Nitride Fibers Prepared from Symmetric and Asymmetric Alkylaminoborazines

By *Bérangère Toury, Philippe Miele,* David Cornu, Henri Vincent,* and *Jean Bouix*

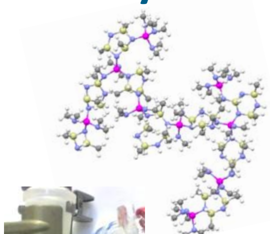
Polymer-Derived Ceramics (PDCs): *Methodology*

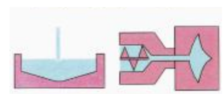
The *Polymer-Derived Ceramics* Route

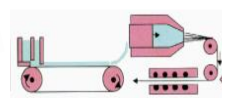
Further Shaping

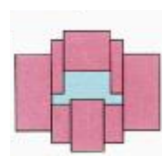
Inert Atm. | *Reactive Atm.*

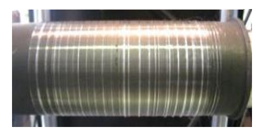
Molecular Precursors — *Synthesis* → **Preceramic Polymers** — *Shaping* → **Shaped Polymers** — *Pyrolysis* → **Shaped Ceramics (PDCs)**

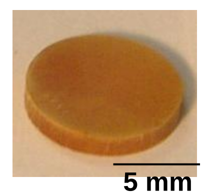


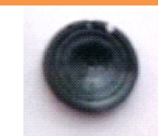


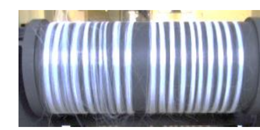


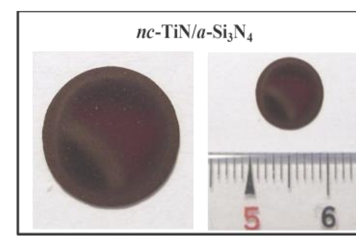












- Commercial
- Can be chemically modified
- Reactive Sites (-Cl, H, Vinyl…)

- Can be chemically modified
- **Contain all elements of the ceramic**
- Reactive Sites (Vinyl, NH, BH, SiH…)
- Ability to be shaped

← ***Sensitive to air and moisture*** →

Non-Oxide PDCs

BN, SiCN, SiBCN, **SiAlCN…**

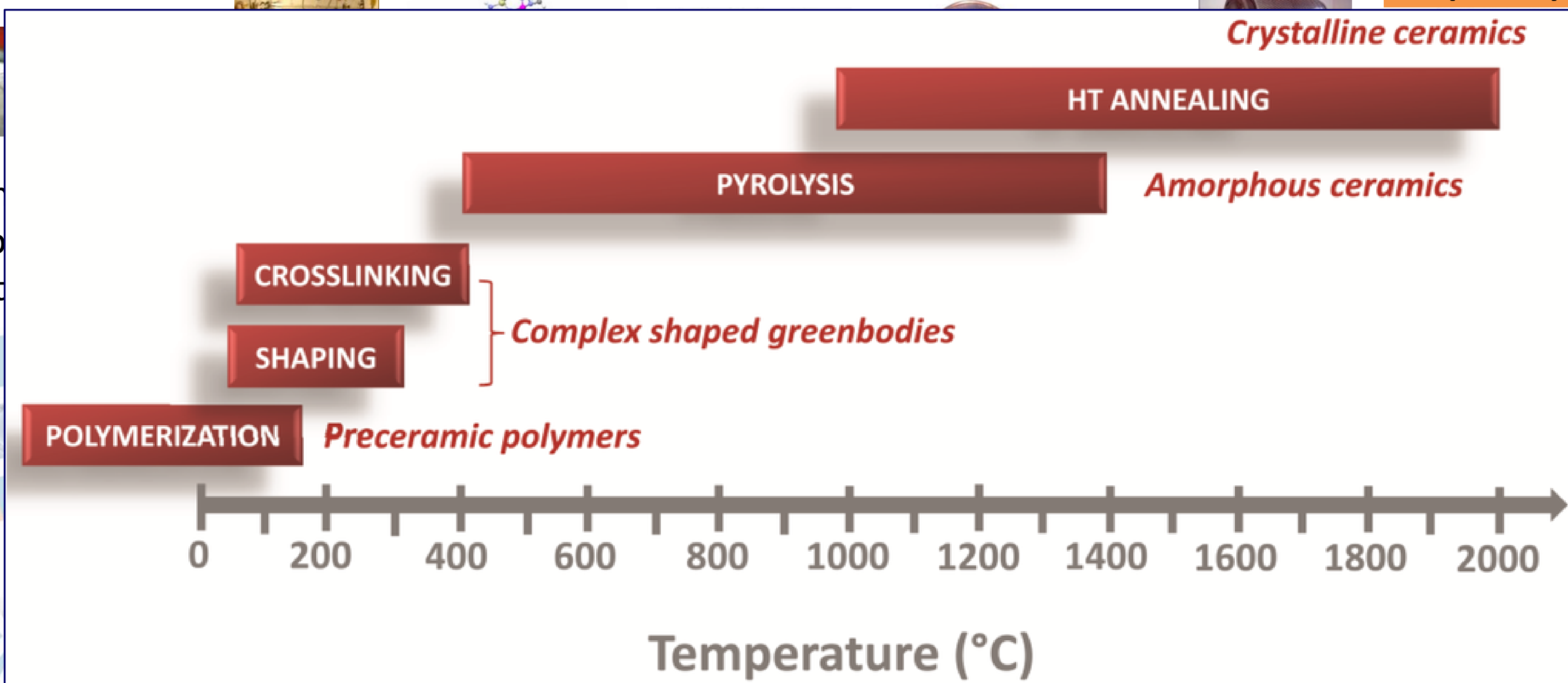
Polymer-Derived Ceramics (PDCs): *Methodology*

The *Polymer-Derived Ceramics* Route

Further Shaping

Inert Atm. — *Reactive Atm.*

Molecular Precursors → *Synthesis* → **Preceramic Polymers** → *Shaping* → **Shaped Polymers** → *Pyrolysis* → **Shaped Ceramics (PDCs)**



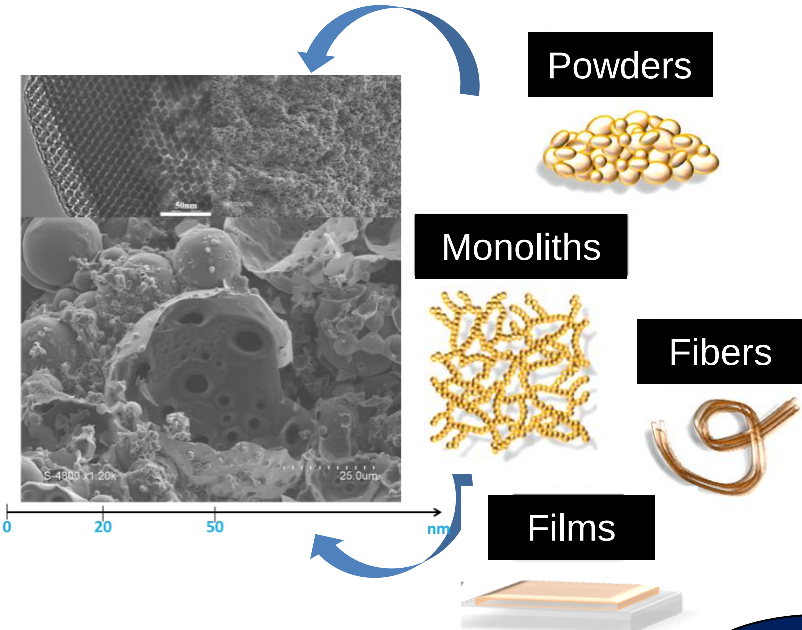
- Comm
- Can b
- React

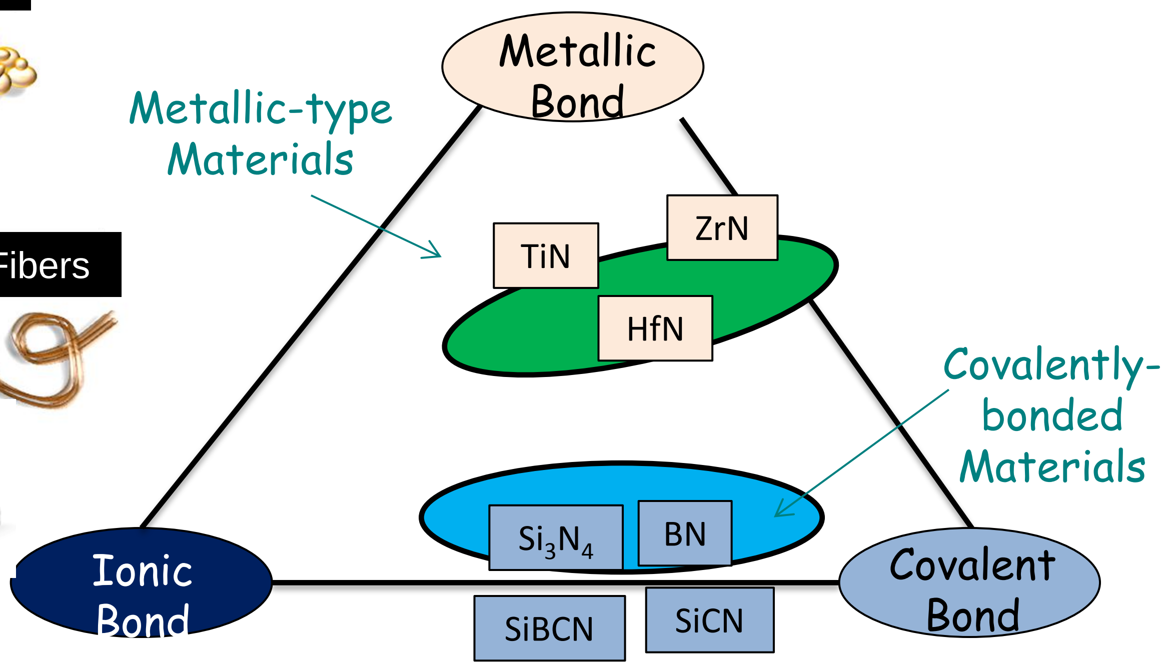
Sensitive to air and moisture

e

BN, SiCN, SiBCN, **SiAlCN…**

Non Oxide (Carbo)Nitride PDCs





H. Holleck, V. Schier, *Surf. Coat. Technol.*, 1995, **76-77**, 328

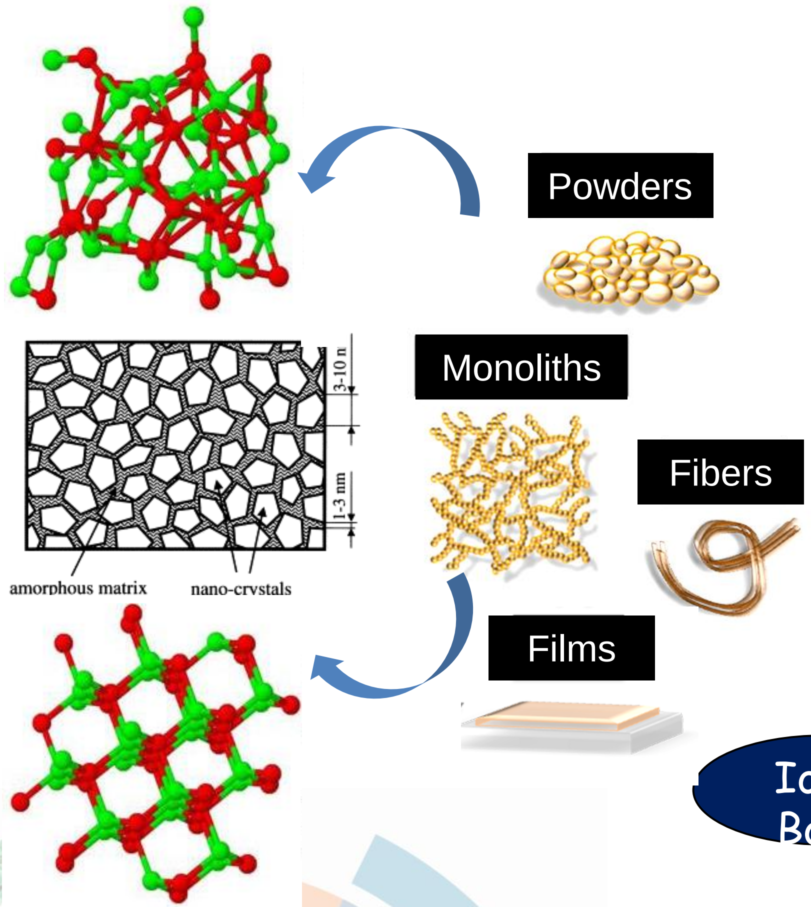
→ **Thermally and chemically stable materials,**

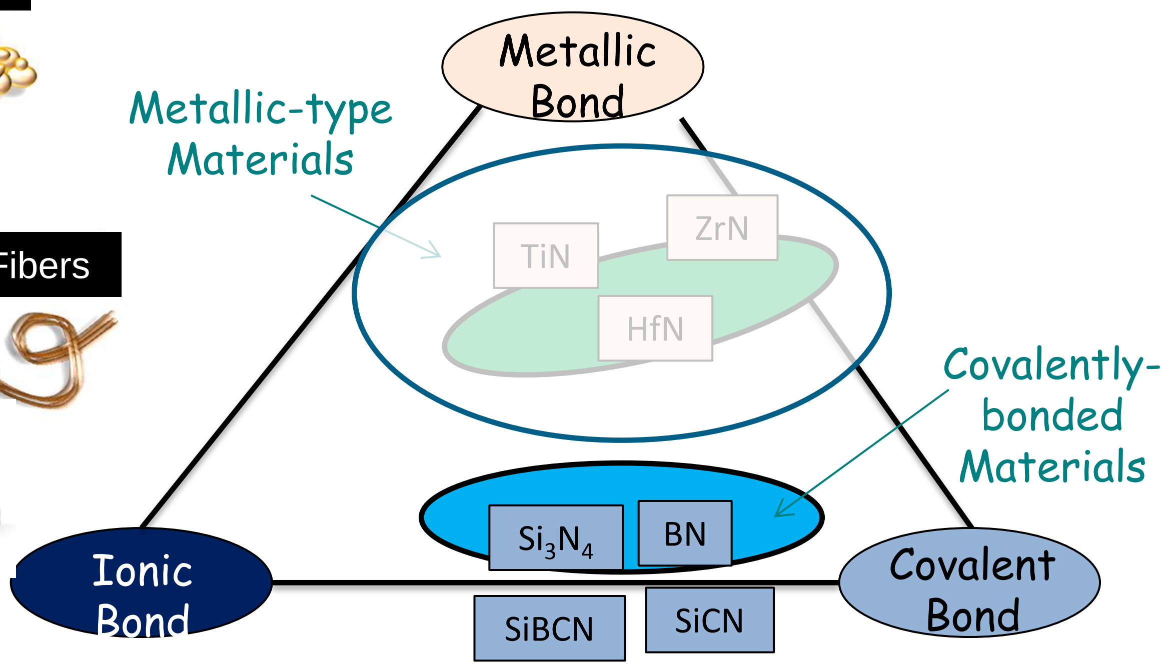
→ **Wide band gap materials**

➔ Insulators, or semi-conductors

→ ***Other specific properties (tenacity, hardness, photocatalytic, …)***

Non Oxide (Carbo)Nitride PDCs





H. Holleck, V. Schier, *Surf. Coat. Technol.*, 1995, **76-77**, 328

→ **Thermally and chemically stable materials,**

→ **Wide band gap materials**

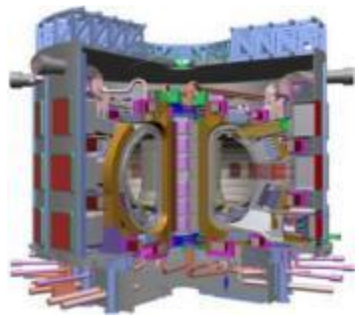
➔ Insulators, or semi-conductors

→ ***Other specific properties (tenacity, hardness, photocatalytic, …)***

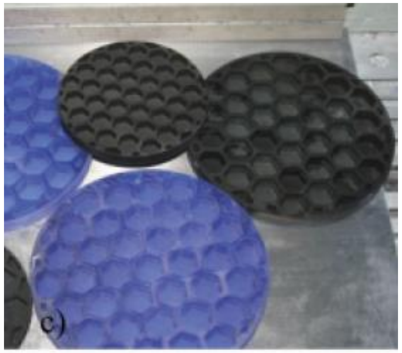
Non Oxide (Carbo)Nitride PDCs : *Selected applications*

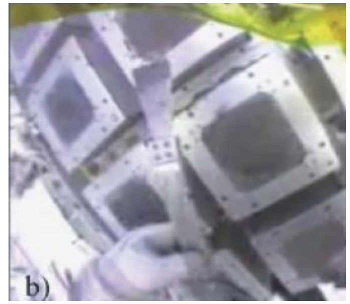
KiON® Specialty Polymers
A Clariant Business

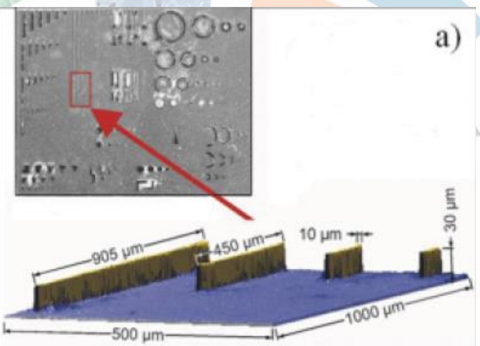
Clariant
Exactly your chemistry.



STARFIRE® SYSTEMS





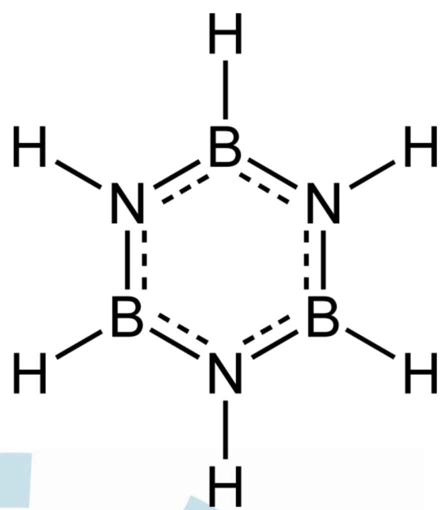


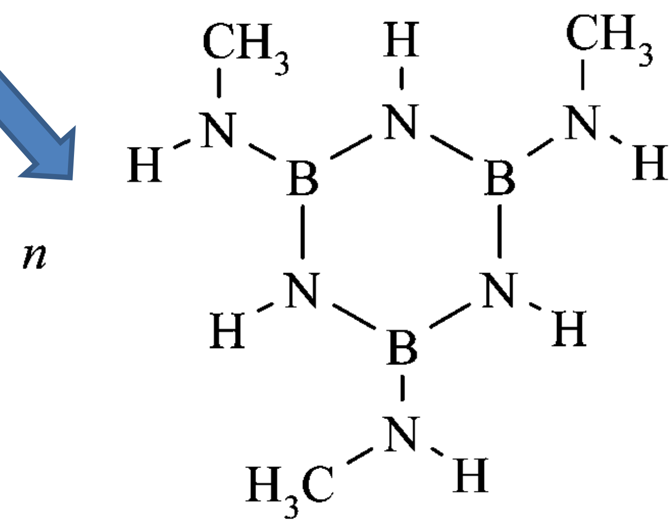
Fibers, Ceramic-matrix composites, porous ceramics for impact absorption, thermal protection, adsorption, gas separation, cotings, joining medium, binders, fillers, microcomponents, component for anode material in lithium battery (SiCN),…

Molecular precursors of boron nitride

- Borazine based precursors (B_3N_3 core : basical pattern of *h*-BN)
- High ceramic yield

  …..but : compromise « ceramic yield / processing properties »





Borazine (l)
Polymers with high ceramic yield
and low processability

↓

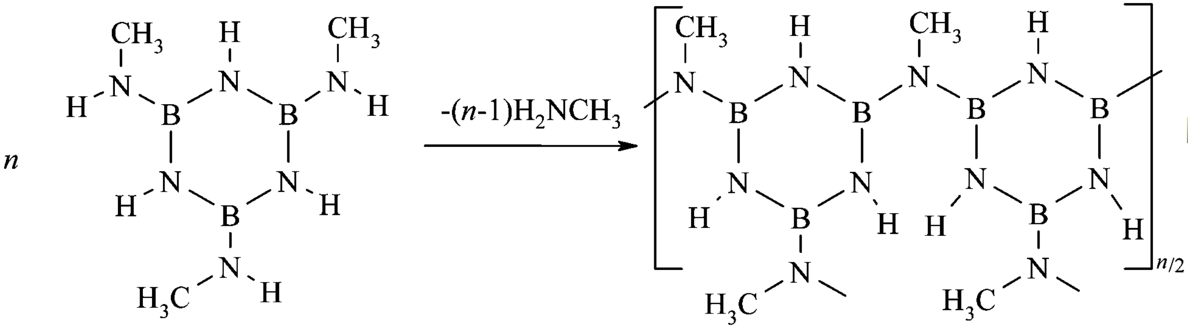
Liquid/Vapor or Liquid/Solid state process

2,4,6-tri(methylamino)borazine (s)
Polymers with lower ceramic yield
and good processability

↓

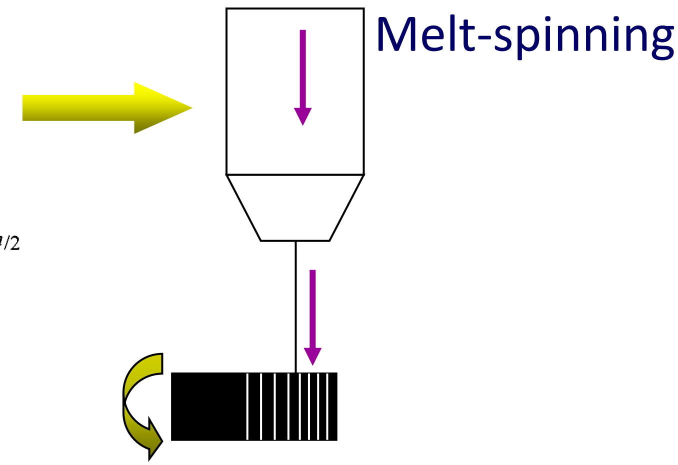
Molten state/solution

Boron nitride fibers : *Polymer melt-spinning*



B-tri(methylamino)borazine

Poly[*B*-(methylamino)borazine]

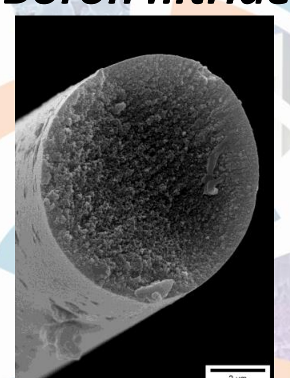


NH_3 /1000°C

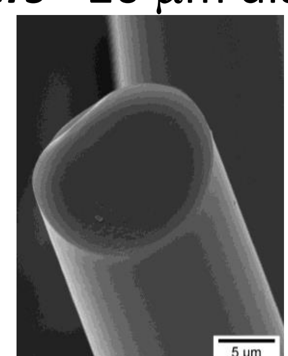
N_2 /1800°C

Boron nitride fibers - 10 µm diameter

Polymeric fibers - 20 µm diameter



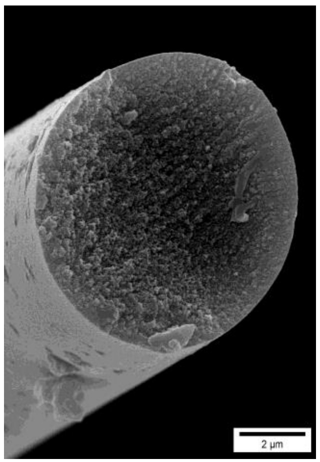
- σ up to 2 GPa and E up to 400 GPa



Boron nitride fibers : *Polymer melt-spinning*

BN FIBERS MECHANICAL PROPERTIES

Fibres BN dérivées de $(NHMe)_3B_3N_3H_3$



- *surface lisse*
- *structure granulaire*

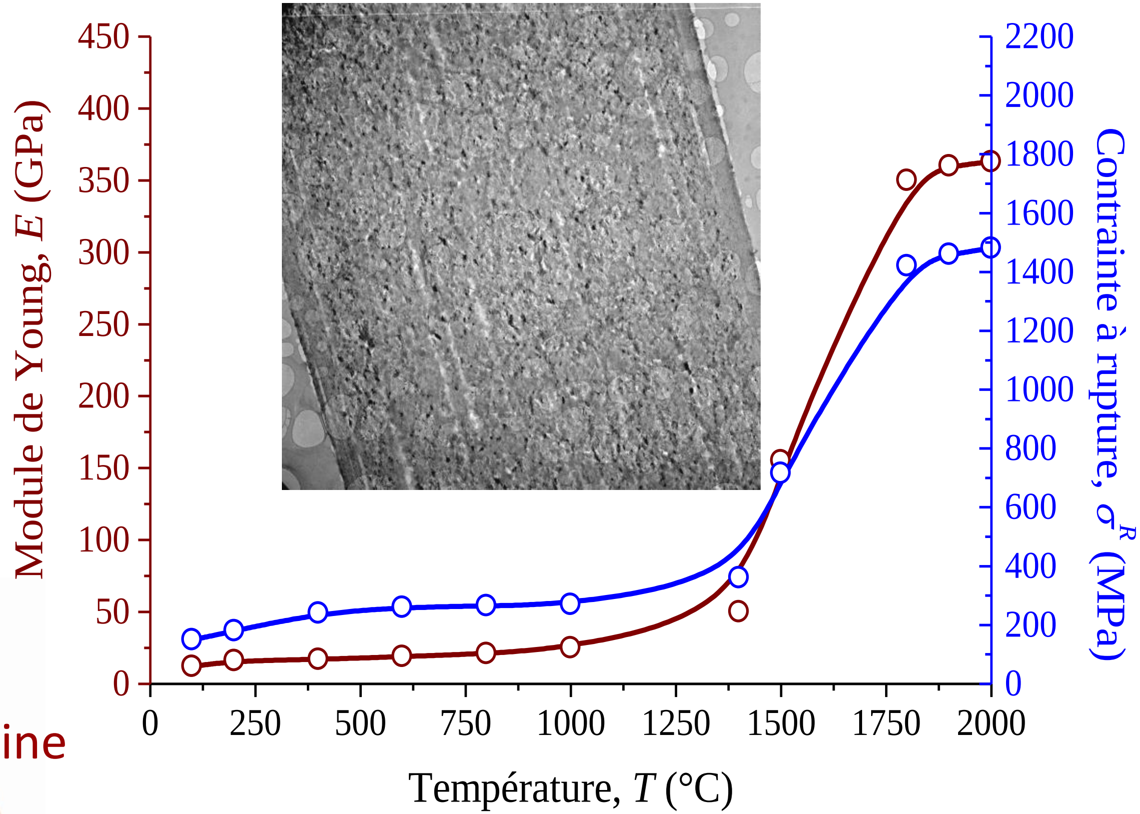
➲ fibre polycristalline

Tensile strength: 1460 MPa

Young modulus: 400 GPa

Diameter: 7.5 µm

Evolution des propriétés mécaniques avec la température:



Contrainte à la rupture ↗ lorque T ↗ 1800°C

σ ~ 2 GPa et E ~ 400 GPa

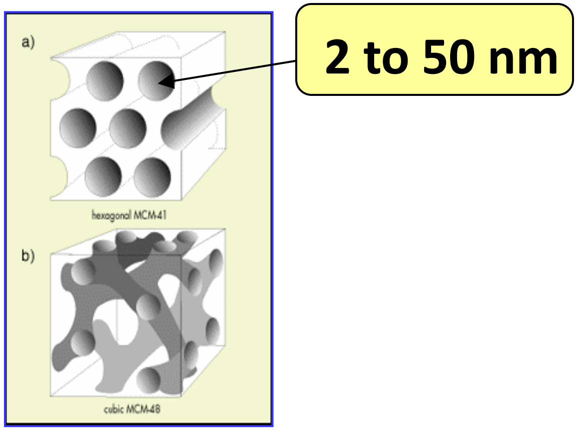
Porous boron nitride : *Nanocasting*

Boron nitride ordered mesoporous powder

➔ **Mesoporous materials :** high specific surface area, narrow pore size distribution

➔**Applications**: Catalysis, separation, nanoreactor,...

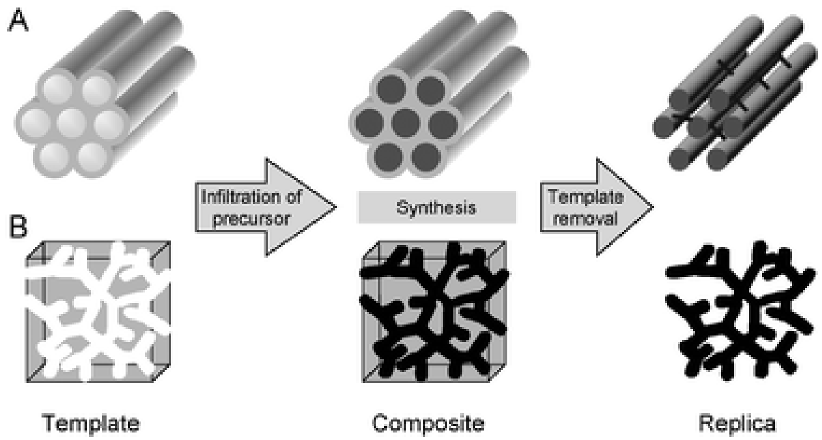
Synthesis : soft template →
(siliceous mesoporous materials)



Non-siliceous mesoporous materials :

Replication of nanoscale structures by direct templating process

➔ **Hard - template** →



A. Walcarius. Chem. Soc. Rev., 2013, **42**, 4098-4140

Refractory mesostructured nanoporous materials : BN, SiBCN

Silica template : SBA-15 (hexagonal) KIT-6 (cubic)

Carbon template : CMK-3 (hexagonal) CMK-8 (cubic)

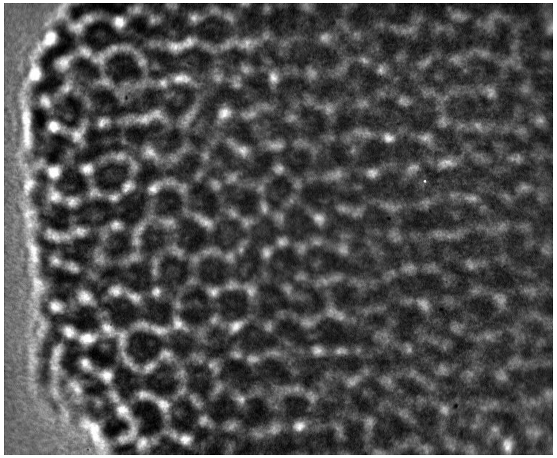
Porous boron nitride : *Nanocasting*

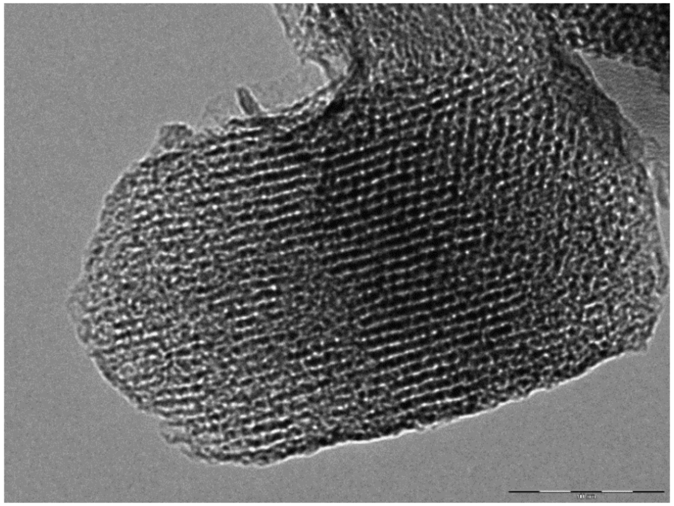
ORDERED MESOPOROUS BORON NITRIDE VIA "HEXAGONAL CARBON" TEMPLATING (CMK-3)

CMK-3

TEM

BN-ex CMK-3





- ➔ **Ordering of the porous structure providing by the carbon template preserved**
- ➔ **Centers of the channels distant of ~ 7 nm in agreement with the SA-XRD**

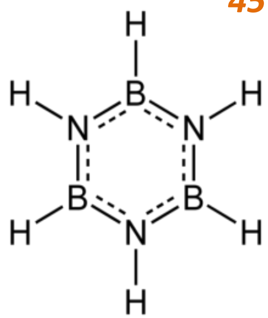
Efficiency of the template elimination process

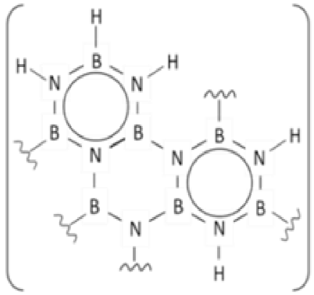
Retention of a porous BN structure

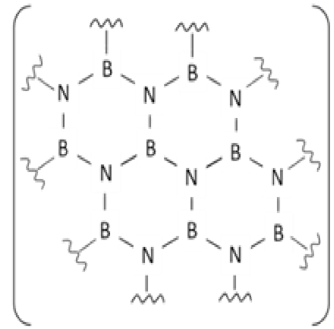
Borazine-derived boron nitride : *Liquid/solid-state process*

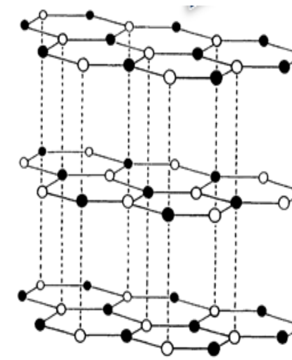
Borazine → Polyborazylene → BN

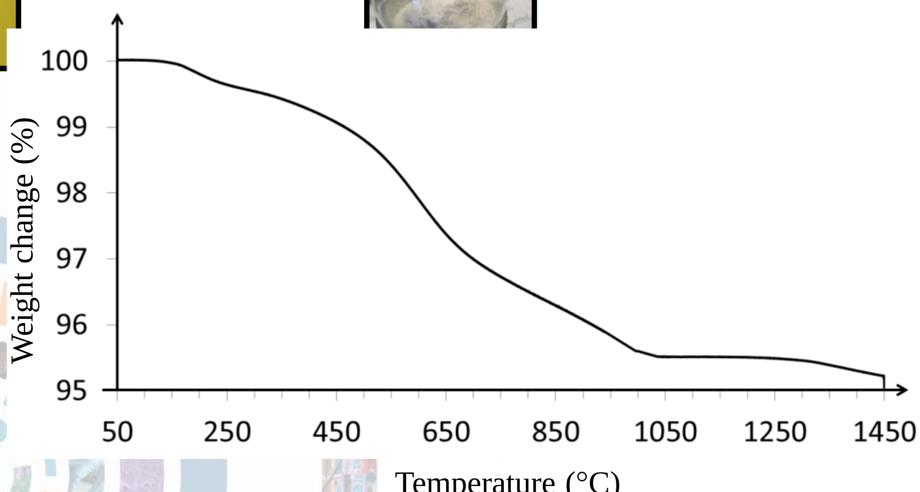
Borazine — *Polymerisation* ($45°C, 50°C, 60°C$) → **Polyborazylene** — *Pyrolysis* (N_2 $1000°C$) → **Amorphous BN** — *Annealing* (N_2 $>1450°C$) → **Crystalline BN**

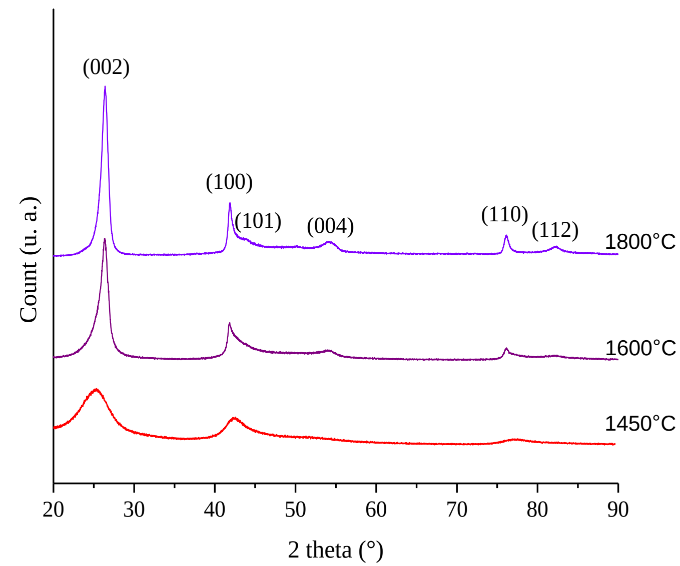








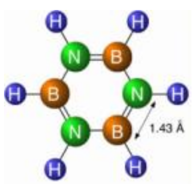




Boron nitride : *Liquid/solid-state process*

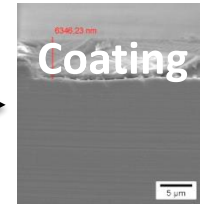
Borazine ➔ Polyborazylene ➔ BN

Borazine



borazine $(HBNH)_3$

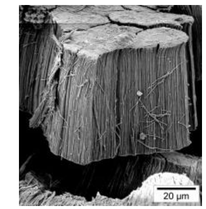
45°C → **Polyborazylene (PB45, l)** — *Dip-Coating* → **Film PB** — *Pyrolysis* →



H. Termoss, B. Toury, S. Payan, A. Brioude, S. Bernard, D. Cornu, S. Vallette, S. Benayoun, P. Miele, *J. Mater. Chem.*, **19**, 2009, 2671

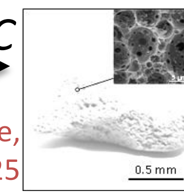
50°C → **Polyborazylene (PB50, l)** — *Impregnation* →

- *Membranes* → **Al_2O_3/PB50** — *Pyrolysis + Al_2O_3 removal* →



M. Bechelany, S. Bernard, A. Brioude, P. Stadelmann, C. Charcosset, K. Fiaty, D. Cornu, P. Miele, *J. Phys. Chem. C*, **111**, 2007, 13378

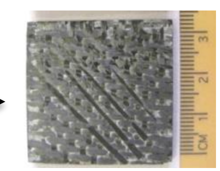
- *C foams* → **C/PB50** — *Pyrolysis + C removal* →



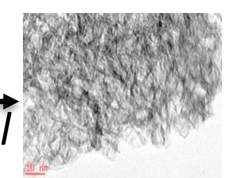
J. G. Alauzun, S. Ungureanu, N. Brun, S. Bernard, P. Miele, R. Backov, C. Sanchez, *J. Mater. Chem.* **21**, 2011, 14025

60°C → **Polyborazylene (PB60, sol.)**

PB50 + PB60 — *Impregnation* → **Composite C/PB50/60** — *Pyrolysis* →



PB60 — *Impregnation of zeolite-derived carbon (ZdC)* → **Hybrid ZdC/PB60** — *Pyrolysis + ZdC removal* →

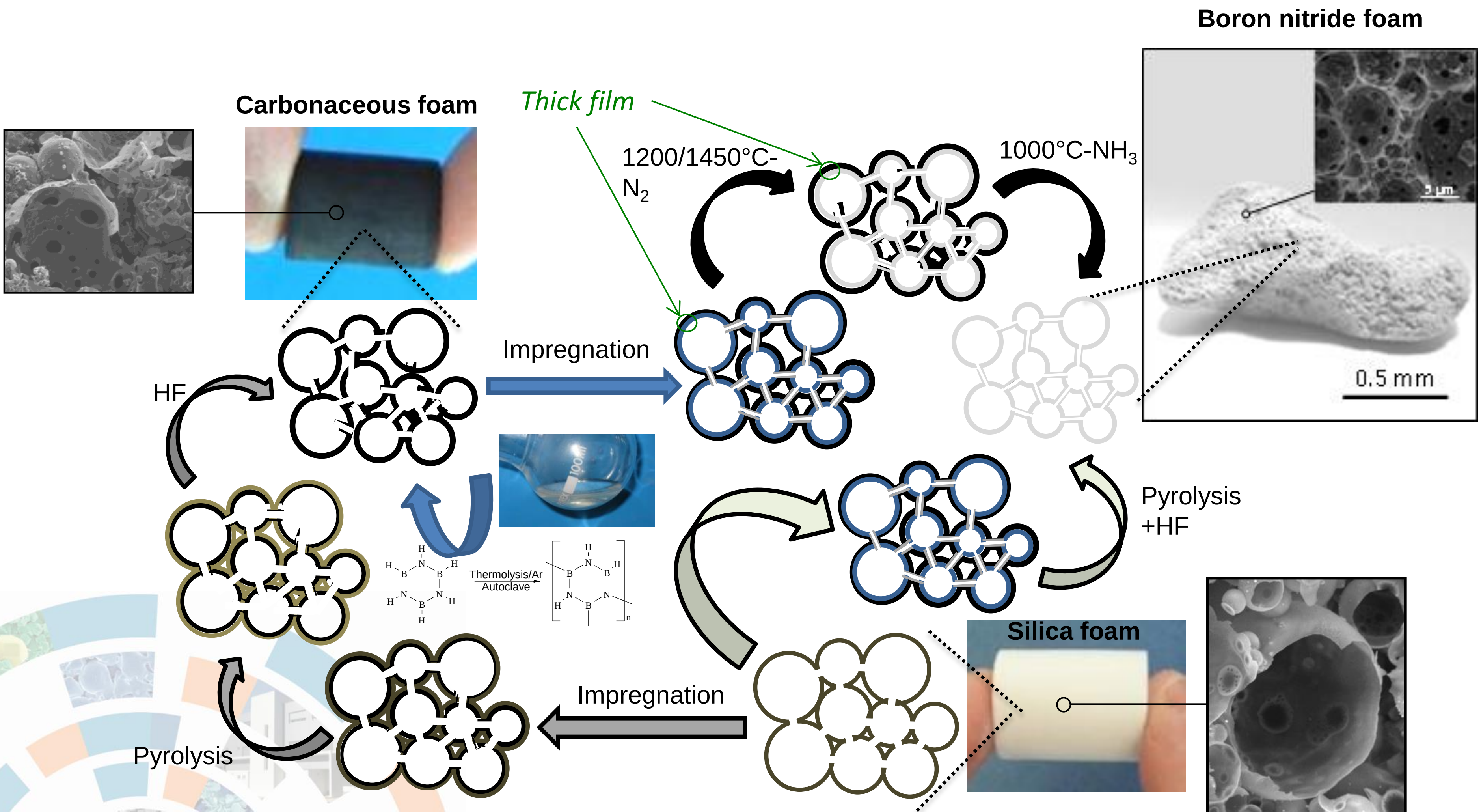


S. Schlienger, J. Alauzun, F. Michaux, L. Vidal, J. Parmentier, C. Gervais, F. Babonneau, S. Bernard, P. Miele and J. B. Parra, *Chem. Mater.*, **24**, 2012, 88

PB60 — *Warm-Pressing* → **PB piece** — *Pyrolysis* →

J. Li, V. Salles, S. Bernard, C. Gervais, P. Miele, *Chem. Mater.*, ***22***, 2010, 2010

Hierarchically porous boron nitride: *Hard templating*

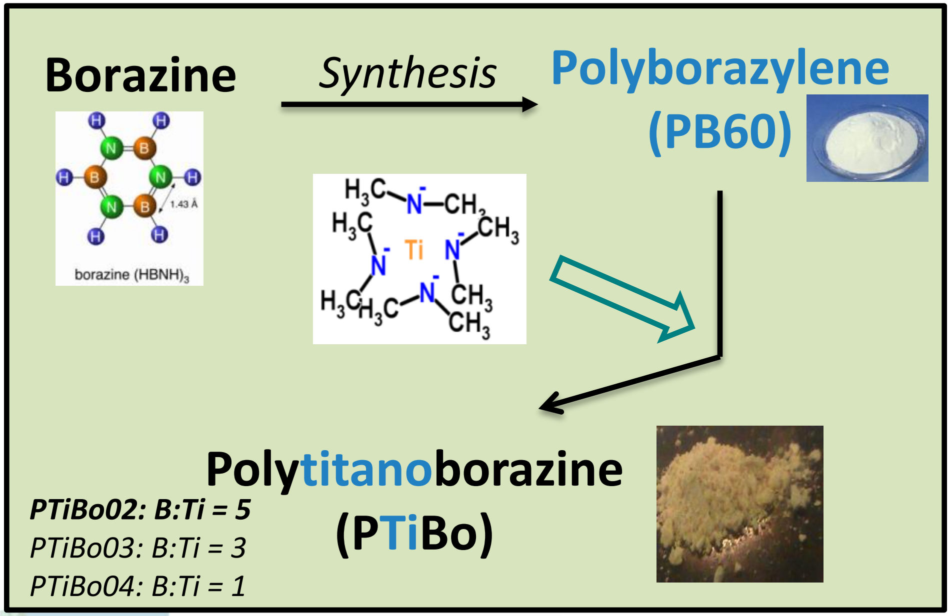


J. G. Alauzun, S. Ungureanu, N. Brun, S. Bernard, P. Miele, R. Backov, C. Sanchez, *J. Mater. Chem.* 2011, **21**, 14025.

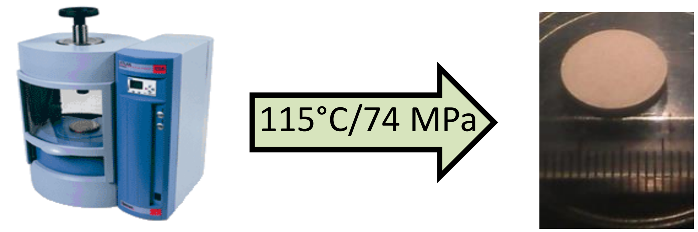
*** High Internal Phase Emulsion Process**
Adv. Funct. Mater. 2009, 19, 3136–3145, **R. Backov *et al*.**
CRPP UPR 8641 Université de Bordeaux

BN*Ti* nanocomposites: *Nanostructure*

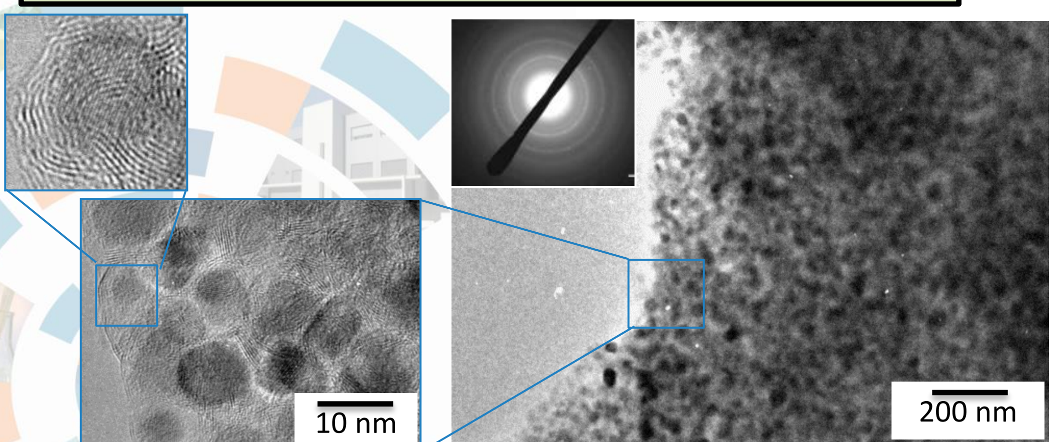
Polytitanoborazine ➔ Generation (after pyrolysis) of compounds with low miscibility

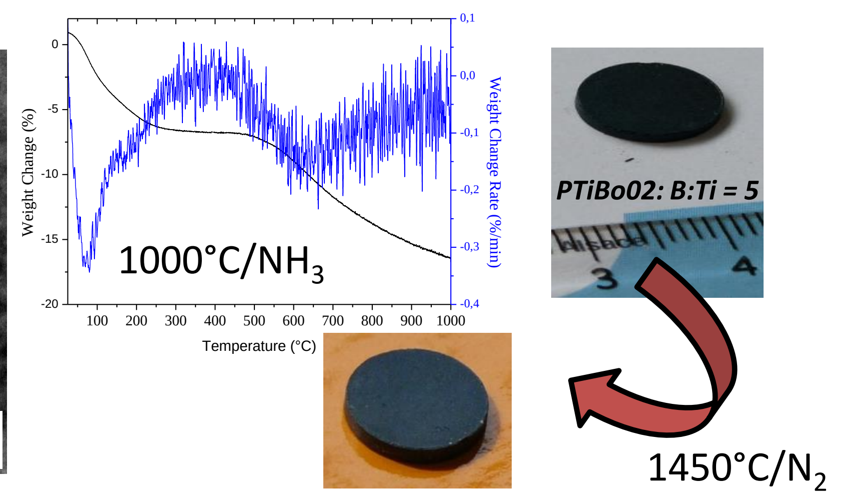


- ✓ Plastic polymers : -NCH_3- bridges



- ✓ Ceramic yield depends on terminating $N(CH_3)_2$ groups and reactive units (BH/NH)

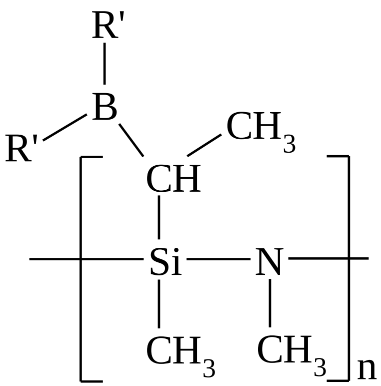




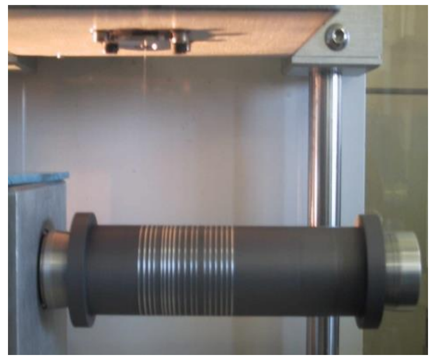
SiBCN fibers : *Polymer melt-spinning*

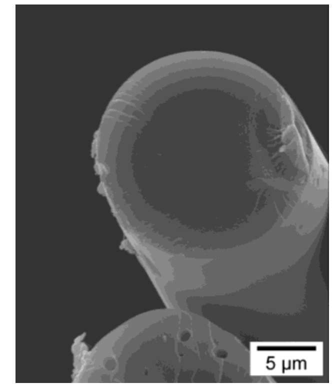
1st generation of SiBCN fibers by the PDCs route

Polymer —— *Melt-spinning* → Green Fibers

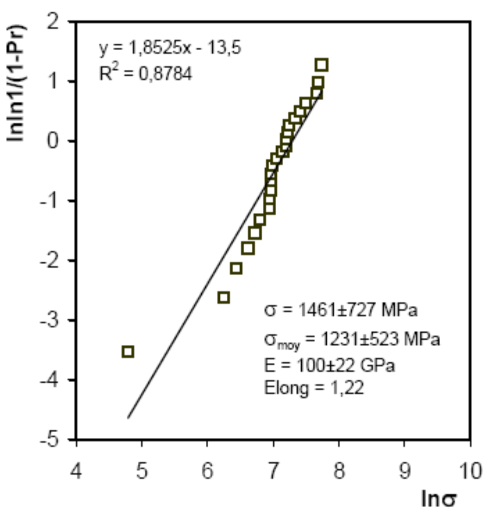


R' = $C_2H_4SiCH_3NCH_3$-





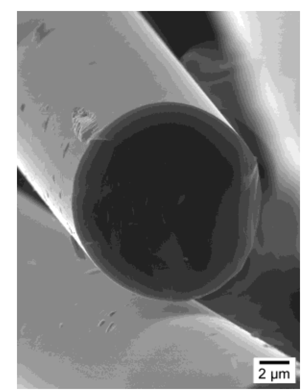
Curing : 200°C in NH_3 +
Pyrolysis : 1000°C in N_2



<u>Curing treatment @ 200°C in NH_3</u>

❖ Crosslinking degree of polymer increased
❖ Fiber cohesion kept during further pyrolysis
❖ Ceramic yield upon pyrolysis increased

<u>Pyrolysis @ 1000°C in N_2</u>



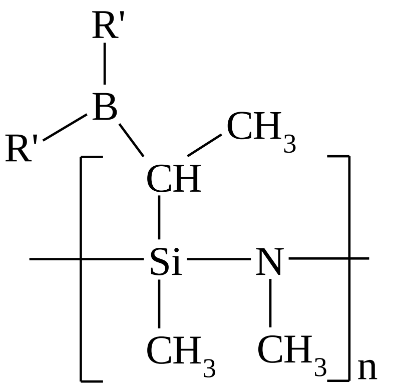
Final Ceramic Fibers

S. Bernard, W. Weinmann, D. Cornu, P. Miele, F. Aldinger. *J. Europ. Ceram. Soc.* (**2005**) **25**, 251-256.
S. Bernard, M. Weinmann, P. Gerstel, P. Miele, F. Aldinger, *J. Mater. Chem.* (**2005**) **15**, 289-299.

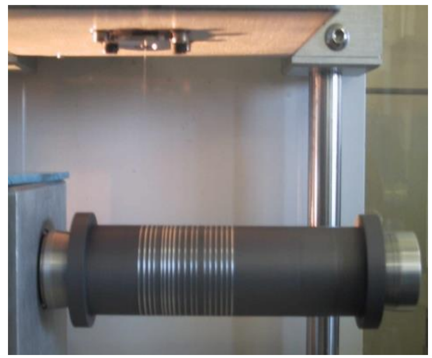
SiBCN fibers : *Polymer melt-spinning*

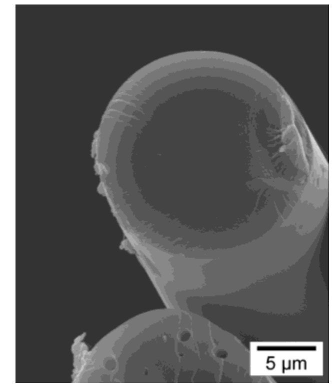
1^{st} generation of SiBCN fibers by the PDCs route

Polymer — *Melt-spinning* → Green Fibers

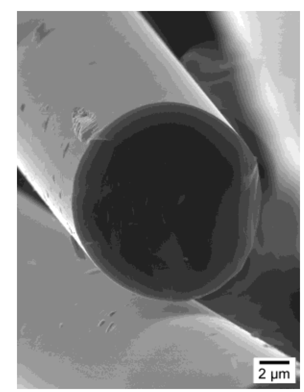


R' = $C_2H_4SiCH_3NCH_3$-

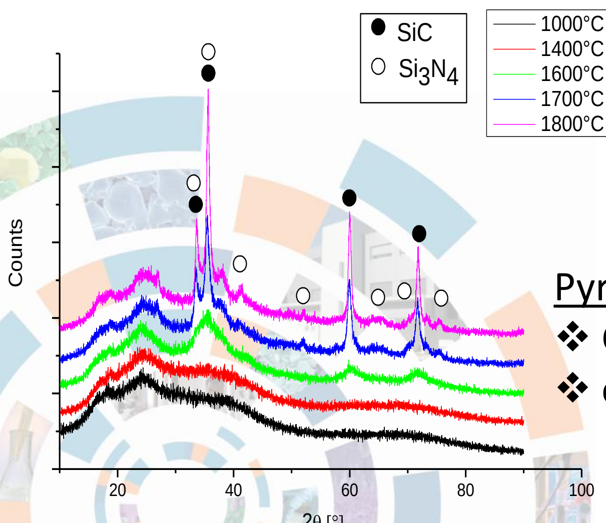




Curing : 200°C in NH_3 +
Pyrolysis : 1000°C in N_2



Final Ceramic Fibers



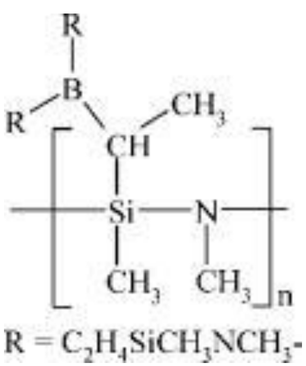
Pyrolysis @ 1000-1800°C in N_2

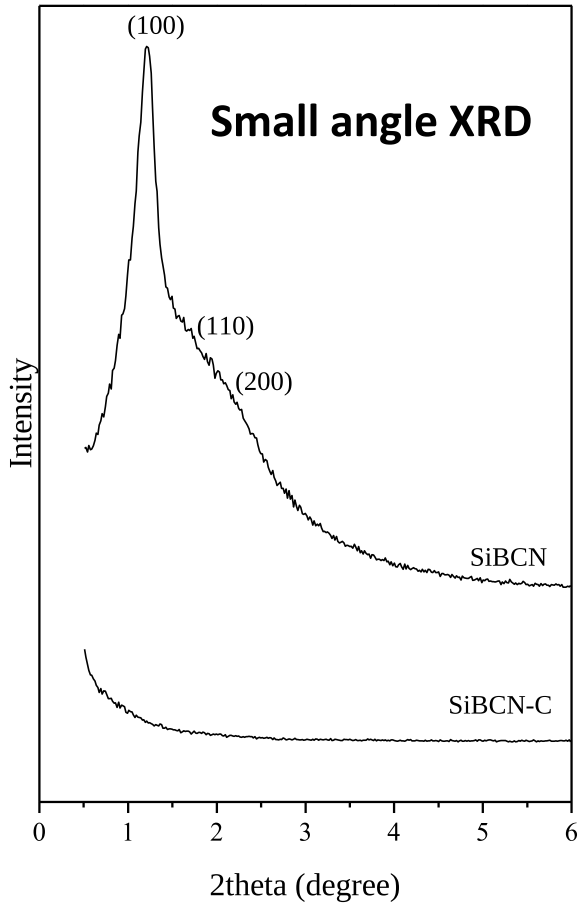
- Complete ceramization at 1400°C
- crystallization to Si_3N_4-SiC-BN

Nanostuctured porous SiBCN : *Nanocasting*

"HEXAGONAL" MESOPOROUS SiBCN *VIA* CMK-3 TEMPLATING

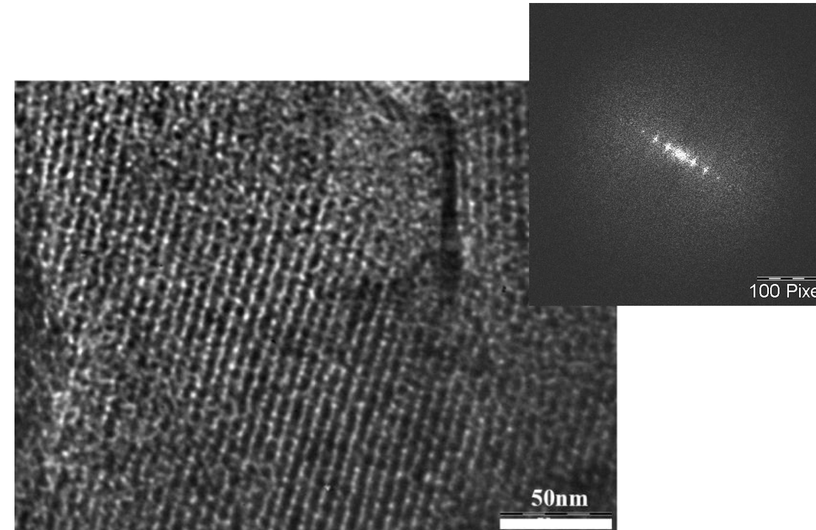
Polymer: $[B[C_2H_4SiCH_3NCH_3]_3]_n$

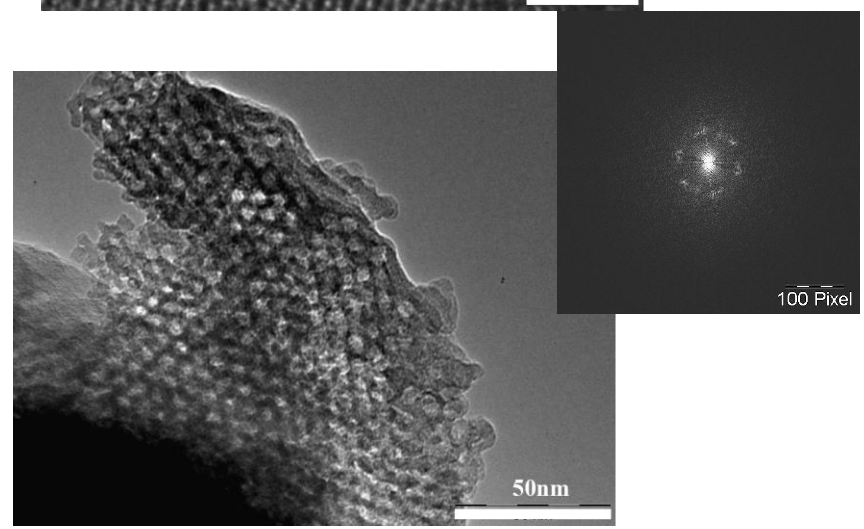




Surface area 600 m^2 g^{-1}
Pore diameter 3.6 nm

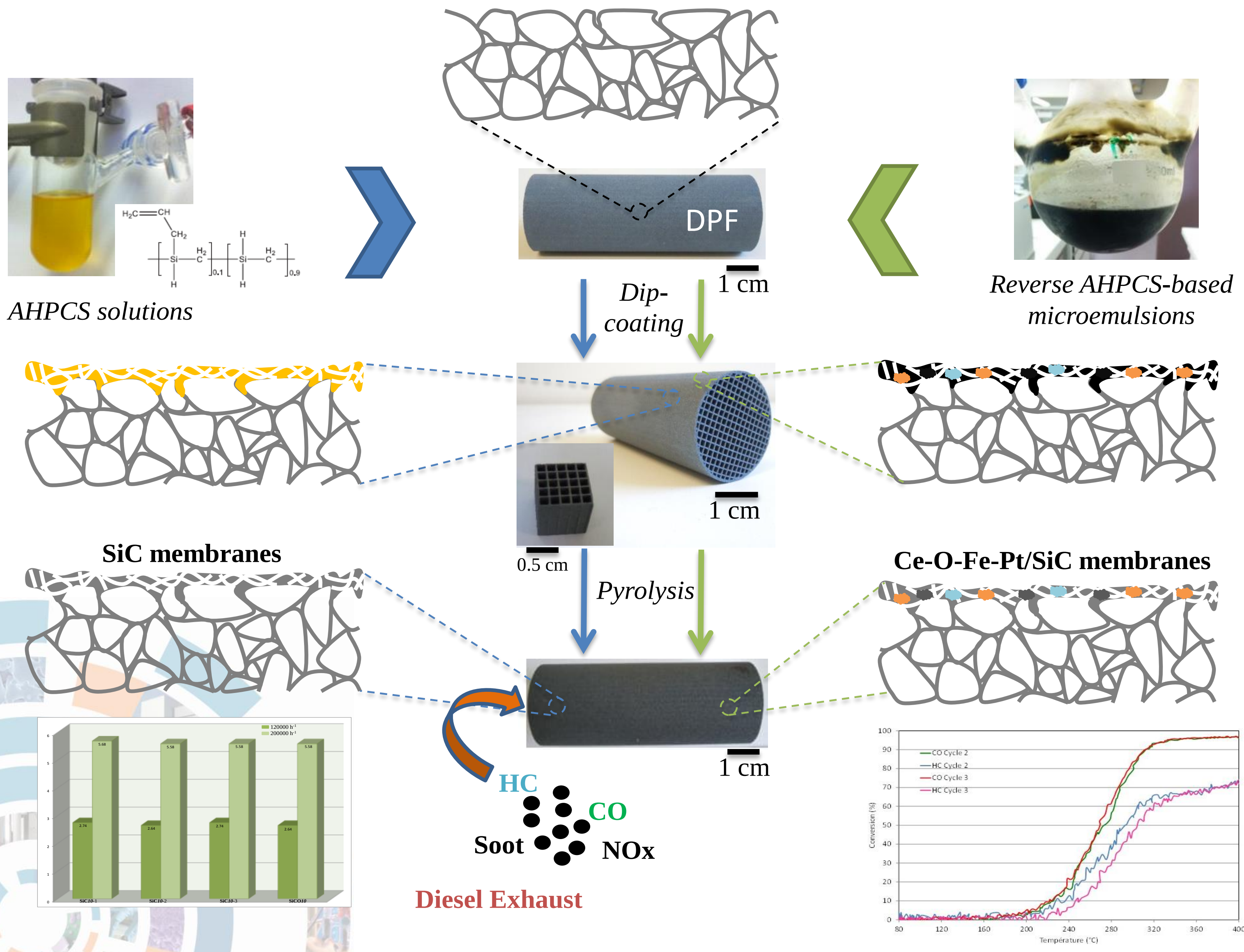
TEM



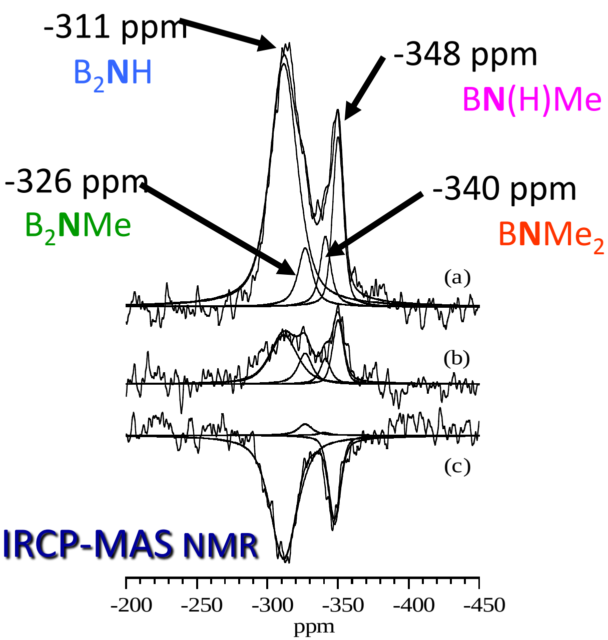


X-B. Yan, S. Bernard, P. Miele *et al.* Chem. Mater. (**2008**)20(20), 6325-6334

Catalytic SiC membranes : *Dip-coating*



Precursors Derived Ceramics et chimie du solide



^{15}N IRCP-MAS NMR

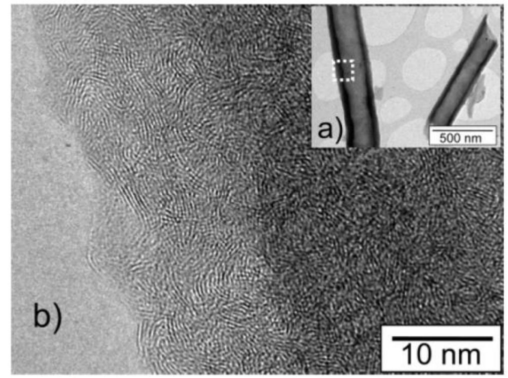
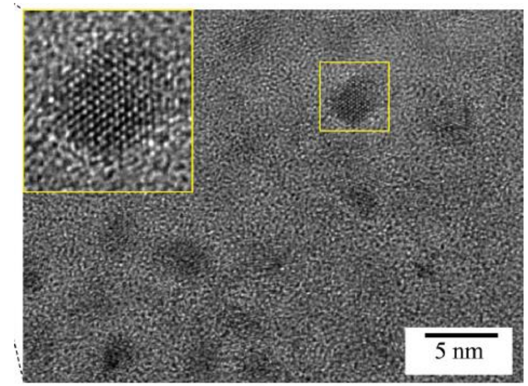
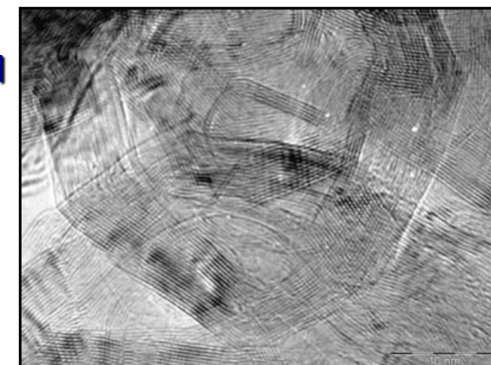


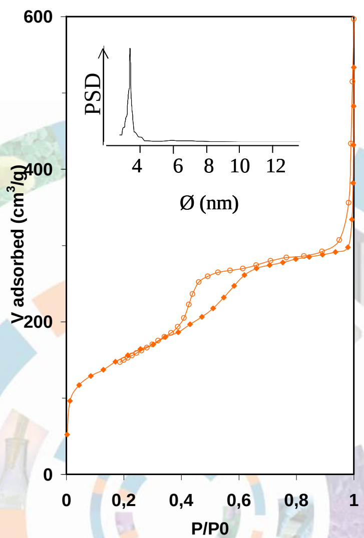
Figure 4. (a) TEM images of nanotubules produced at 1200 °C. (b) HRTEM observation of the stacking ordering (zone marked by the dotted square in the TEM image).

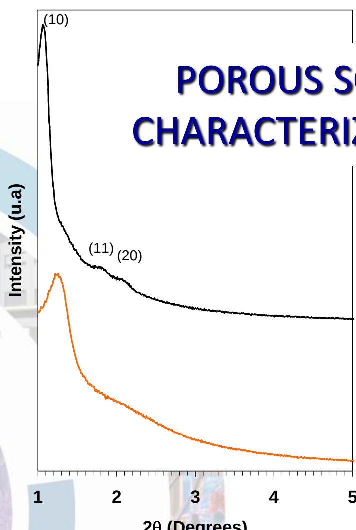


PDCs

HR TEM







POROUS SOLID CHARACTERIZATION

N_2 sorption Isotherms **Small-Angle XRD**

***AB INITIO* SIMULATION**

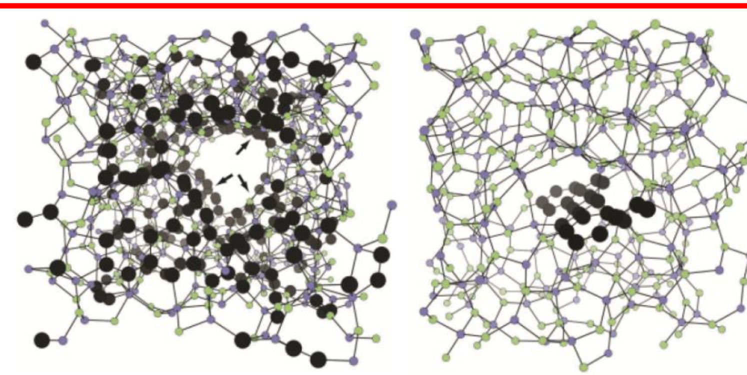


Fig. 18. Models for the segregation of carbon phase in SiCN ceramics.[361] (Images courtesy of P. Kroll).

Collaborations/contacts/réseau

France :

LCTS UMR5801, Bordeaux

LCMCP UMR7574, Paris 6

IS2M UMR7228, Mulhouse

CIRIMAT UMR5085, Toulouse

SPCTS UMR7315, Limoges

IPR UMR6251, Rennes

CRISMAT UMR6508, Caen

Germany : Technische Universität Darmstadt, Universität Bayreuth

Italy : Universita di Trento (Trento), Universita di Padova

Slovakia : Slovak Academy of Sciences (Bratislava)

Sweden : Stockholm University

Japan : Waseda University (Tokyo); Nagoya Institute of Technology (Nagoya)

USA : Clemson University (Clemson)

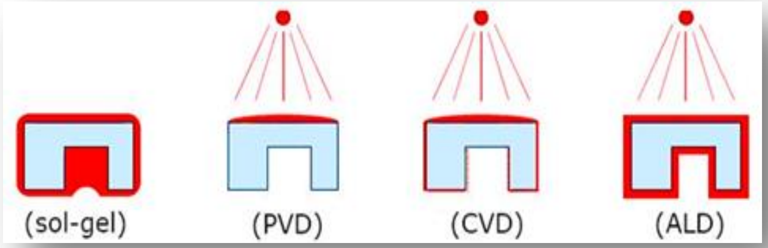
Brasil : Federal University of Santa Catarina (Florianopolis)

India : Indian Institute of Technology (Madras)

Atomic Layer Deposition : *Interest*

4 Home-made ALD setups (LTALD, HTALD and PEALD)

Oxides (i.e. ZnO, TiO_2, Al_2O_3)
Non-oxides (i.e. Nitride: BN, TiN, AlN)
Metallic nanoparticles



Conformal coating

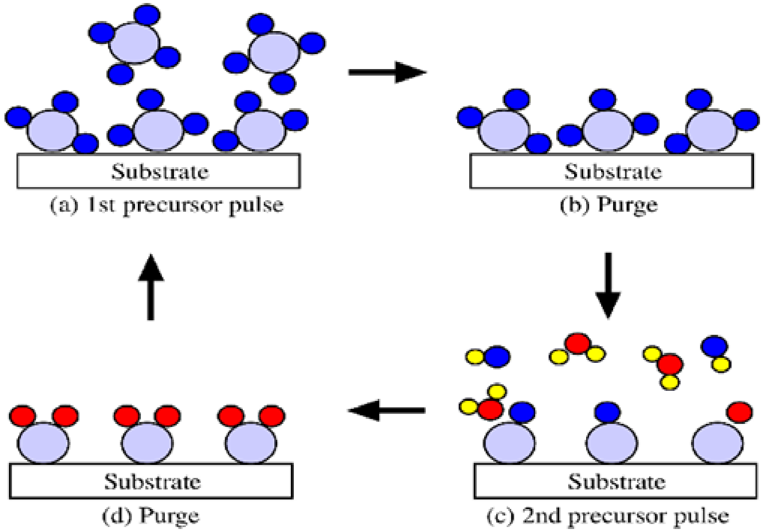
One Cycle of ALD:

Step 1 : Pulse precursor 1

Step 2 : Exposure + Purge

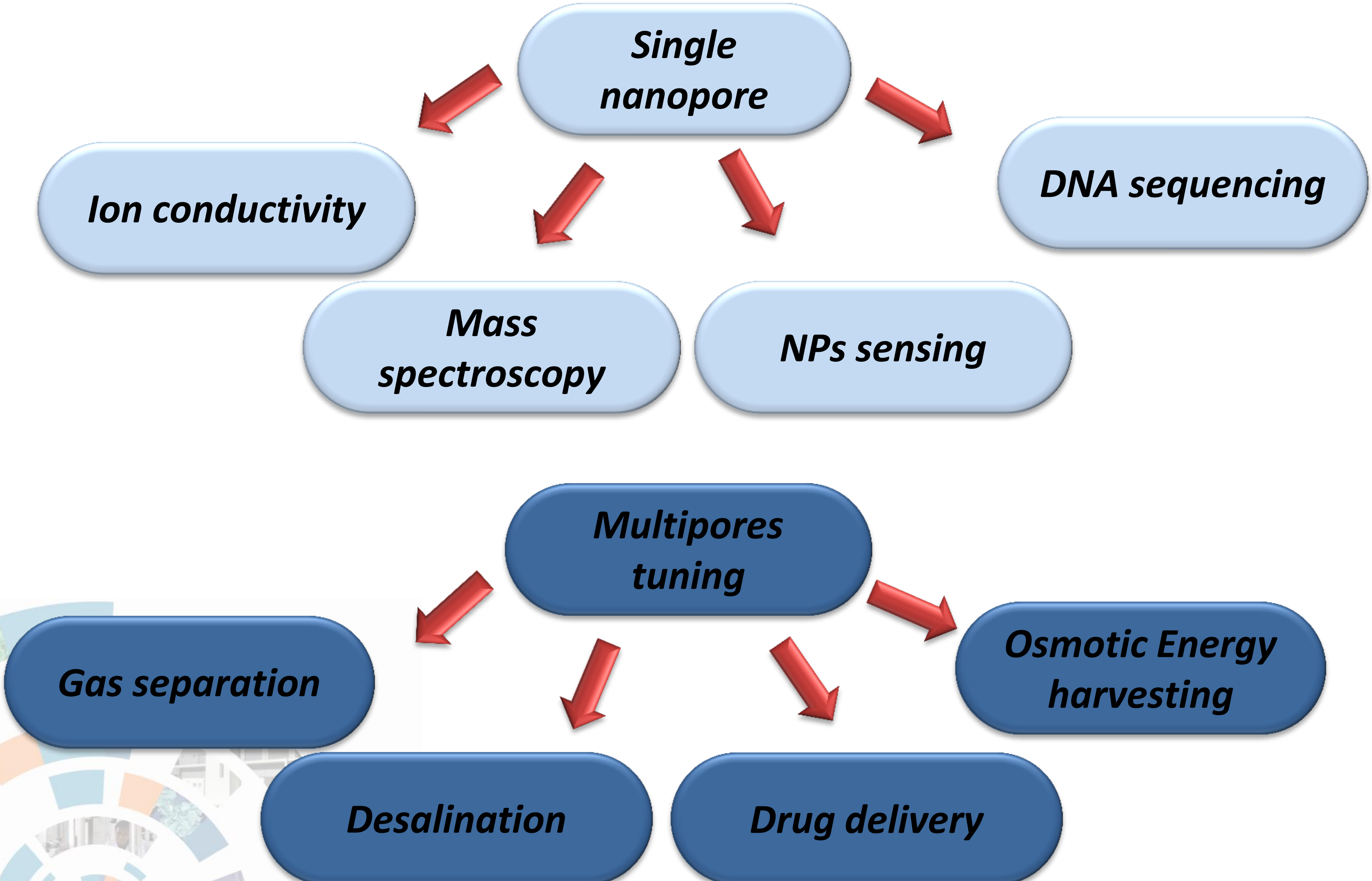
Step 3 : Pulse precursor 2

Step 4 : Exposure + Purge



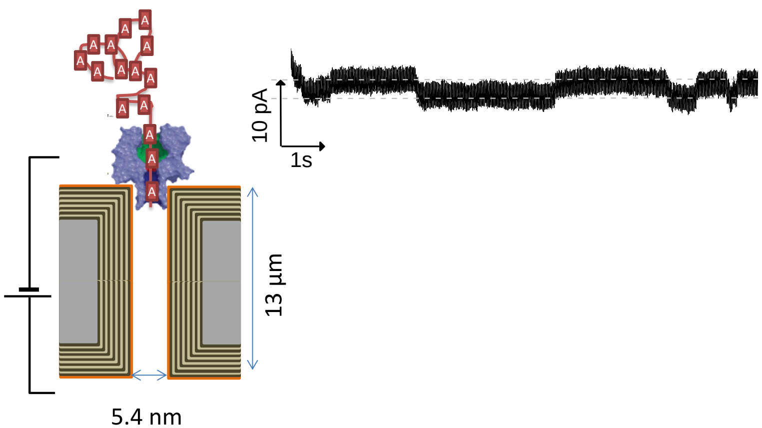
Adv. Mater. 2012 **24** 1017

Atomic Layer Deposition : *Membranes applications*



Atomic Layer Deposition : *Membranes applications*

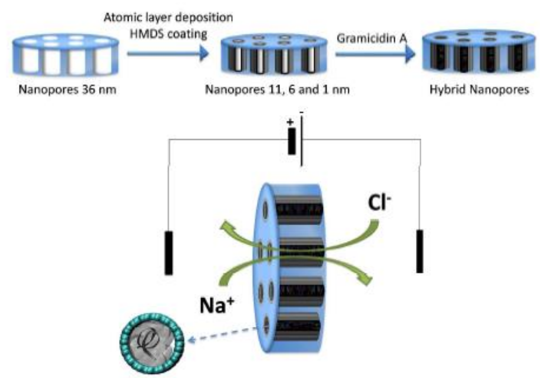
DNA sequencing



Nanoscale 2013 **5** 9582

Nanotechnology 2015 **26** 144001

Water desalination

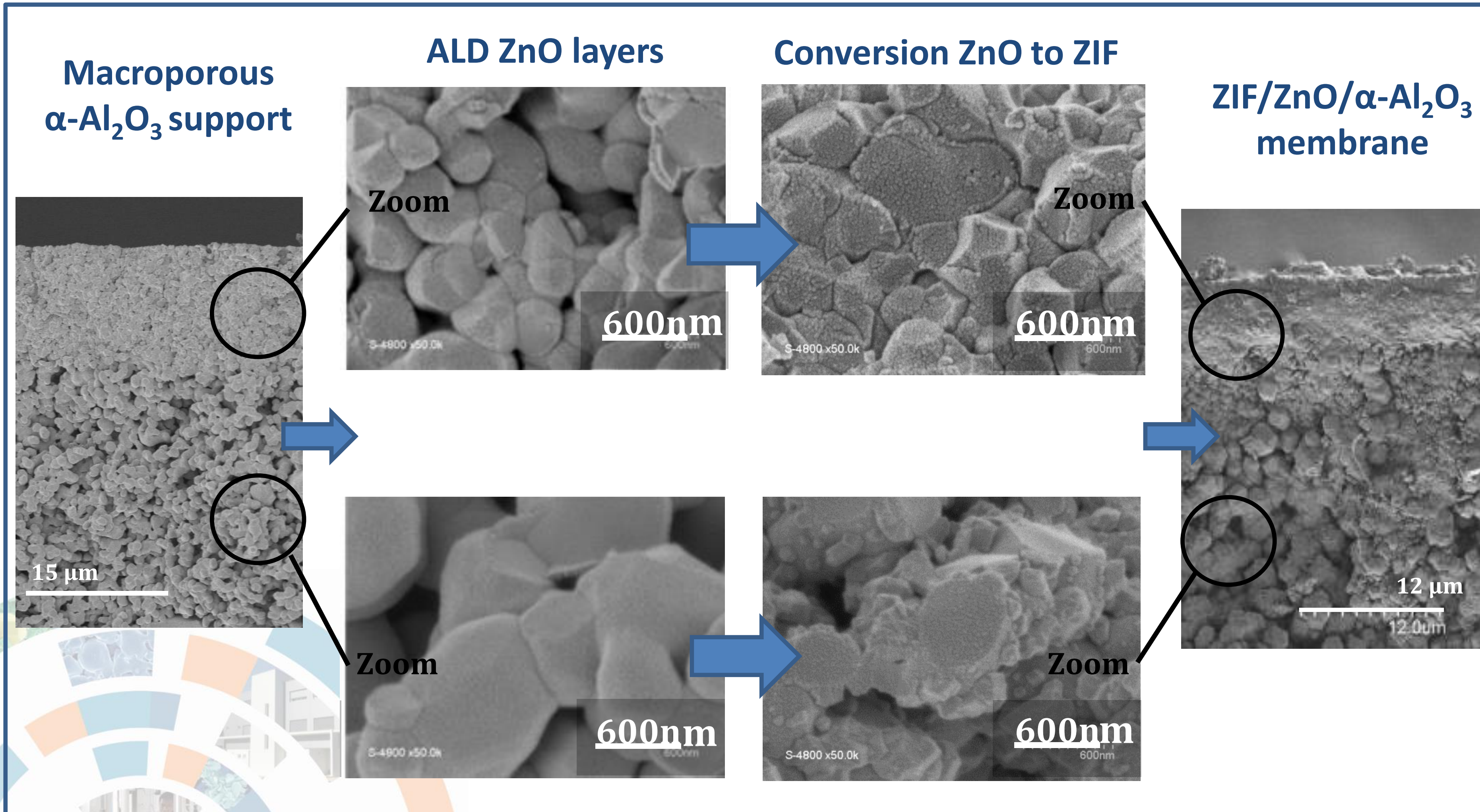


J. Phys. Chem. C 2013 **117** 15306

Chem. Comm. 2015 **51** 5994

Confinement of MOFs for membranes preparation

- *COUPLING "ALD" AND "SOLVOTHERMAL CONVERSION"*

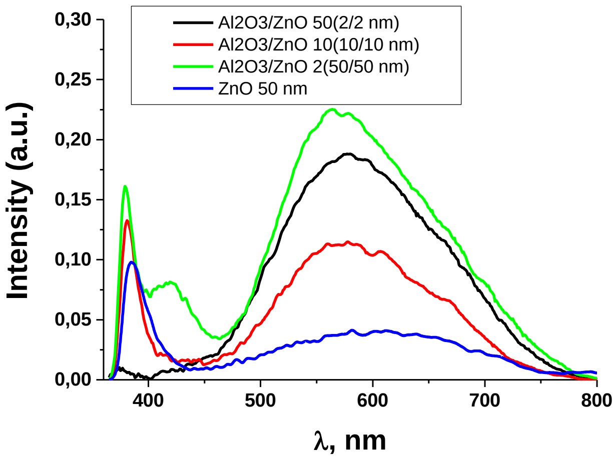


→ Gas selective membrane with high mechanical and thermal stability

M. Drobek, M. Bechelany et al., Journal of Membrane Science 475 (2015) 39–46

Atomic Layer Deposition : *Other applications*

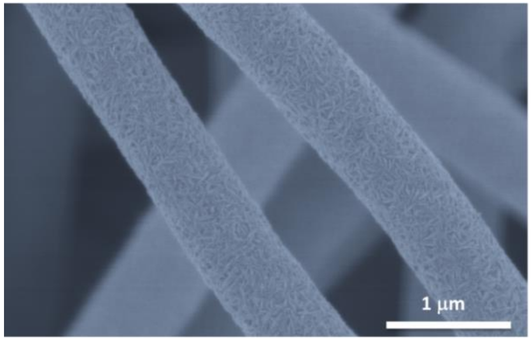
Optical (Bio)Sensing

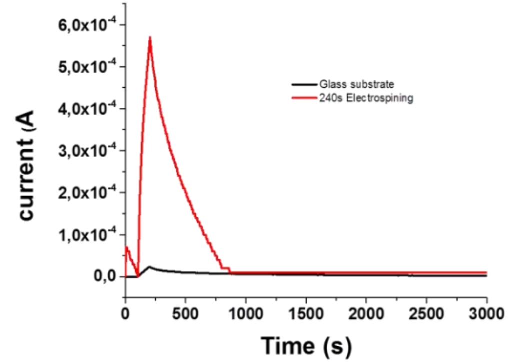


J. Phys. Chem. C 2014 **118** 3811

J. Mater. Chem. C 2015 **3** 6815

UV & Gas sensing

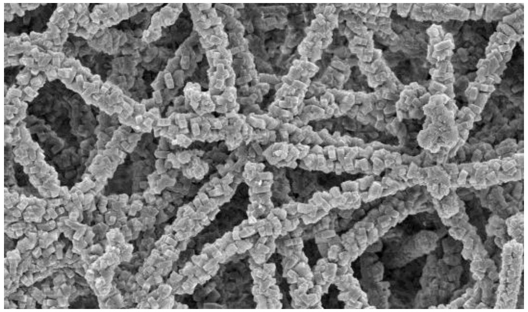




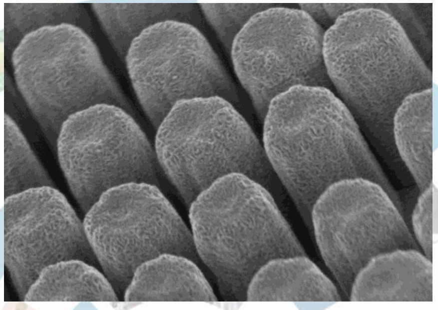
J. Mater. Chem. A 2014 **2** 20650

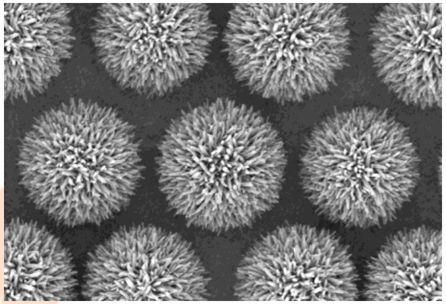
Nanotechnology 2015 **26** 105501

MOF conversion



Photovoltaïc





Nano Energy 2012 **1** 696

Nanoscale 2015 **7** 5794

J. Membr. Sci. 2015 **475** 39

Collaborations/contacts/réseau

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EMPA

Materials Science & Technology

Acknowledgments

Dalton Transactions

Boron Nitride Ceramics from Molecular Precursor: Synthesis, Properties and Applications

Samuel Bernard, Chrystelle Salameh† and Philippe Miele*

Received 00th January 20xx,
Accepted 00th January 20xx

DOI: 10.1039/x0xx00000x

Materials Views
www.MaterialsViews.com

Adv. Mater. **2012**, *24*, 1017–1032

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Atomic Layer Deposition of Nanostructured Materials for Energy and Environmental Applications

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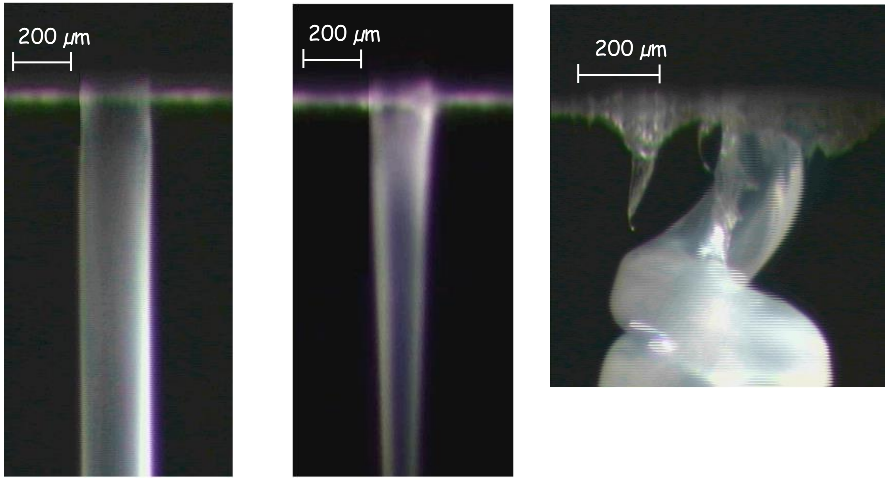
+ nombreux thésards

Boron nitride fibers : *Polymer melt-spinning*

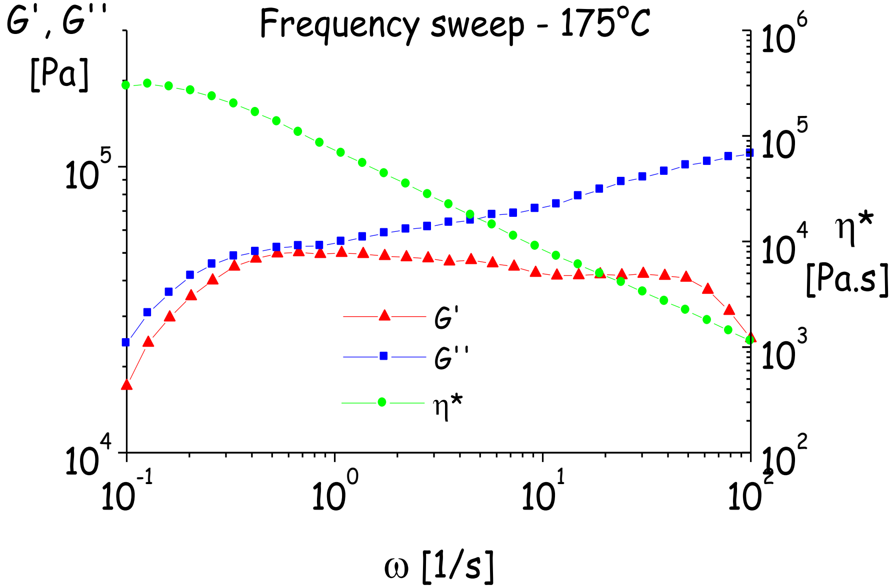
MELT-SPINNABILITY OF POLY(METHYLAMINO)BORAZINE

- **Medium-T_g Polymer (T_g~80°C)**

Pure extrusion | Stretching | Rupture



- **Viscoelastic behavior (shear rheometry)**

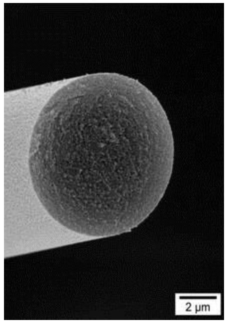


- **good spinnability at medium rate**
- **fiber rupture at high rate**
- **smooth, defect-free green fibers**

G'' (viscous modulus) > G' (elastic modulus) at all ω

Drop of elasticity at high ω

- **high-performance BN fibers**

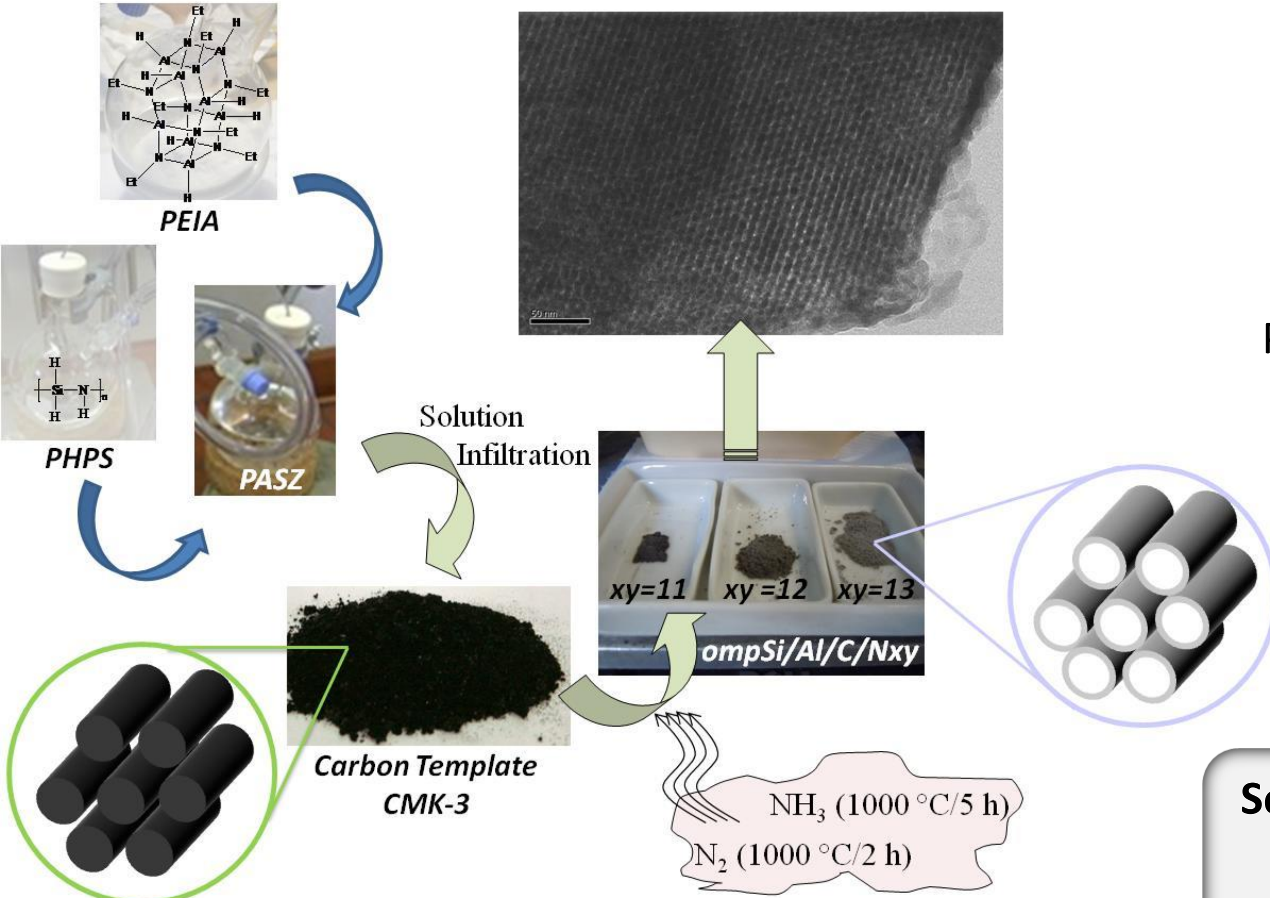


Tensile strength: 1460 MPa

Young modulus: 400 GPa

Diameter: 7.5 µm

Nanostuctured porous SiAlCN : *Nanocasting*



PolyEthylIminoAlane
= Precursor for Al(C)N

+

Poly(PerHydroPolySilazane)
= Precursor for Si_3N_4/Si

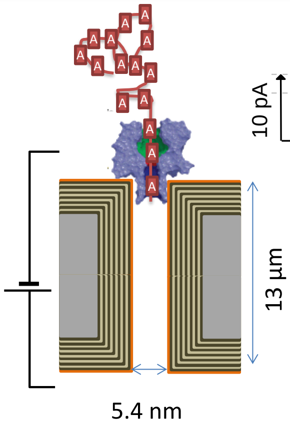
↓

PolyAluminoSilazane
= Precursor for Si/Al/C/N

Series of PASZ with different PEIA:PHPS (*Al:Si*) Ratio
⇒*1:1*; *1:2*; *1:3*

- First thermal treatment: under **N_2** at 1000°C for the **ceramic conversion**
- Second thermal treatment: under **NH_3** at 1000°C for the **template removal**

Atomic Layer Deposition : *Membranes applications*

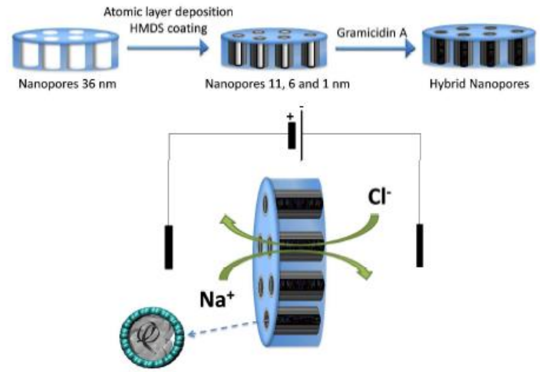


DNA sequencing

Nanoscale 2013 **5** 9582

Nanotechnology 2015 **26** 144001

Water desalination



J. Phys. Chem. C 2013 **117** 15306

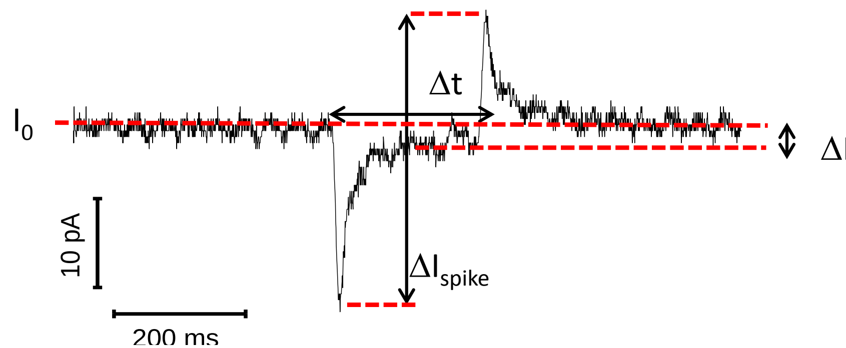
Chem. Comm. 2015 **51** 5994

Gas barrier

	Permeability (Barrer) O_2
PET substrate	**6.35 E-04**
ZnO 200 nm	1.02 E-06
Al_2O_3 200 nm	2.13 E-06
NL 100nm	1.31 E-07
NL 20nm	**8.74 E-08**
NL 4 nm	9.31 E-08

Paper in preparation

Mass spectroscopy



Sci. Rep. 2015 **5** 10135

Phys. Chem. Chem. Phys. 2014 **16** 17883

Soft Matter 2014 **10** 8413