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Colloidal processing of macroporous ceramic suspensions for preparing multilayer membrane supports

Presentation held at the International Symposium on inorganic interfacial engineering,

Stockholm, Sweden, June 20-21, 2006

B.C. Bonekamp

A. van Horssen

L.A. Correia

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Acknowledgement/Preface

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Abstract

The key factor in obtaining defect free macroporous membrane supports is found in the application of multiple inorganic suspension coatings rather than the use of a single somewhat thicker macroporous layer. Colloidal processing plays an important role in achieving such a multiple layer system. Finding the optimal coating conditions is, however, not a trivial task. In this presentation we discuss possible processing routes to obtain virtually defect free multiple layer systems through the use of design of experiments (DoE) in finding suitable coating conditions.

Keywords: membrane support, colloidal processing, suspension, porometry, bubble point, defect size, percolation, experimental design.

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Macroporous Ceramic Coatings for Membranes; Design of Experiments Colloidal Processing and Defects

Ben Bonekamp

IIE 2006

Stockholm June 21

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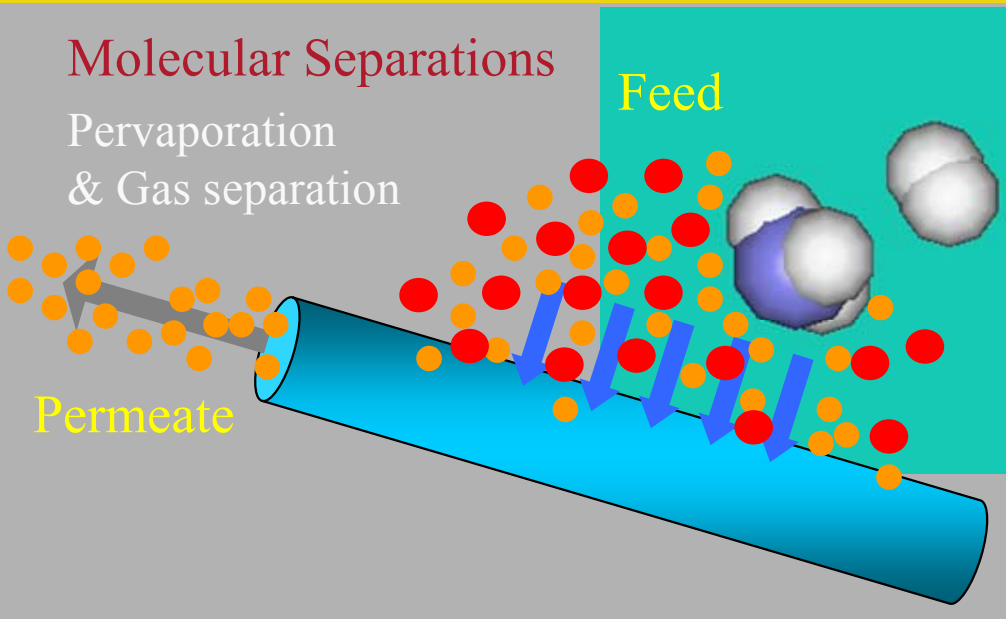
Molecular Separations

Pervaporation
& Gas separation



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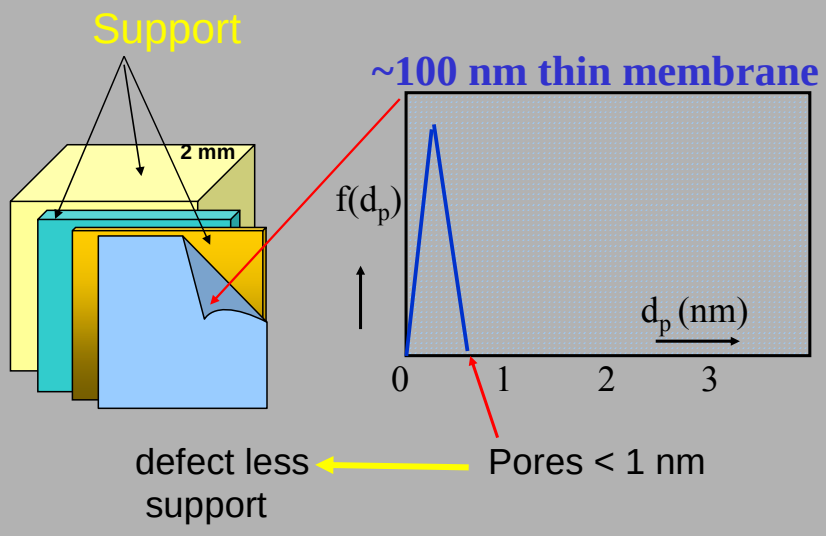
Molecular separation membrane



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The selectivity of a microporous membrane layer is largely determined by the defect density of the membrane substrate.

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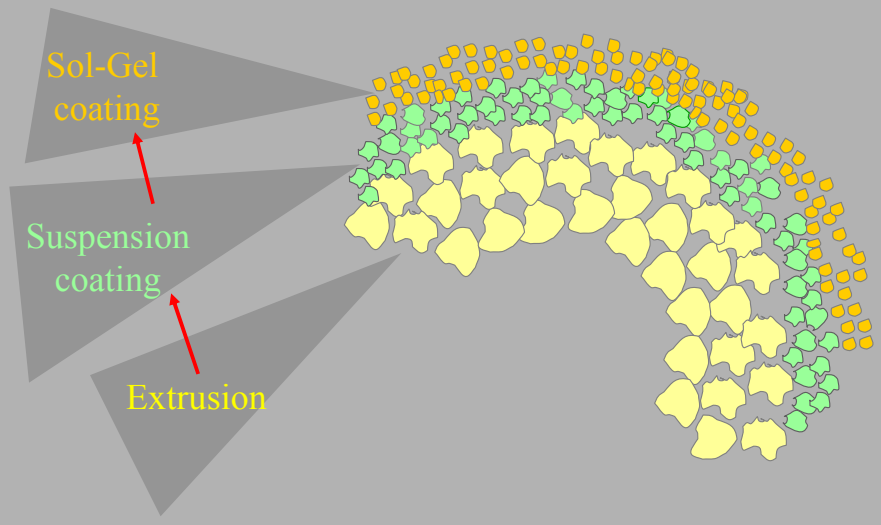
Multilayer porous support

Colloidal processing



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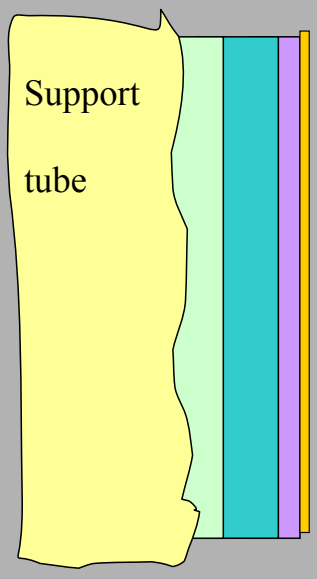
Optimizing the support system

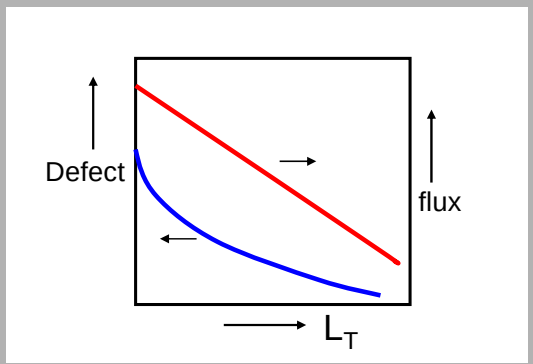
Design of Experiments



Stacking of layers

Minimum defect density

$L_T = L_1 + L_2 + \ldots ?$



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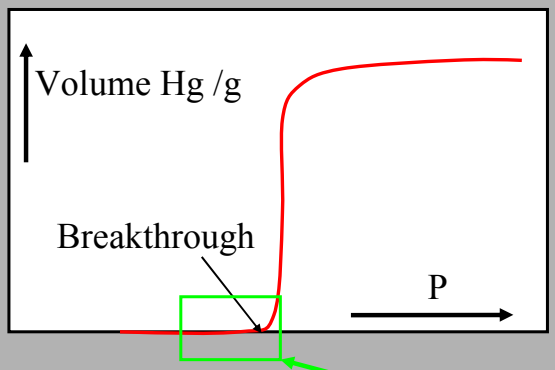
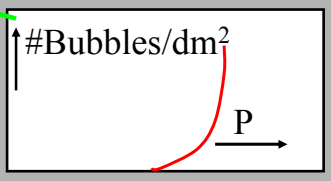
Bulk compacts:Hg porosimetry



$$J = \frac{4}{d} = \frac{1}{\gamma \cos\theta} \times \Delta P$$

Coatings: Bubble porometry



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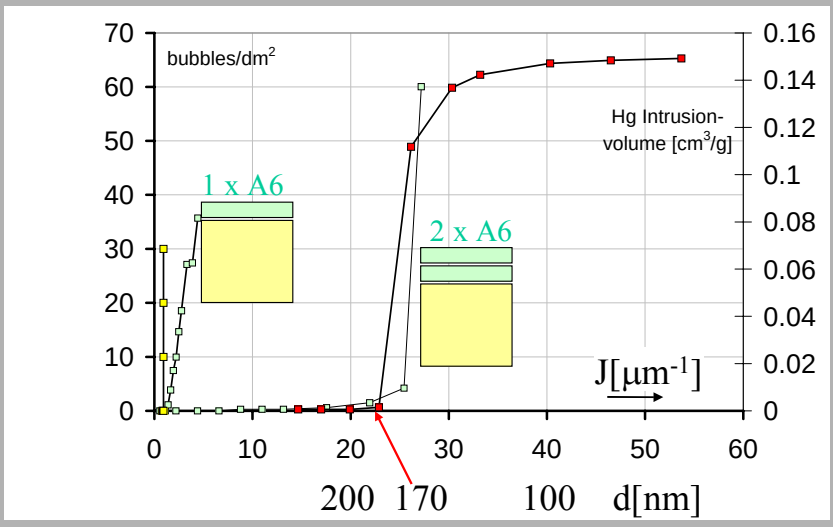
Porometry A6 support coatings



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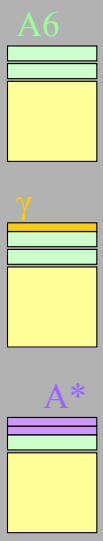
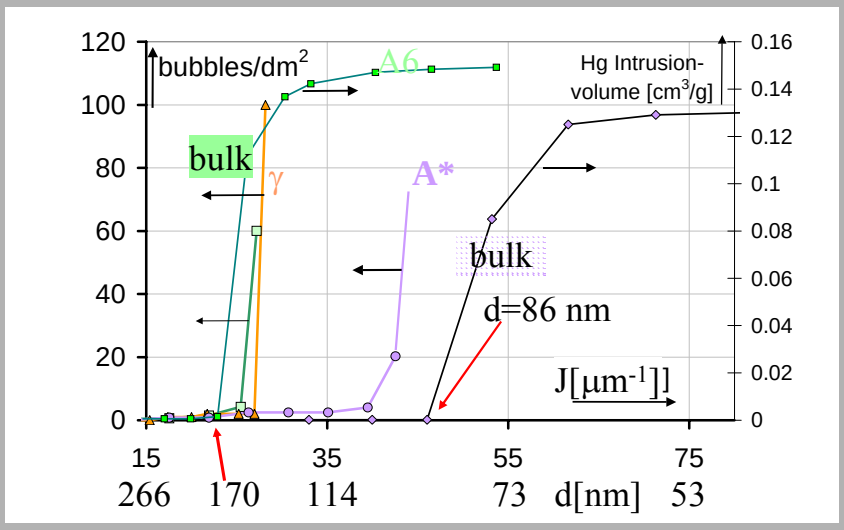
Porometry A6 and A* coatings





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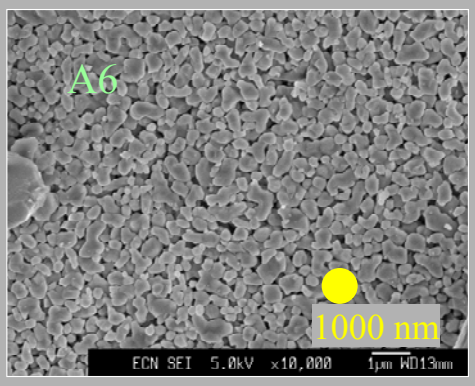
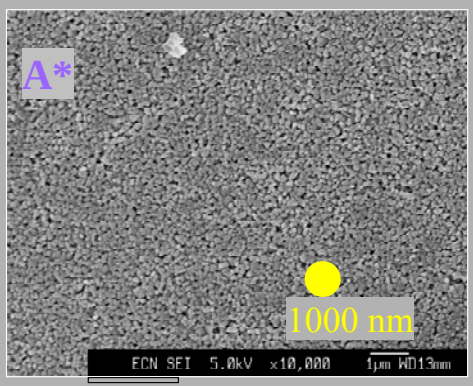
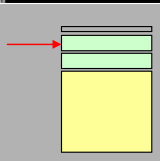
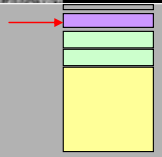
Surface α-alumina coatings









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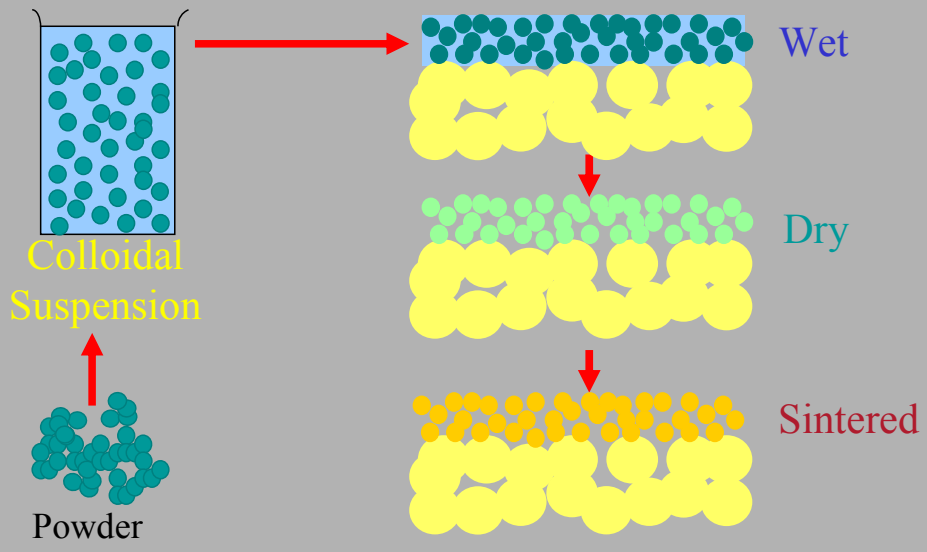
Suspension coating



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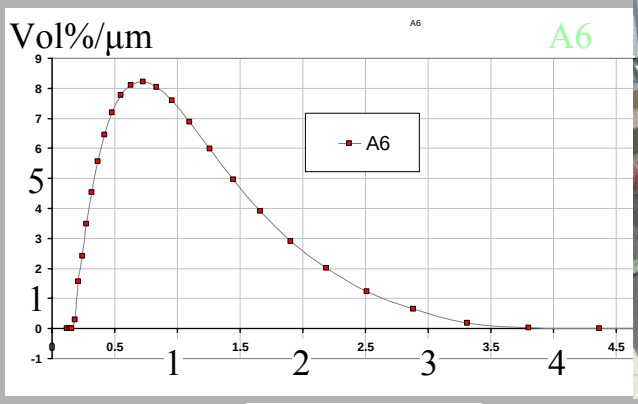
Powder dispersion using an attritor



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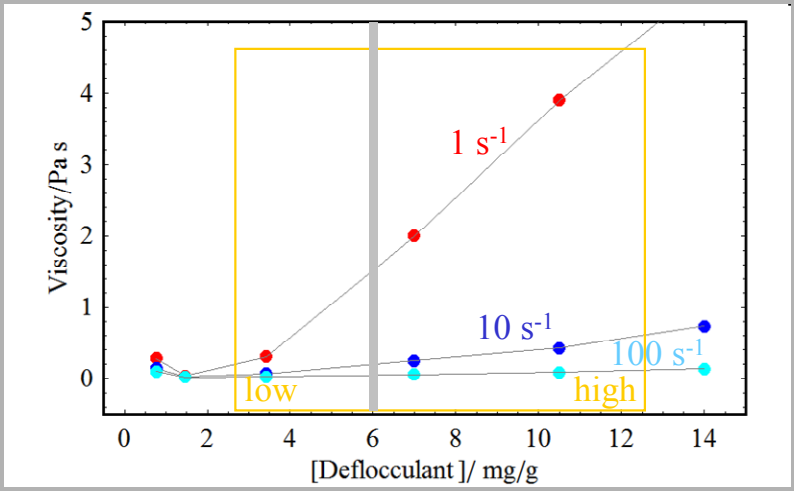
A6 Alumina suspension φ=0.44



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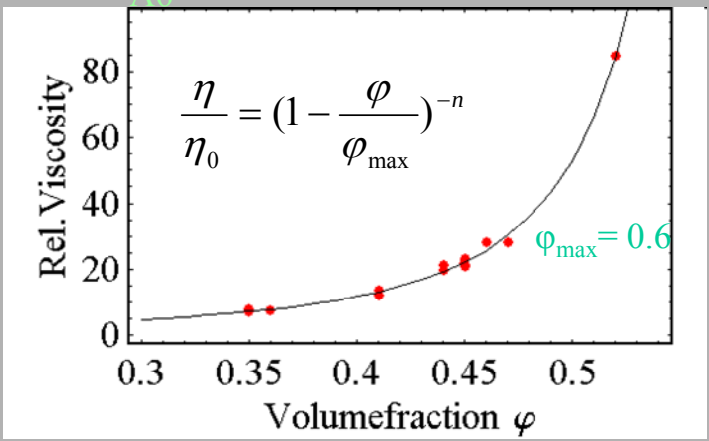
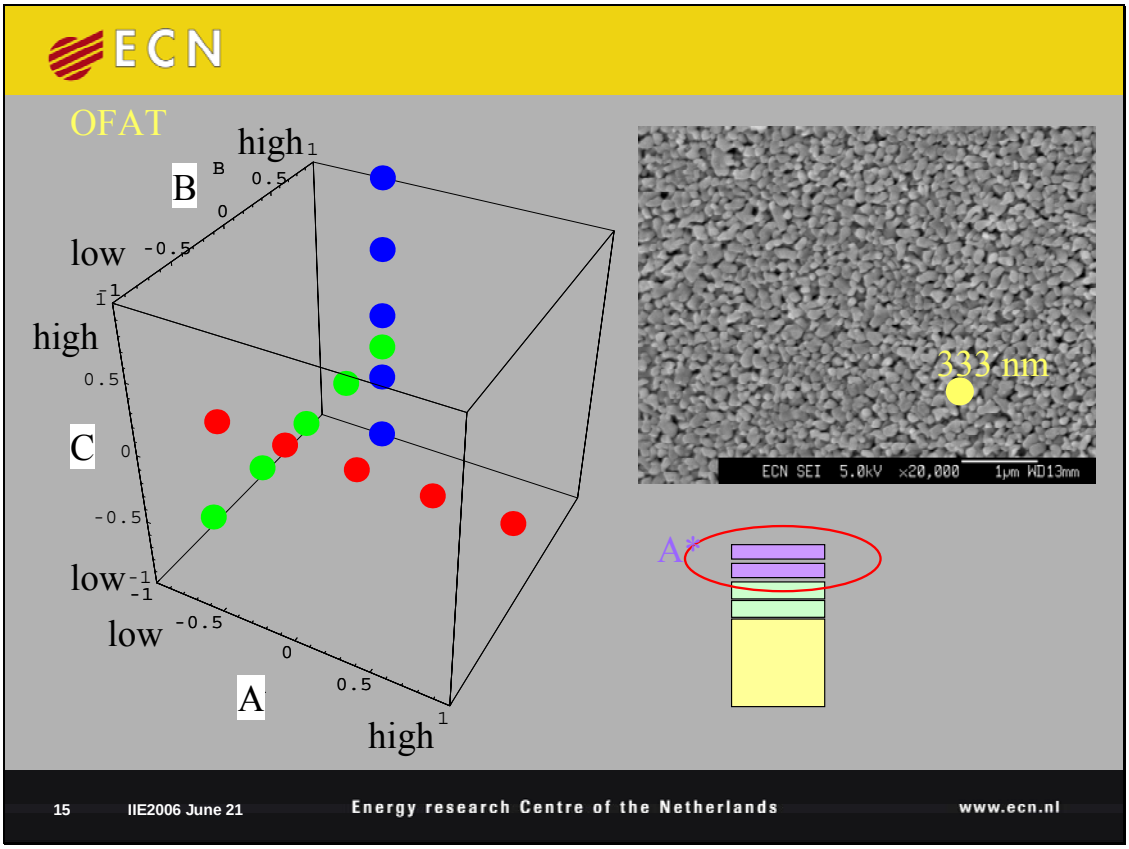
High shear viscosity- volume fraction

A6

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OFAT
high
B
low
high
C
low
low
A
high
333 nm
ECN SEI 5.0kV ×20,000 1µm WD13mm
A*
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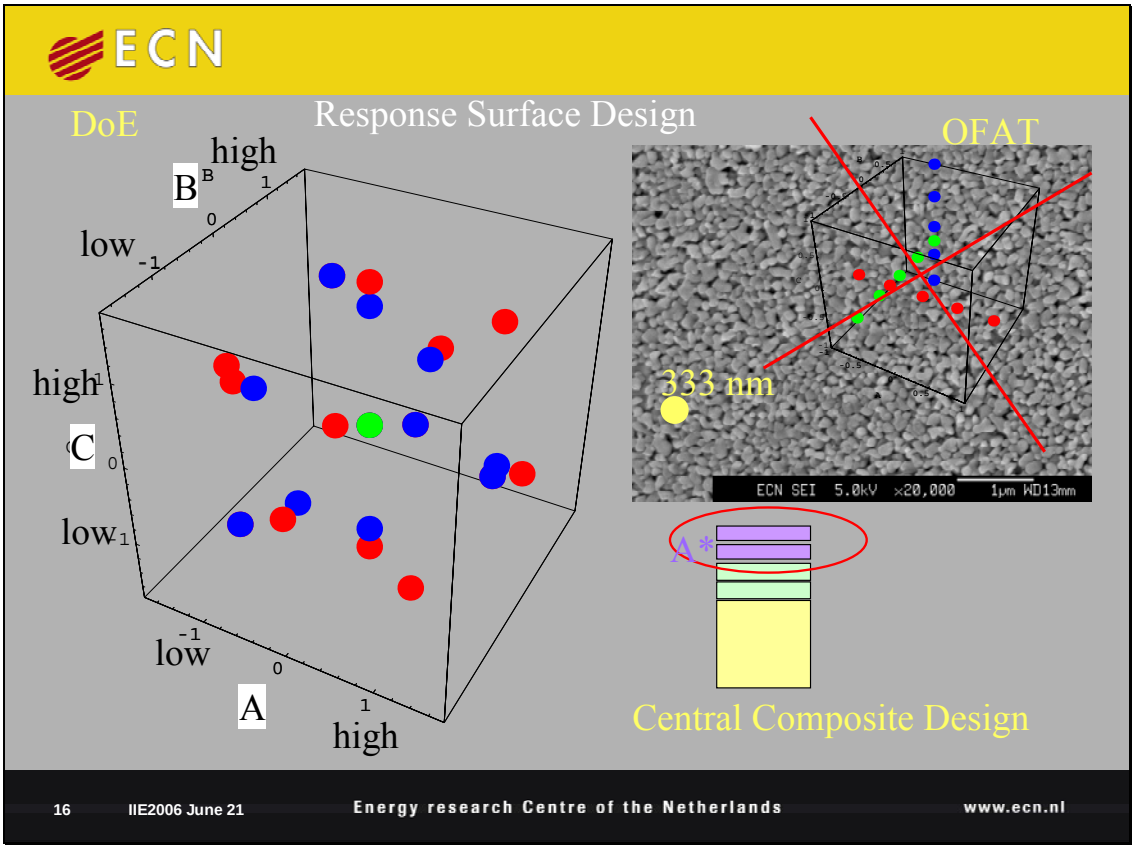
ECN
DoE
Response Surface Design
high
B
low
high
C
low
low
A
high
OFAT
333 nm
ECN SEI 5.0kV ×20,000 1µm WD13mm
A*
Central Composite Design
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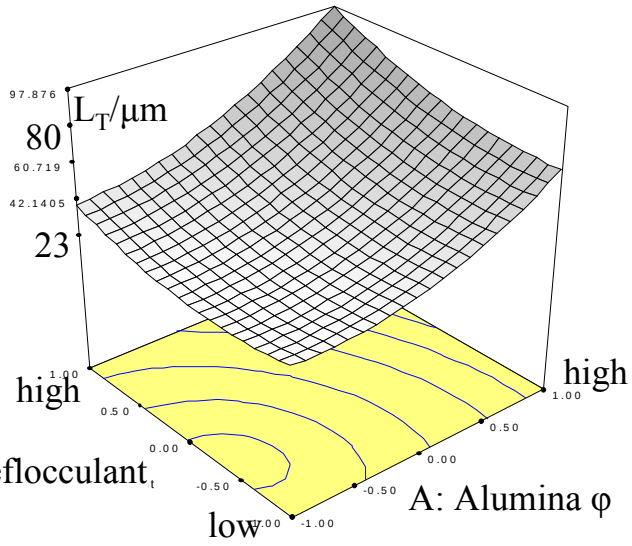
DoE

DESIGN-EXPERT Plot

ThicknessLT
X = A: Alumina
Y = B: Deflocculant

Coded Factor
C: Additive = 0.000



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DoE

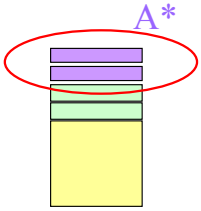
Defects

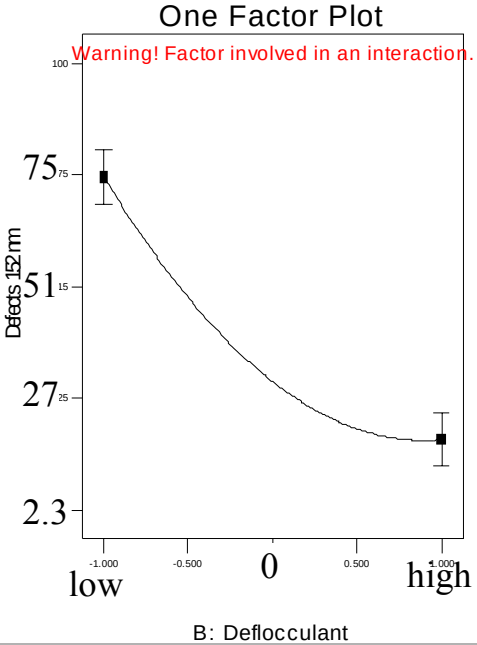
DESIGN-EXPERT Plot

Defects 152 nm

X = B: Deflocculant

Coded Factors
A: Alumina = 1.000
C: Additive = 0.000





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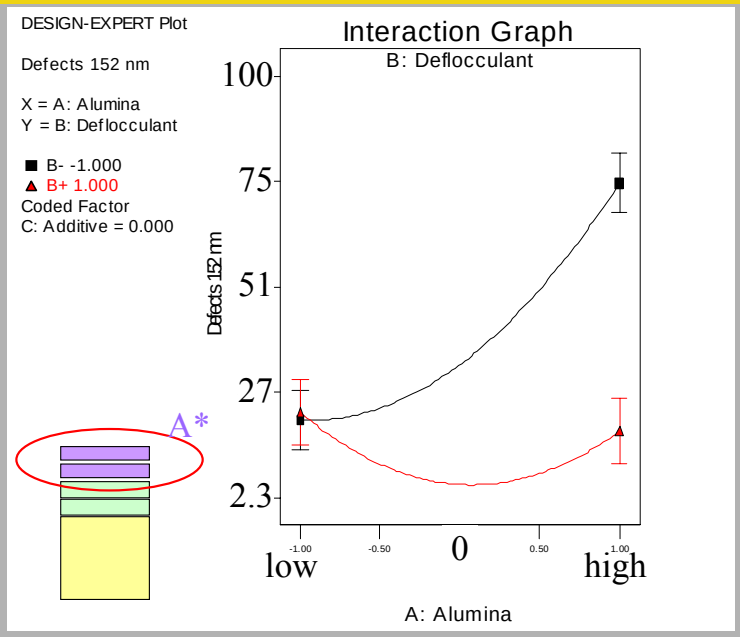
DoE

Defects



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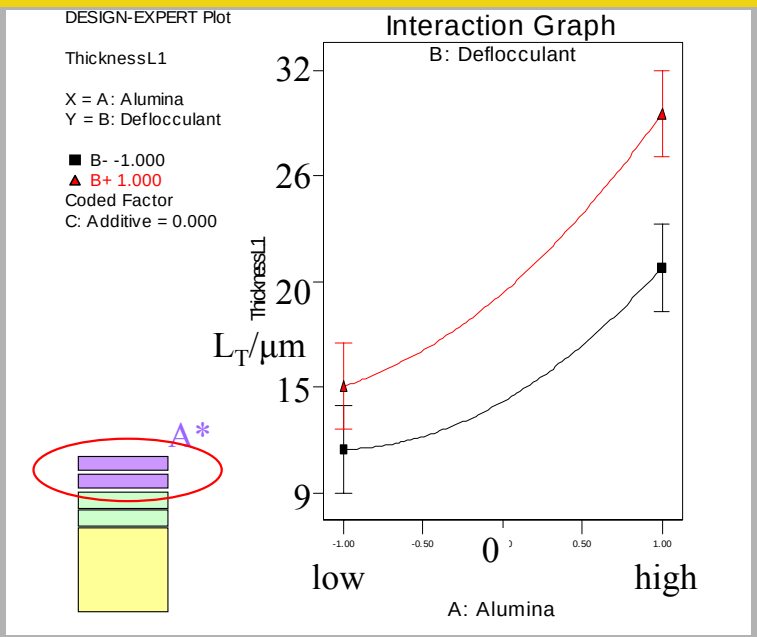
Layer thickness



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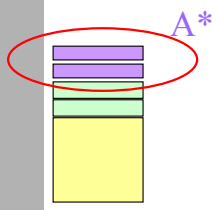
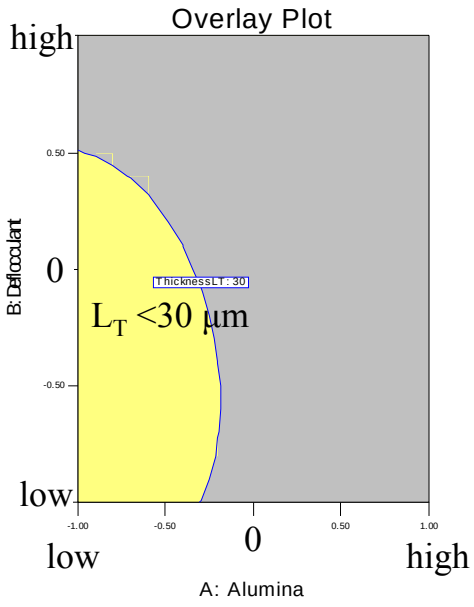
DESIGN-EXPERT Plot

Overlay Plot
X = A: Alumina
Y = B: Deflocculant

Coded Factor
C: Additive = 0.000





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DoE

DESIGN-EXPERT Plot

Overlay Plot
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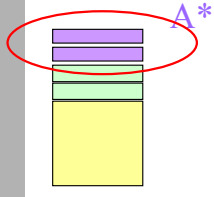
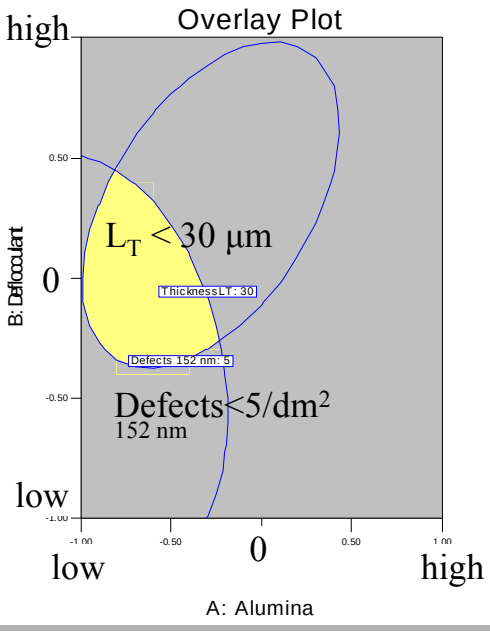
Y = B: Deflocculant

Coded Factor
C: Additive = 0.000





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Thank you for your attention

Contact us!

www.ecn.nl bonekamp@ecn.nl +31 224 56 4540

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