

# Surface structure characterization for mottling assessment on coated papers

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## Outline

- Introduction
  - SEM surface assessment
  - SEM cross-sectional analysis
- Laser profilometry analysis
- Gloss assessment
- Mottling assessment
- Quadtree assessment
- Conclusion



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# Introduction

- Quantification and characterisation of the coating layer structure details are important for predicting the printing ink behaviour on the paper surface during printing
- Porosity, surface roughness and pigment particle details seem to be important parameters in this context
- Microscopy and image analysis techniques offer direct assessment of such parameters facilitating the acquisition of important morphometrical structure details

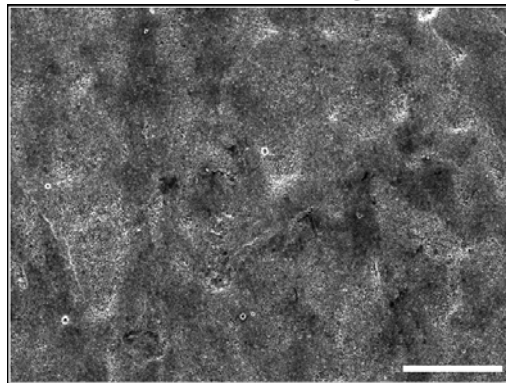


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# SEM Surface assessment

## Surface images



Secondary electron image of a LWC paper surface. Bar: 50  $\mu\text{m}$ .



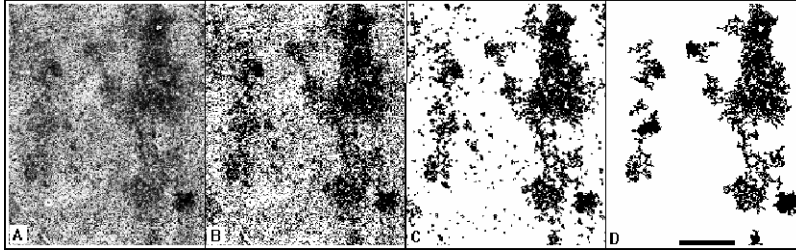
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# SEM Surface assessment

## Surface images

### Closed area segmentation and characterization



Segmentation procedure of closed areas on SE images of LWC paper surfaces.

A) Original equalised image reflecting differences in topography

B) Thresholded image

C) The same area after running erosion filter

D) Noise particles smaller than 100 pixels have been removed. Bar: 50  $\mu\text{m}$ .

*Reproduced from Chinga and Helle. J. Pulp Pap Sci. 29(6) 179-184 (2003)*



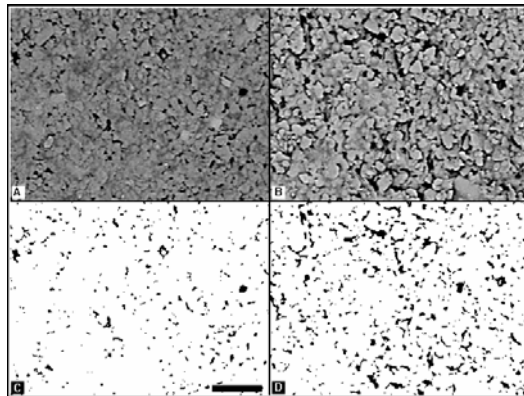
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# SEM Surface assessment

## Surface images

### Surface pore segmentation based on BSE images



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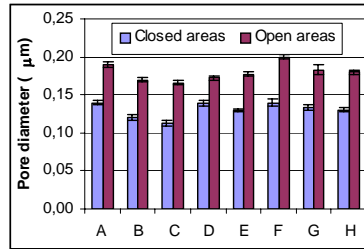
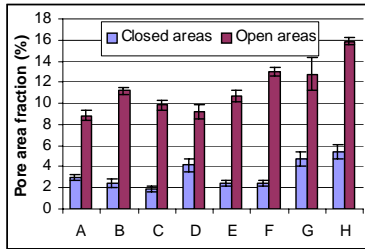


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# SEM Surface assessment

## Image analysis of paper surface images



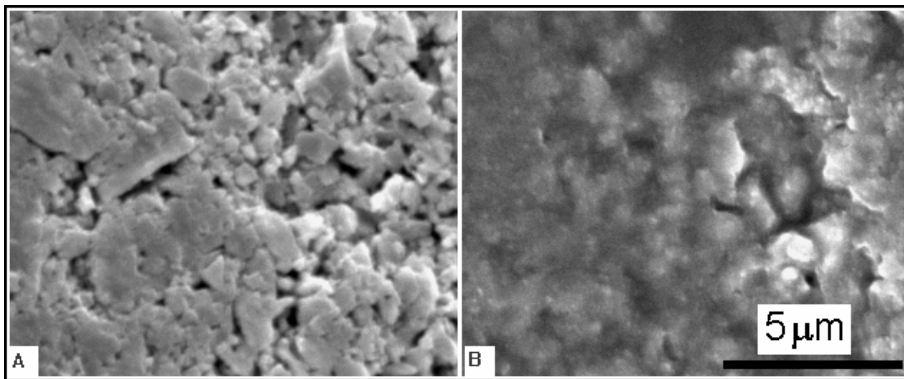
Pore area fraction (left) and mean pore diameter (right) on the closed and open surface areas for the tested papers.

*Reproduced from Chinga and Helle. J. Pulp Pap Sci. 29(6) 179-184 (2003)*



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# SEM Surface assessment



Calendered LWC surface

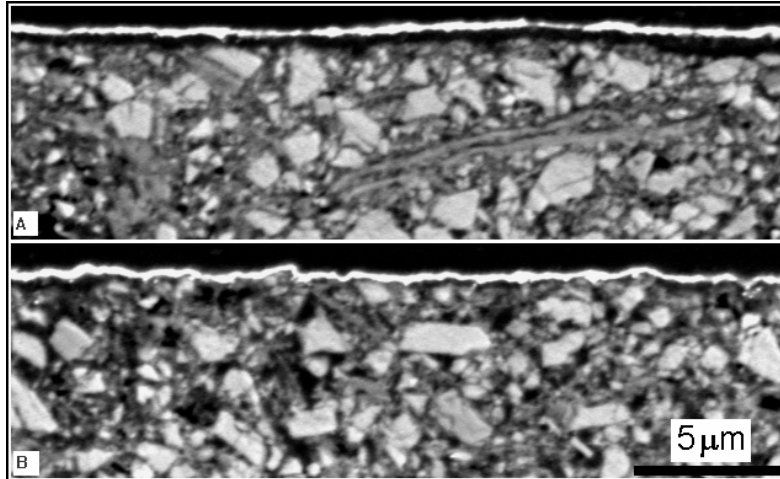
Printed LWC surface

*Reproduced from Chinga et al. 86th Annual meeting, Montreal, Quebec, Canada (2000)*



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# SEM cross-sectional analysis



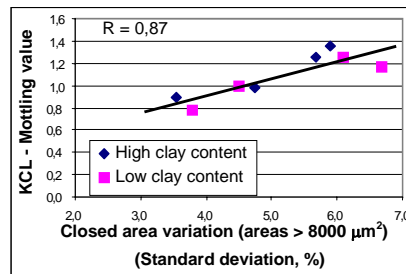
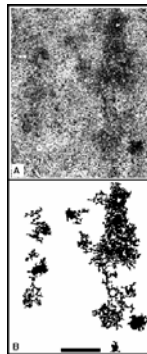
Reproduced from Chinga et al. 86th Annual meeting, Montreal, Quebec, Canada (2000)



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# SEM Surface assessment

## Image analysis of paper surface images



The relationship between the closed area variation and mottling

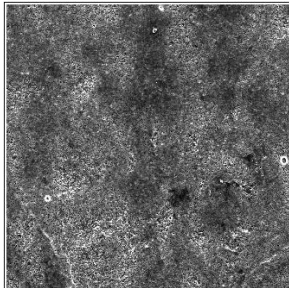
Reproduced from Chinga and Helle. *J. Pulp Pap Sci.* 29(6) 179-184 (2003)



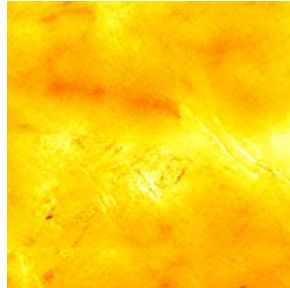
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# Laser profilometry analysis

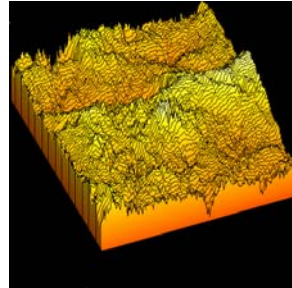
- Laser profilometry is an effective method for assessing the paper surface
  - Fast method
  - Large areas are assessed
  - Non-invasive method



SEM, SEI image



Laser profilometry



Topographical representation

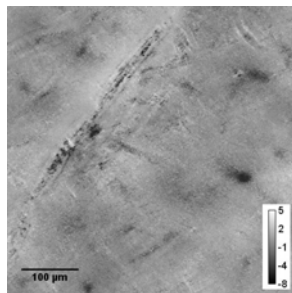


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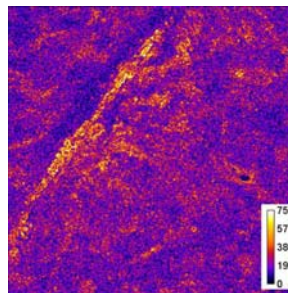
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# Laser profilometry analysis

- Surface gradients



Profilometry representation



Gradient image, facet orientation

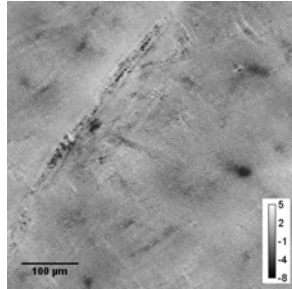


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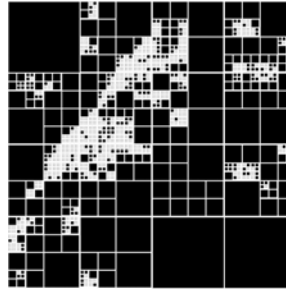
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# Laser profilometry analysis

- Quadtree decomposition



Profilometry  
representation



Quadtree  
decomposition



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# LWC paper samples

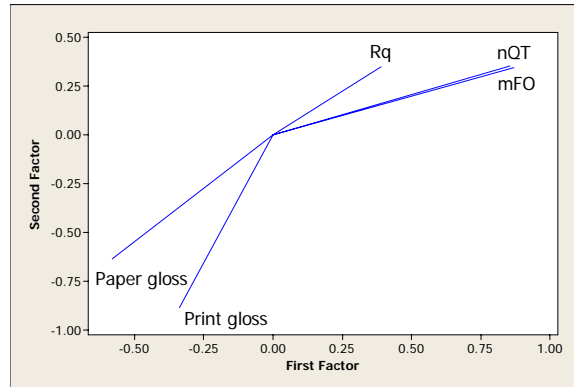
- 15 commercial LWC paper samples were analyzed
- The samples were commercially printed
- Properties like gloss, print gloss and mottling were assessed
- The samples were also submitted to a laser profilometry analysis



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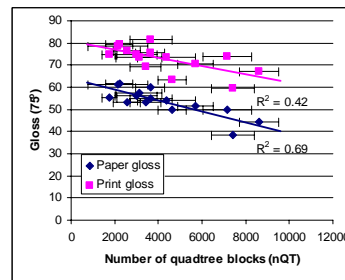
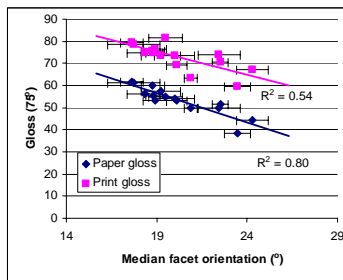
# Gloss assessment



- The facet orientation (mFO) and the number of quadtree blocks (nQT) correlates well with paper and print gloss.



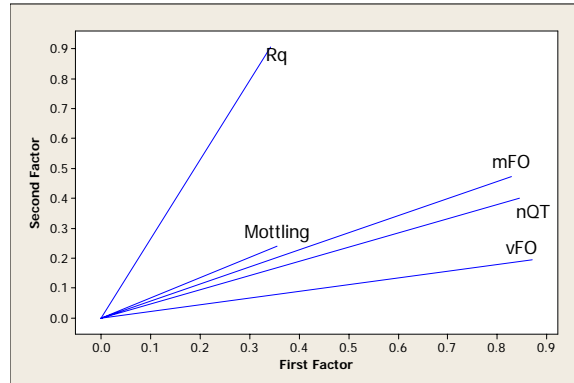
# Gloss assessment



- The facet orientation (mFO) and the number of quadtree blocks (nQT) correlates well with paper and print gloss.



# Mottling assessment



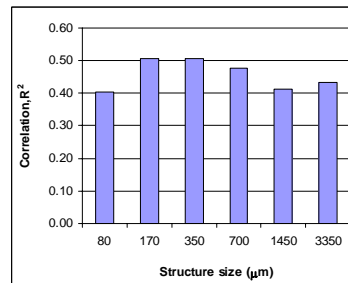
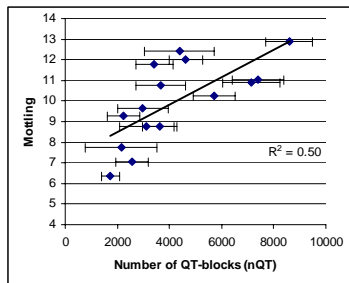
- The facet orientation (mFO), the variation of facet orientations (vFO) and the number of quadtree blocks (nQT) correlates with mottling



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# Mottling assessment



- The number of quadtree blocks (nQT) correlates with mottling
- The highest correlation is encountered with structure sizes between 170 and 350  $\mu\text{m}$
- This agrees with the size of the assessed profilometer images
- Topography images of larger areas may be necessary for assessing the mottling pattern reported to influence visual perception



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## Quadtree assessment

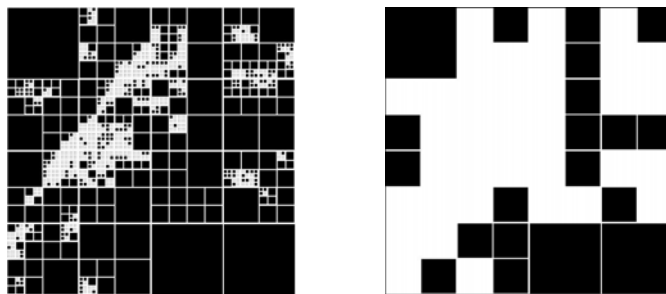
- Quadtree decomposition is used to assess the surface roughness
- Quadtrees seems also to be a good basis for assessing the surface horizontal variation
- Cluster quantification of presumptively closed areas may add more information to the prediction of e.g. mottling and gloss variation



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## Quadtree assessment



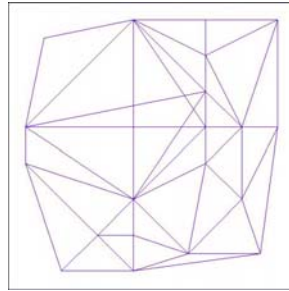
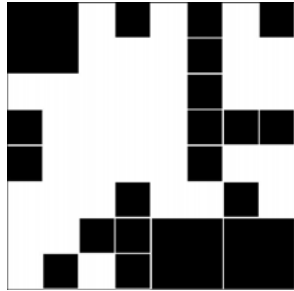
- Segmentation of presumptively closed areas



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## Quadtree assessment

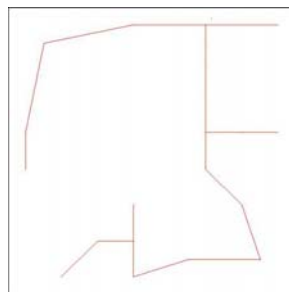
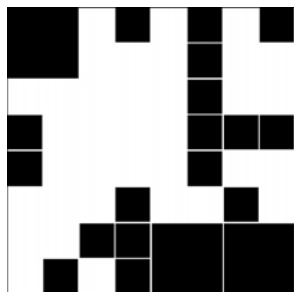


- Segmentation of presumptively closed areas
- Quantification of the distances between selected areas



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## Quadtree assessment



- Segmentation of presumptively closed areas
- Quantification of the distances between selected areas
- Quantification of the minimum spanning tree



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## Conclusion

- SEM surface image analysis provides good assessment of the surface pore structure and variation
- Alternative methods such as Laser profilometry are also suitable for measuring the topographical details of surfaces
- New methods like quadtree decomposition seems to be appropriate for assessing the surface vertical and horizontal variation



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## Conclusion

- The influence of the surface variation on mottling has been confirmed
- Complementary algorithms can be applied for assessing the surface horizontal homogeneity, thus facilitating the quantification of clusters of closed areas
- This may add more information to the prediction of mottling and gloss variation.



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# Acknowledgements

- Norske Skog ASA is acknowledged for cooperation and for providing the commercial LWC samples and the results from the printing trial.



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