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Water invasion by condensation in a model porous medium

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1. INTRODUCTION

Vapour condensation is a key phenomenon occurring in the cathode side of proton exchange membrane fuel cell (PEMFC), i.e. [1]. In this context, our objective is to develop a pore-network (PN) model taking into account the condensation phenomenon in the presence of a thermal gradient. Here we present a validation step where the condensation phenomenon was studied experimentally in two-dimensional micromodels of controlled wettability. The experimental results provide data to be compared with the PN simulations.

2. EXPERIMENTAL SET-UP

Micromodels were fabricated using OSTE polymers. OSTE polymers can be treated by fluorinated or hydrooxylated methacrylate monomers to render the surface hydrophobic (contact angle ~ 105°) or hydrophilic (contact angle ~ 70°), respectively. A typical two – dimensional micromodel is sketched in Figure 1. The micro-model is a square lattice with N_w = 30 and N_t = 20 channels in the longitudinal and transversal directions respectively. The distance λ between two pillars is constant and set to 1 mm. The pillars are rectangular and have a height of h = 1 mm. The width of the channels is distributed randomly around ω = 0.5 mm according to a normal distribution of standard deviation σ = 0.1 mm. The right wall - where are located the humid gas inlet and outlet - is 3 mm away from the porous pattern. The two – inlet and outlet – holes are drilled on the transparent cover plate as sketched in Figure 1. Note that the gas can escape only through the outlet tube. A temperature gradient is imposed along the micromodel with the cold side on the left hand side in Figure 1 and the hot side on the right hand side. The micomodel contains no liquid initially.

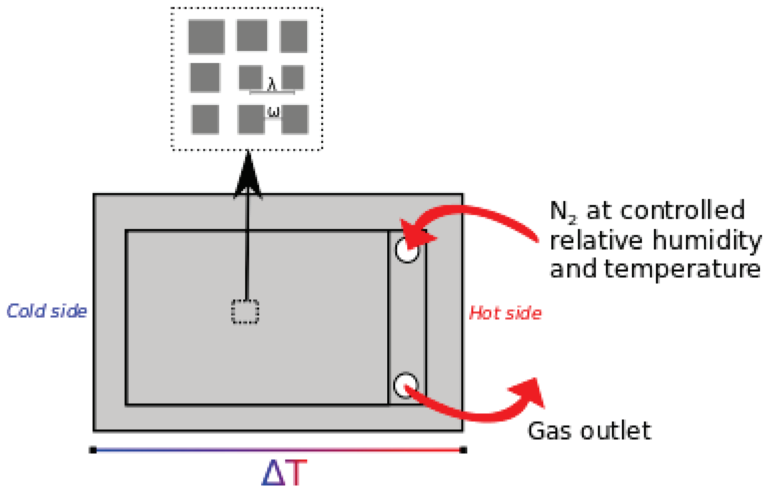

Figure 1: Top view of micromodel

3. EXAMPLE OF RESULTS

An example of experimental results obtained for a hydrophobic micromodel is shown in Figure 2. As expected, a capillary fingering pattern developping from the cold edge is obtained. This type of pattern, as well as the condensation kinetic (no shown), is well reproduced by our PN model as illustrated in Figure 3.

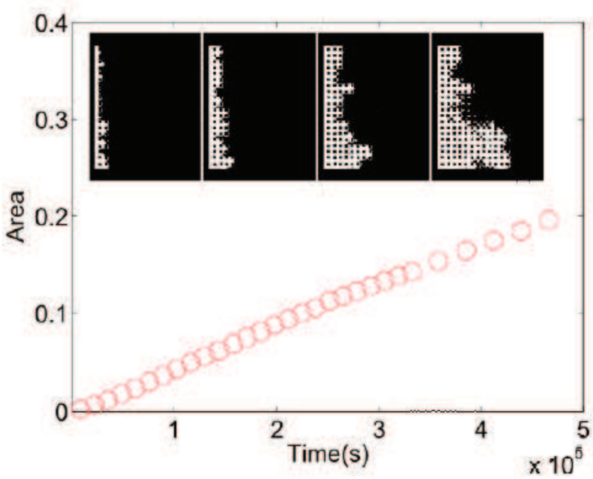

Figure 2: Condensation process in a hydrophobic micromodel. The inset shows the phase distribution (water in grey, gas phase in black) at various times. The graph shows the surface fraction of micromodel occupied by condensed water as a function of time.

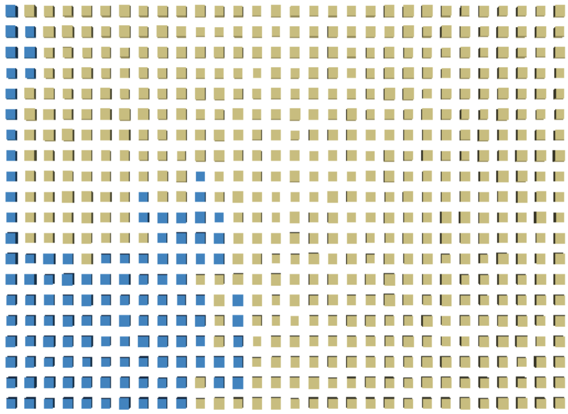

Figure 3: PN simulation of water invasion due to condensation. Water cluster in blue.

4. CONCLUSION

Our experimental set-up enables us to study condensation pattern and condensation kinetics induced by temperature gradients in fully hydrophilic, fully hydrophobic or mixed hydrophilic / hydrophobic micromodels. The PN simulations for the various cases lead to good agreements with the experiments. This allows us to study with confidence the condensation process in PEMFC components from PN simulations in relation with the water management issue in PEMFC.

5. AKNOWLEDGMENTS

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6. REFERENCES

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