Effect of Substrate Contact Angle on Ink Transfer in Flexographic Printing

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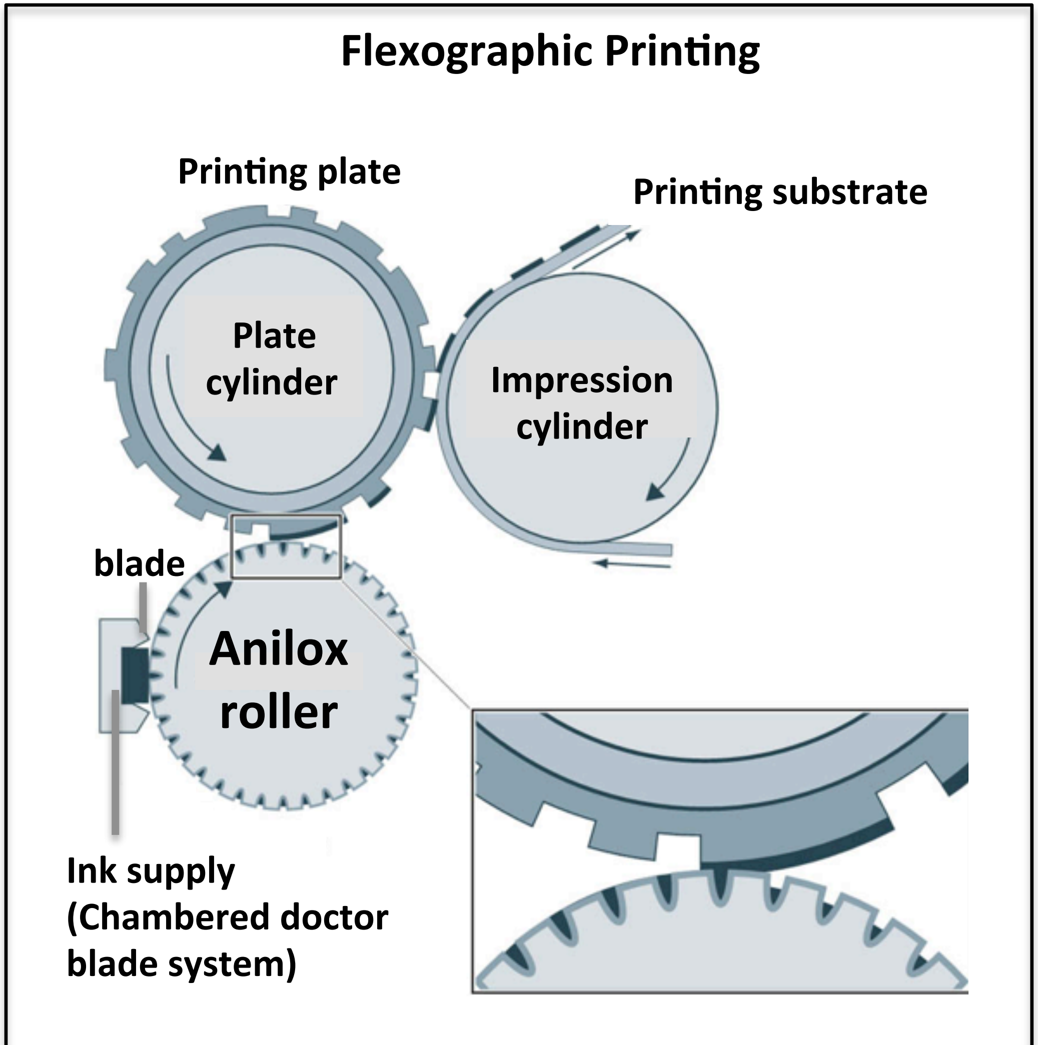
2014 BOSTON

Outline

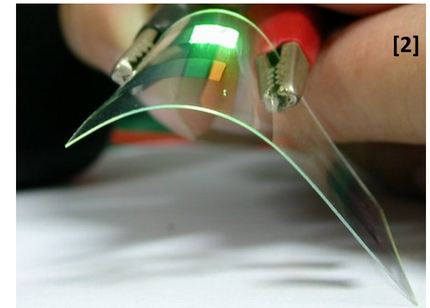
- Introduction
- Motivation and Objectives
- Simulations
. Methodology
. Results
- Conclusions and Future Work

Flexography

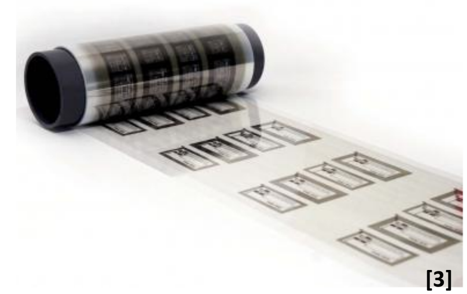


thin film transistor

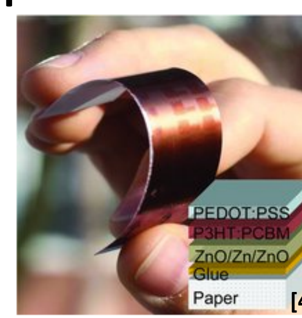
OLED



RFID

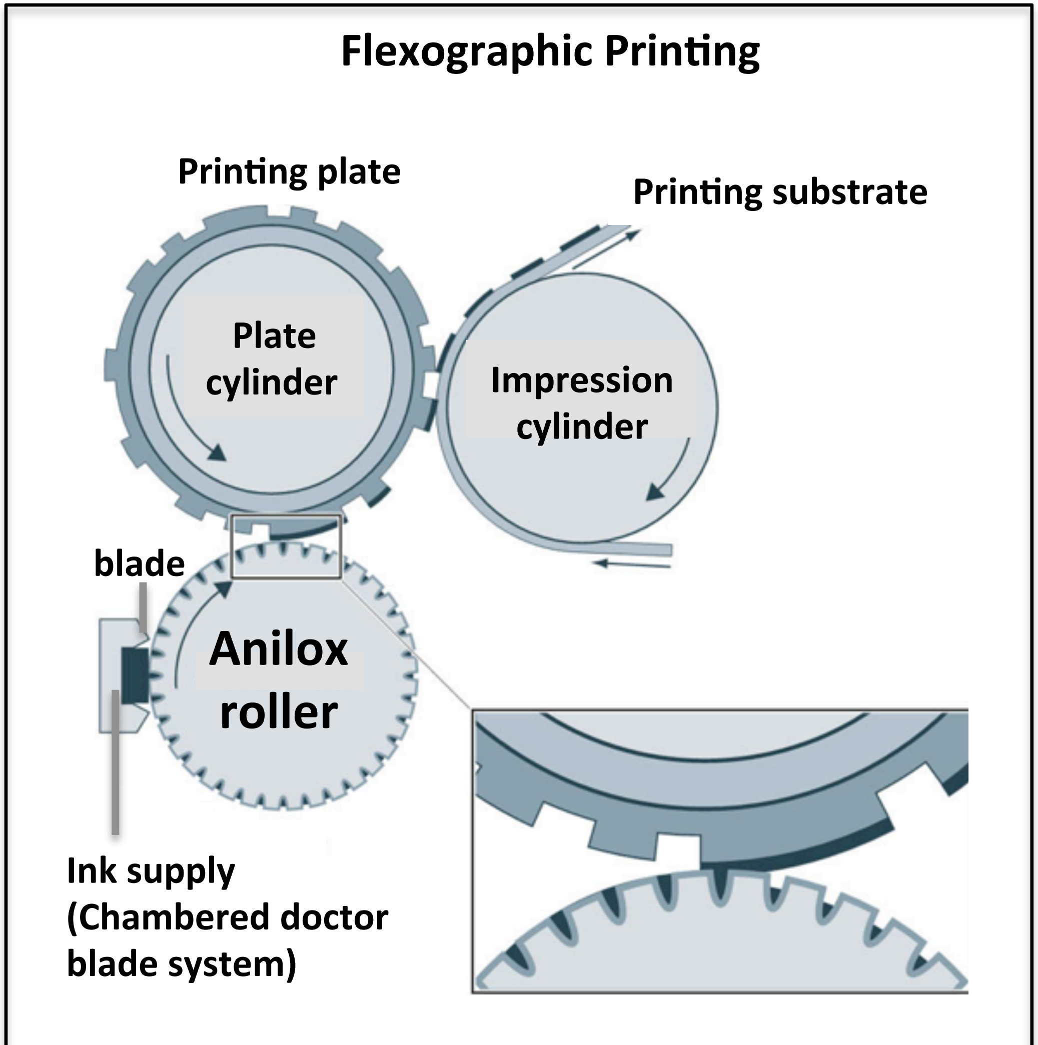


photovoltaic cell



[1] H. Kang *et. al.*, Advanced Materials, 2012
[2] Wikimedia/meharris
[3] Gyou-Jin Cho/Sunchon National University
[4] A. Hubler et. al., Advanced Energy Materials, 2011

Ink Transfer in Flexography



INK TRANSFER TO THE ANILOX ROLLER

↓

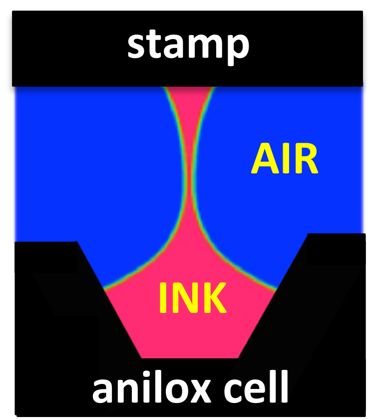
BLADING OF THE ANILOX ROLLER
(fill the cells + remove excess ink layer)

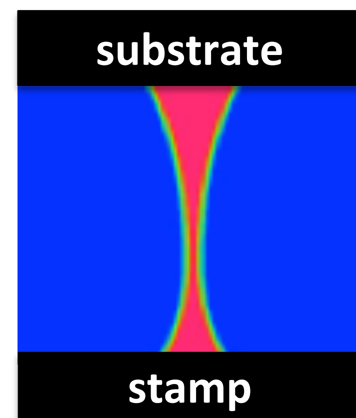
↓

INKING OF THE STAMP
(partial cell evacuation by ink splitting)

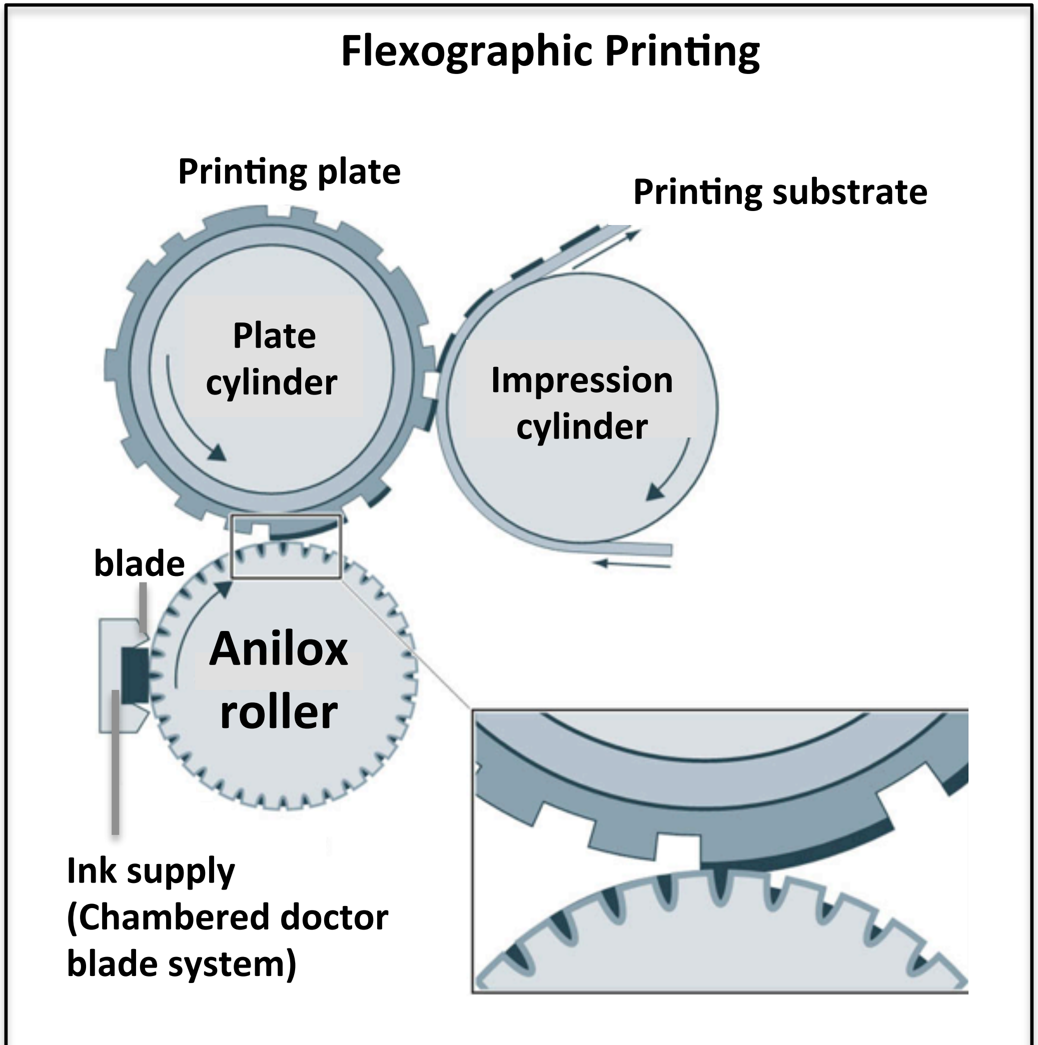
↓

INK TRANSFER TO THE SUBSTRATE
(ink splitting)





Ink Transfer in Flexography



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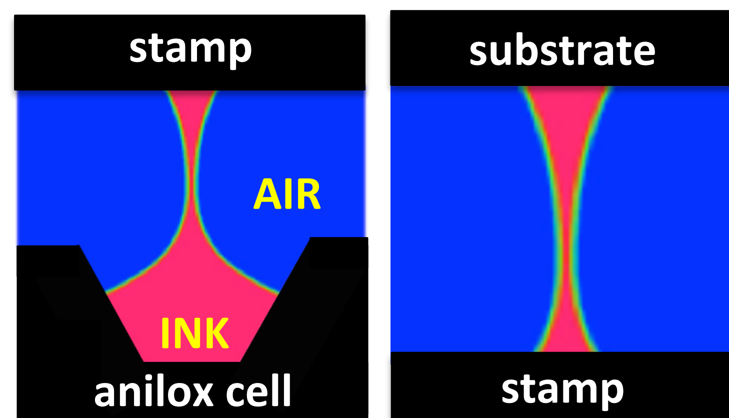
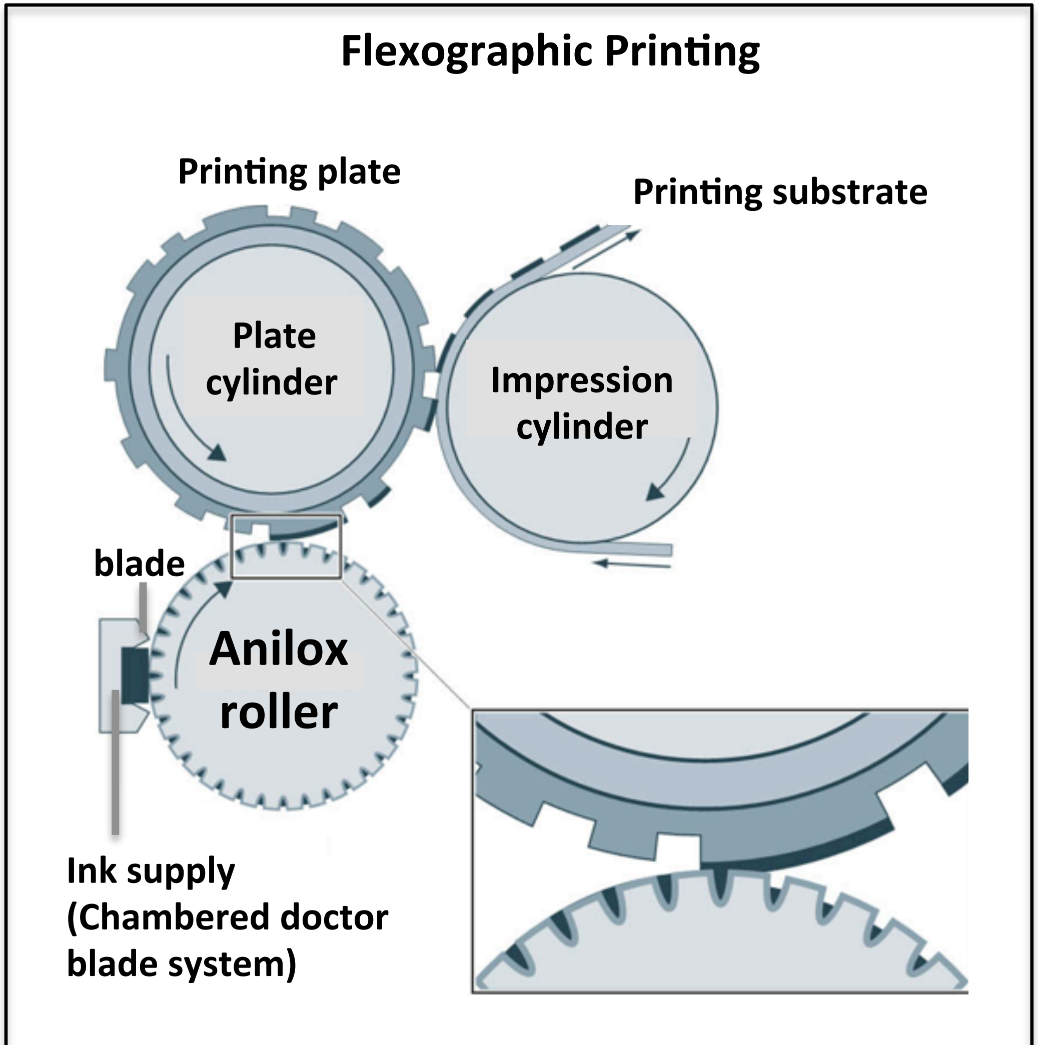
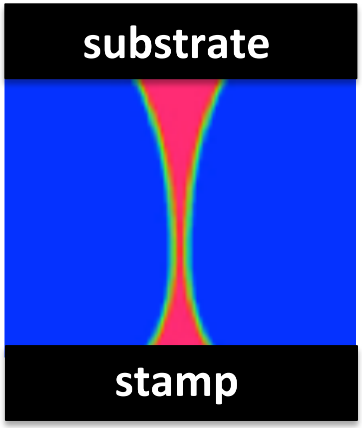


Motivation and Objectives



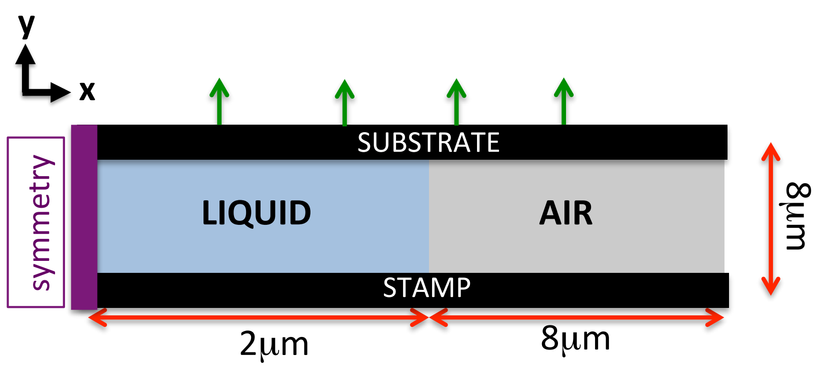
<u>Ink Transfer from Stamp to Substrate</u>
- Thickness of printed product
- Device performance

<u>Objectives</u>
- Guidelines for substrate and stamp design
- Control printed layer thickness
- Investigate contact angle effects



Simulation Domain

Simulation domain and its dimensions

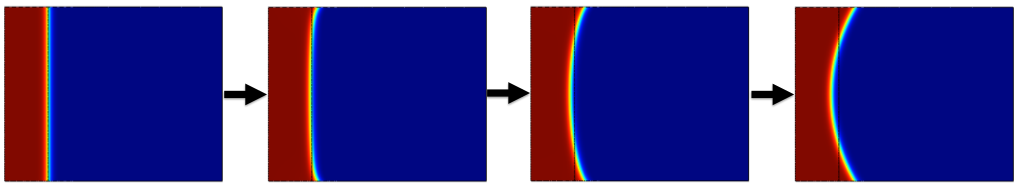


Parameters used in the simulation

Ink dynamic viscosity	0.1 $N.s/m^2$
Ink density	1000 kg/m^3
Air dynamic viscosity	1.81e-5 $N.s/m^2$
Air density	1.16 kg/m^3
Gravity acceleration	0
Separation speed	0.1 m/s
Volume of liquid	32μm2
Surface tension coefficient	1 N/m

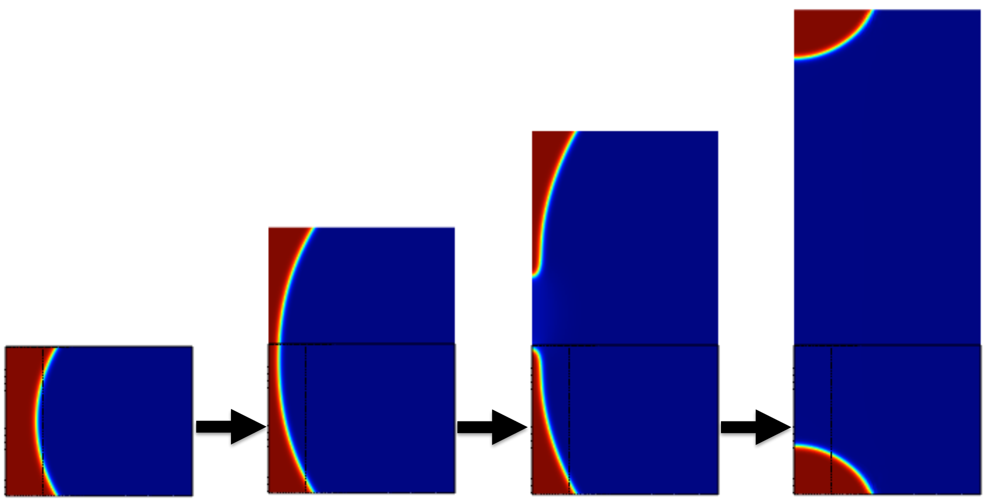
Simulation Setup

Interface Reaches Equilibrium Shape



t=0 sec t=2.5 μsec t=7.5 μsec t=50 μsec

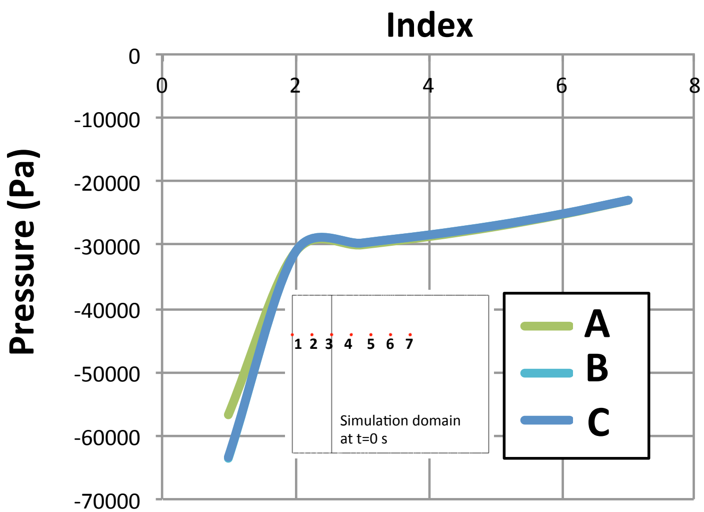
Ink splits into Two

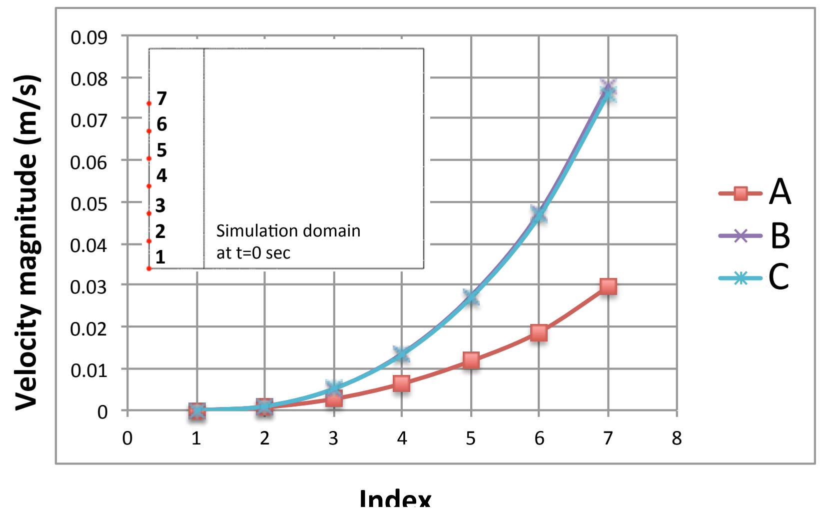


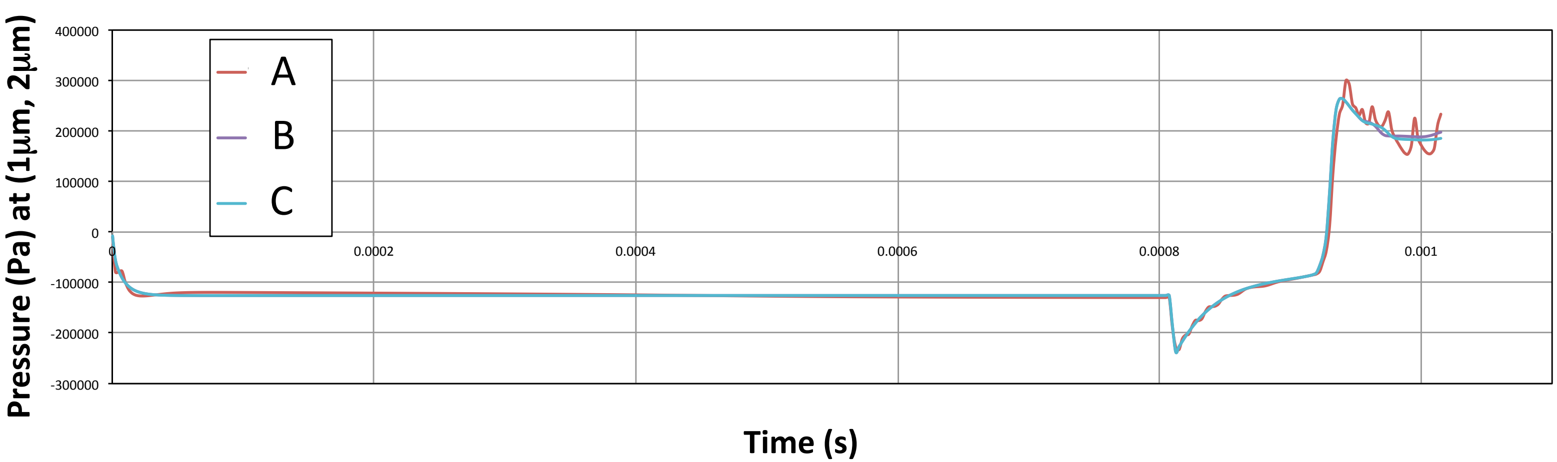
t=810 μsec t=872 μsec t=925 μsec t=990 μsec

- **Moving mesh interface** is coupled with **laminar two-phase flow, phase field interface**.
- Initial velocity and pressure values are set to zero for the two fluids.
- Initial mesh displacement is set to zero.
- Pressure is set to zero at right boundary which is defined as inlet.
- Stationary bottom surface is defined as “wetted wall” with 60^o ink contact angle.
- Upper surface is defined as “moving wetted wall” with 60^o contact angle.

Mesh Refinement ($\theta_{top} = \theta_{bottom} = 60^o$)







Maximum mesh element size for left of domain: A→0.25 µm, B→ 0.08 µm, C→ 0.06 µm

Change in total mass < 2%

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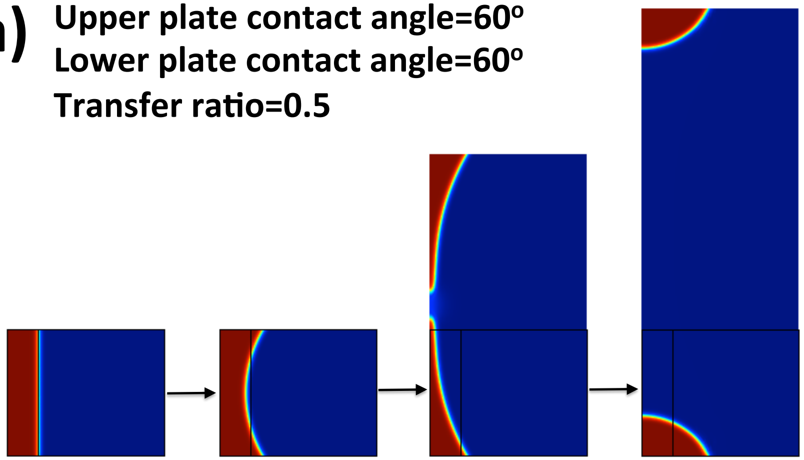
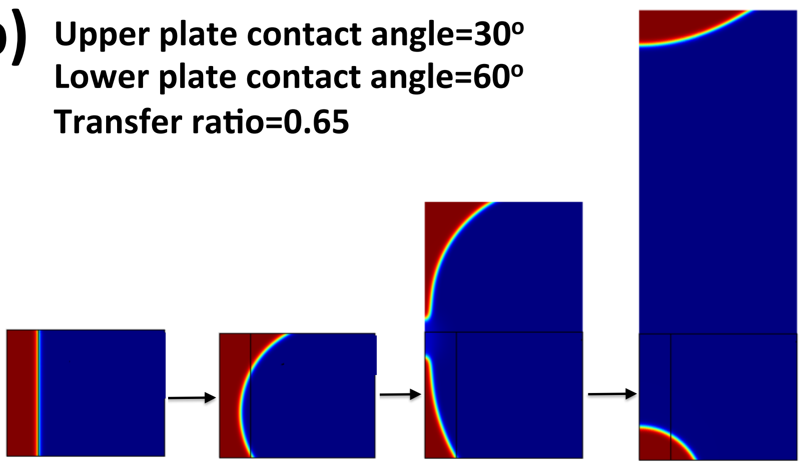
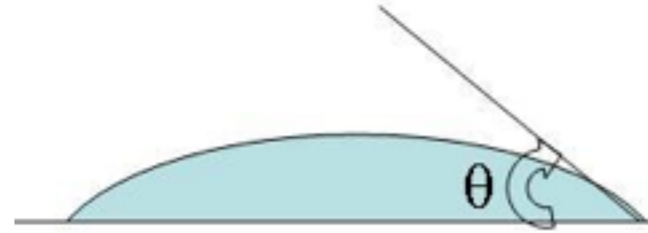
Effect of Contact Angle

a) **Upper plate contact angle=60º**
Lower plate contact angle=60º
Transfer ratio=0.5



b) **Upper plate contact angle=30º**
Lower plate contact angle=60º
Transfer ratio=0.65





Young-Dupre Equation

$W_{adhesion} = \gamma \,.\, [1+\cos(\theta)] \rightarrow \theta \downarrow \; W_{adhesion} \uparrow$

Results

- Expected trend is observed
- Results do not exactly match with literature
- High computation times

Conclusions and Future Work

- Splitting of ink between two parallel plates is simulated
- Ink transfer ratio to the upper plate is found to increase with decreasing ink contact angle on its surface
- High computation times due to fine mesh requirements is the main difficulty
- Future work is to cover a larger range of contact angles in the simulations

Thank you

Q&A