prof. Marco Mazza

Ecole d'ingénieurs et d'architectes de Fribourg
Hochschule für Technik und Architektur Freiburg

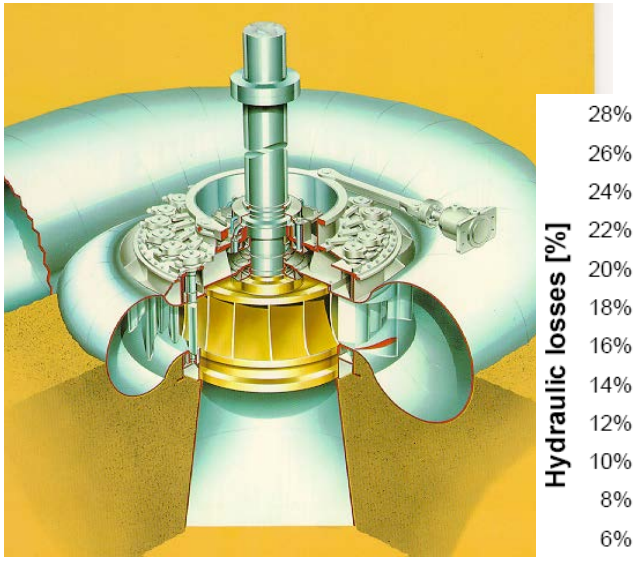
MEMSonIC2

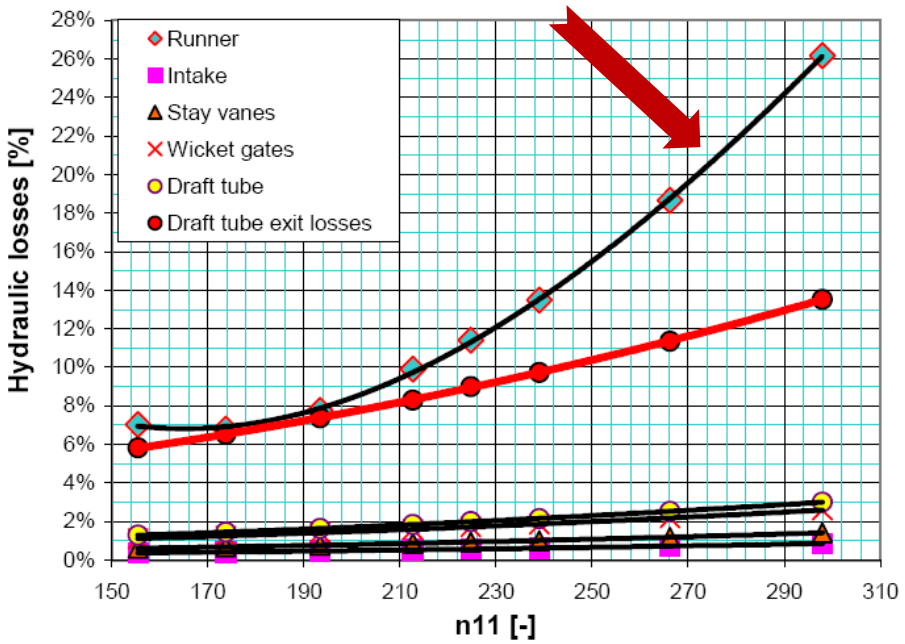
Ultra thin pressure sensor for turbine blade optimisation

Manno, September 26th, 2013

Main objective

- ✓ to develop a miniaturized, fully integrated pressure sensor for turbine blade optimization;





Turbine losses based on numerical flow simulation, "Axial Flow turbine development for Ultra Low-Head (ULH) Hydro projects", Jacek Swiderski

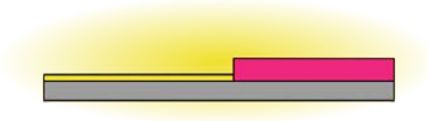
Requirements

- ✓ Dimensions
  - ✓ Thickness: smaller than 1mm
  - ✓ Diameter: smaller than 10mm
- ✓ Consumption
  - ✓ Less than 50 µA
- ✓ Range and sensibility
  - ✓ 0-100 bar, precision 1 bar

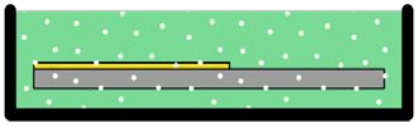
Sensor design and fabrication

Sensor fabrication process

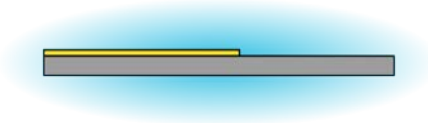
Glass substrate



Sputtering of the bottom gold electrode

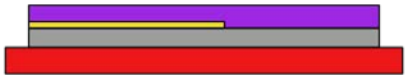


Ultrasonic cleaning in isopropyl alcohol



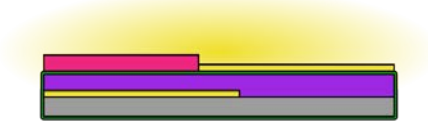
Plasma cleaning

Spin-coating of the PDMS layer



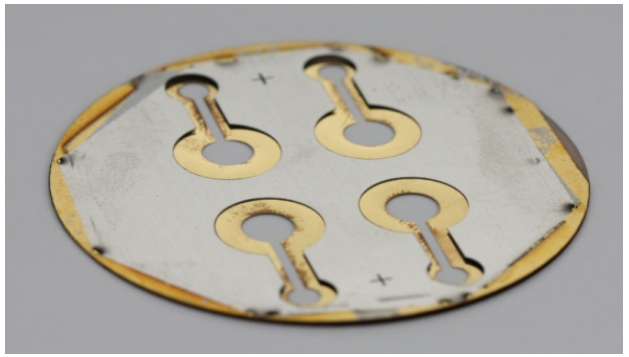
Curing of the PDMS on a hot plate

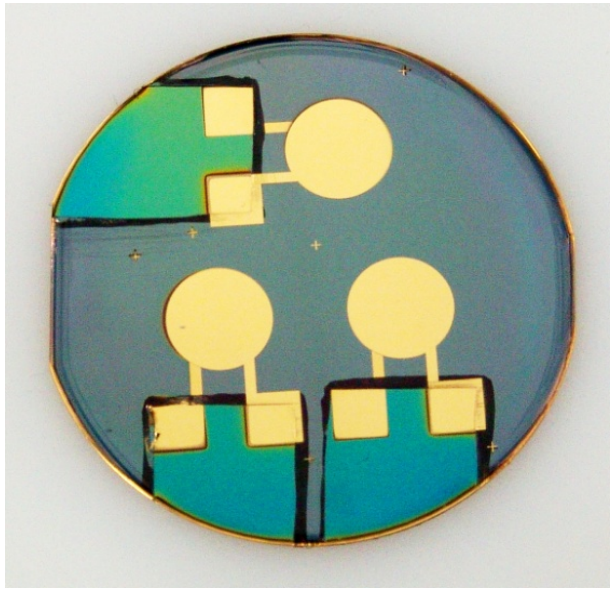
Parylene encapsulation



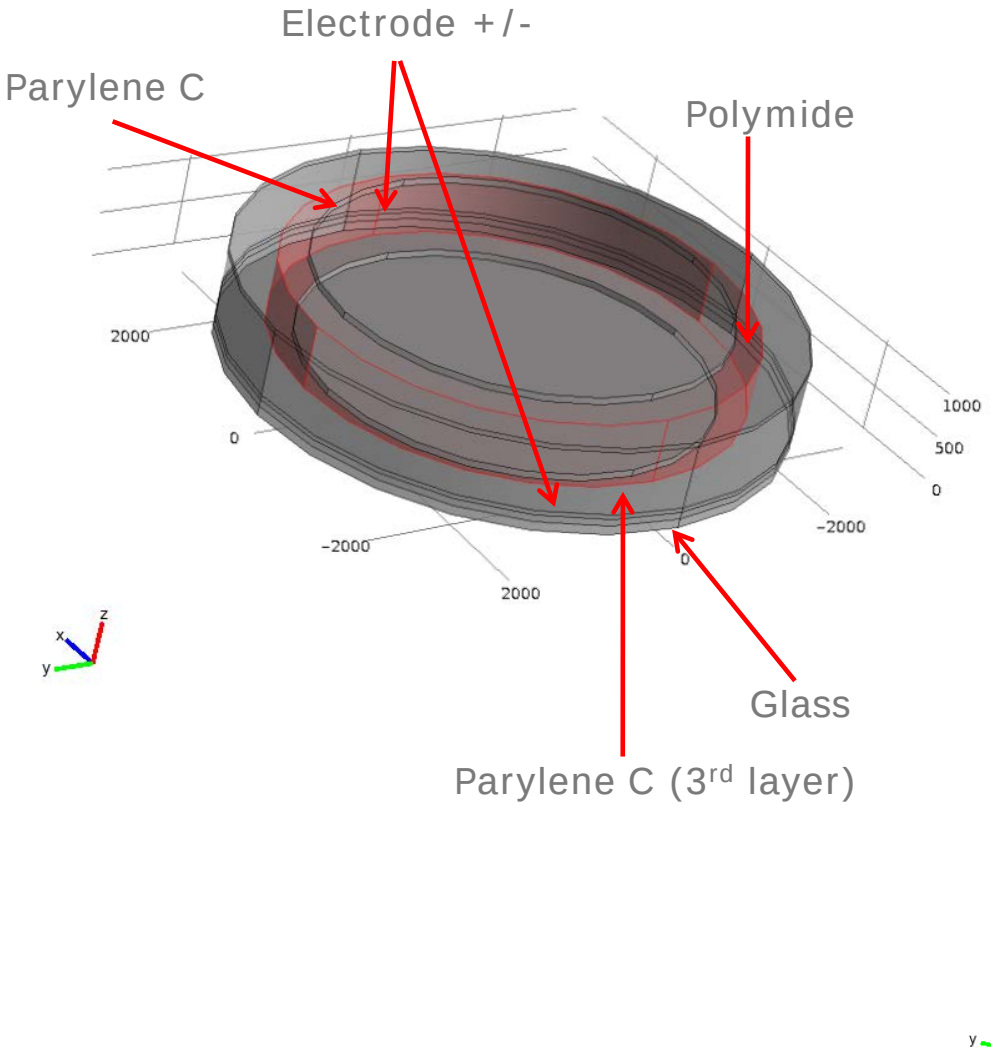
Sputtering of the top gold electrode

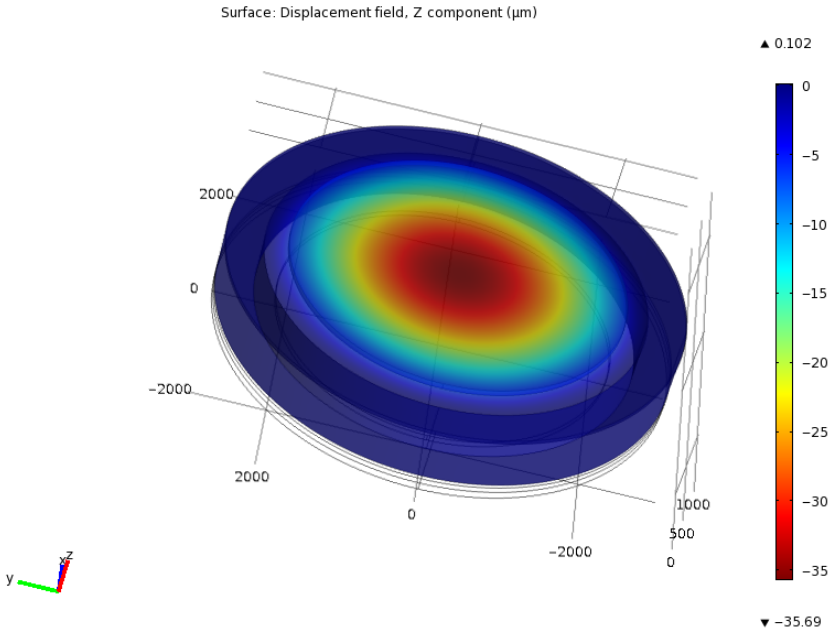
Freeing of the bottom electrode



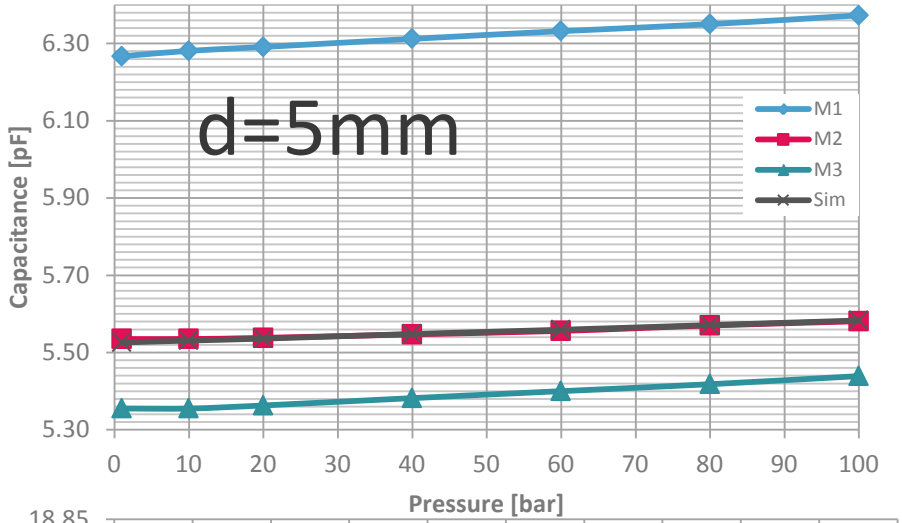


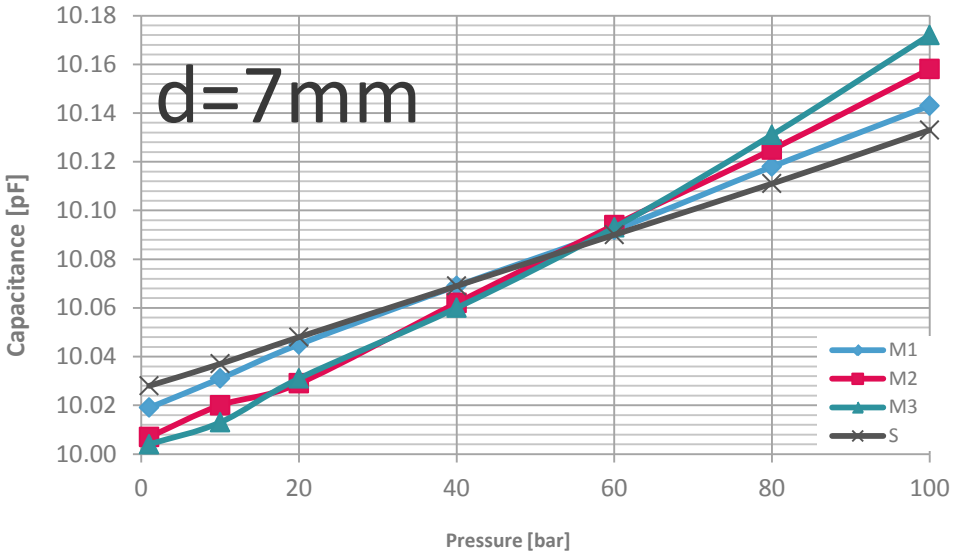
FEA modeling

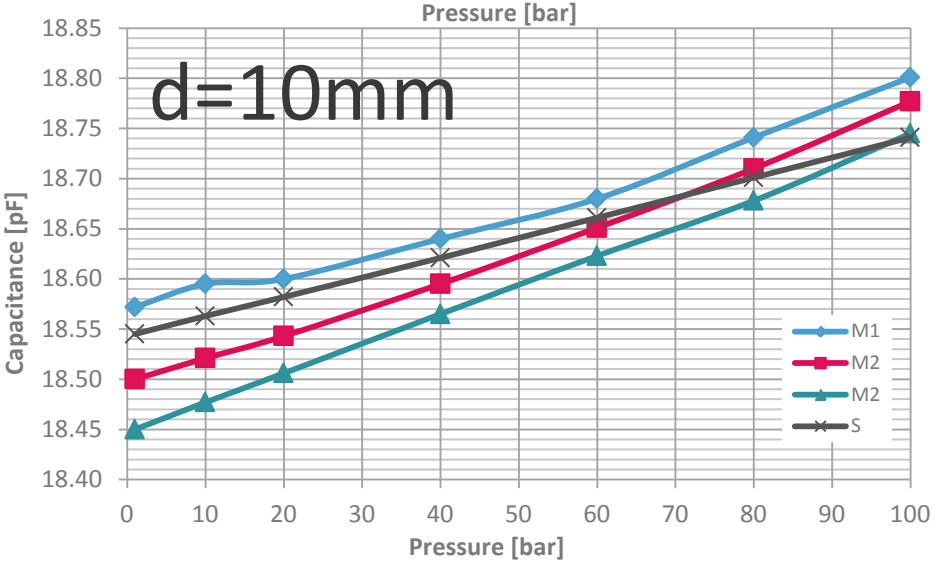


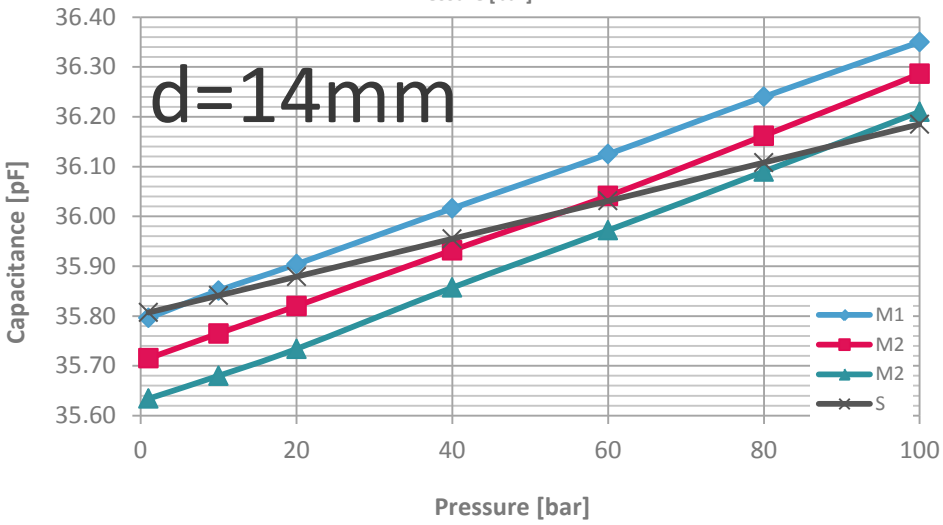


Simulation vs. measurements



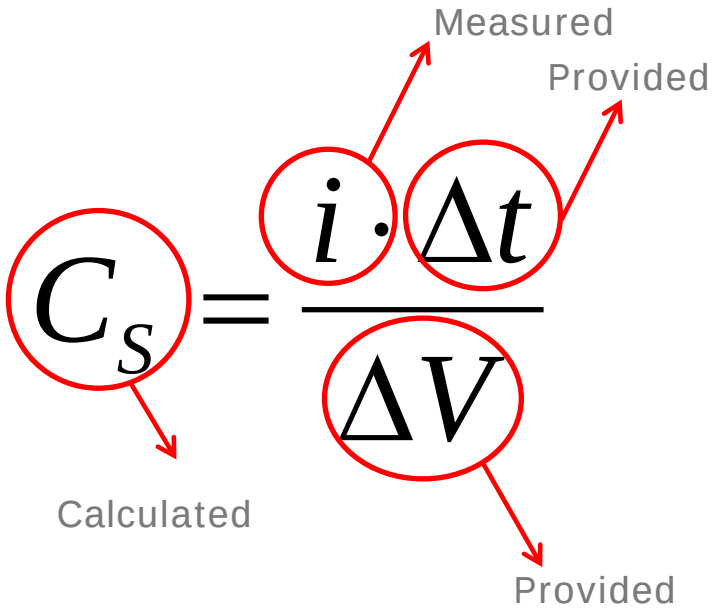


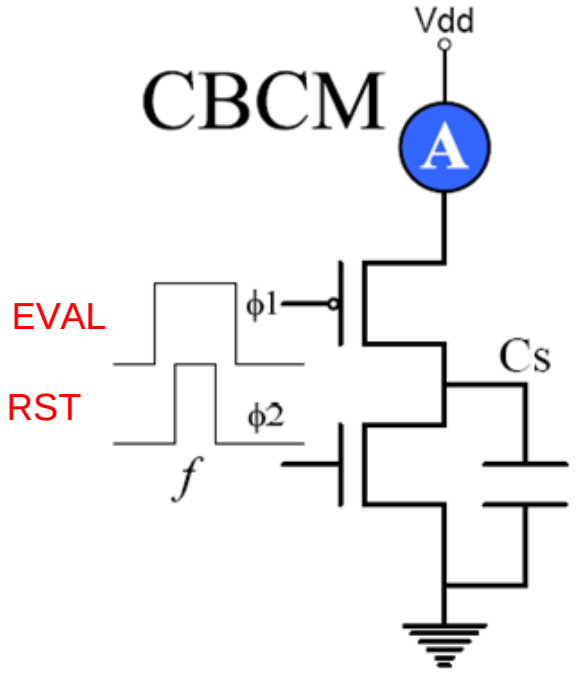




Read-out integrated circuit

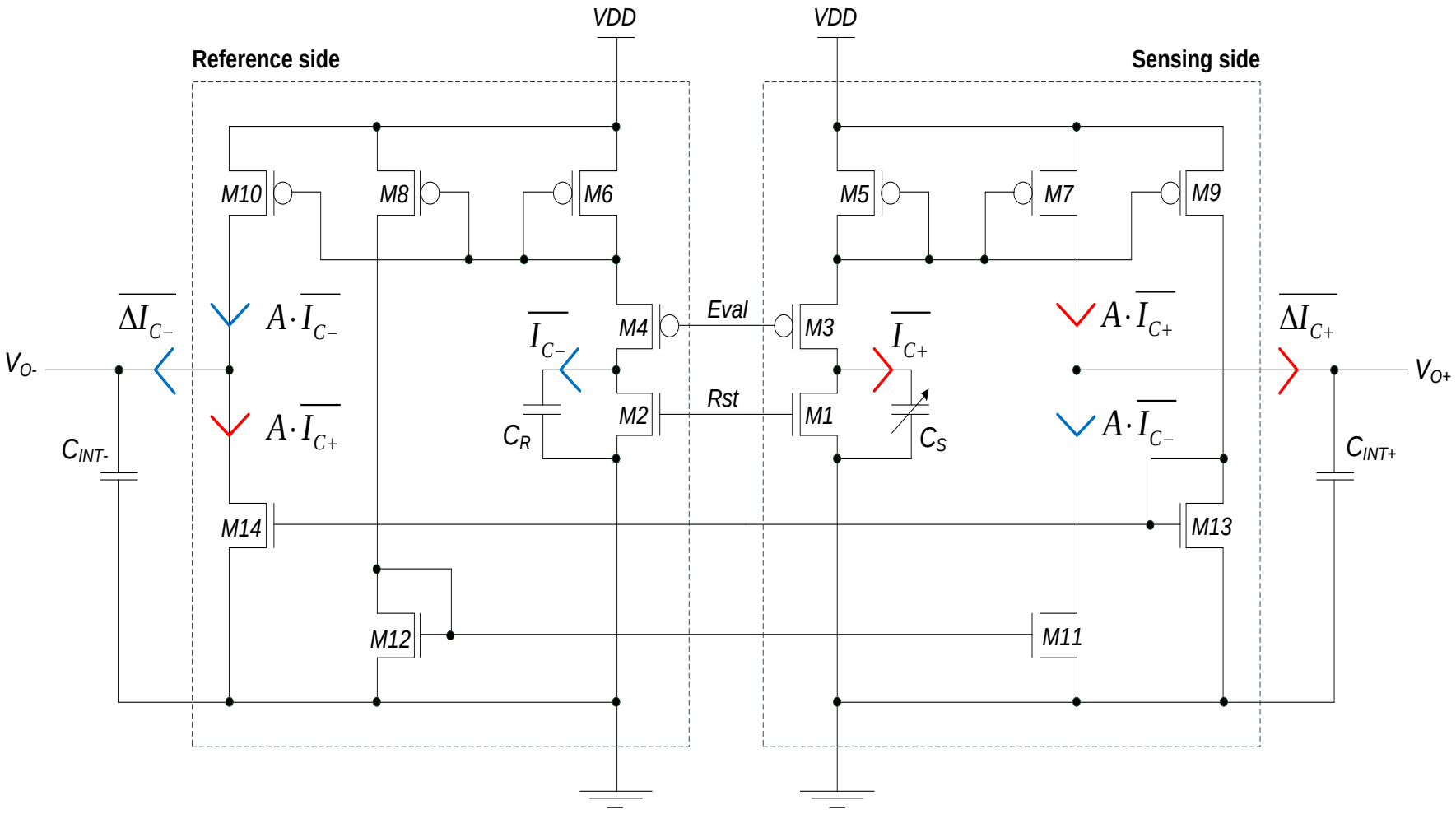
Sensing principle



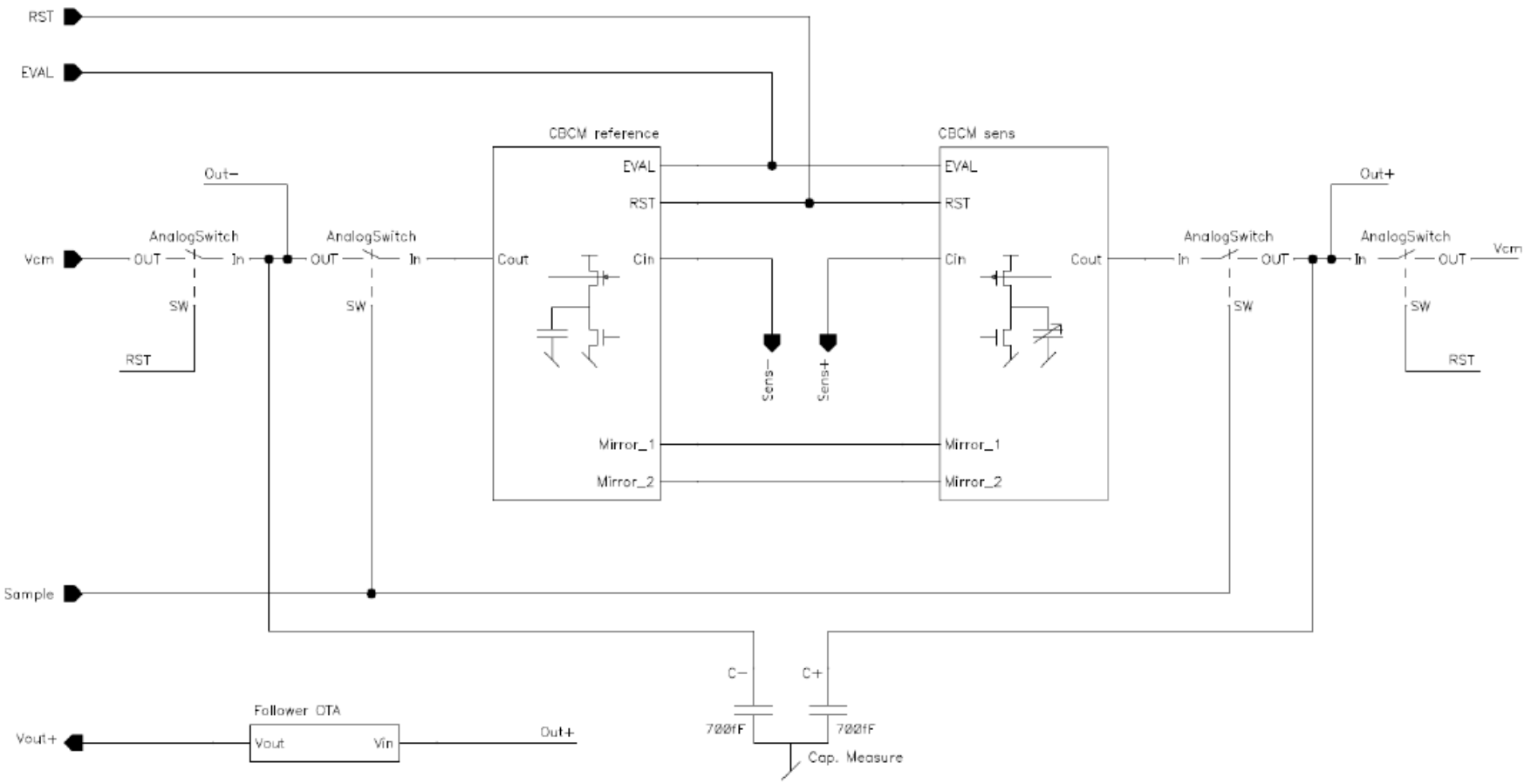


CBCM: Charge-Based Capacitance Measurement

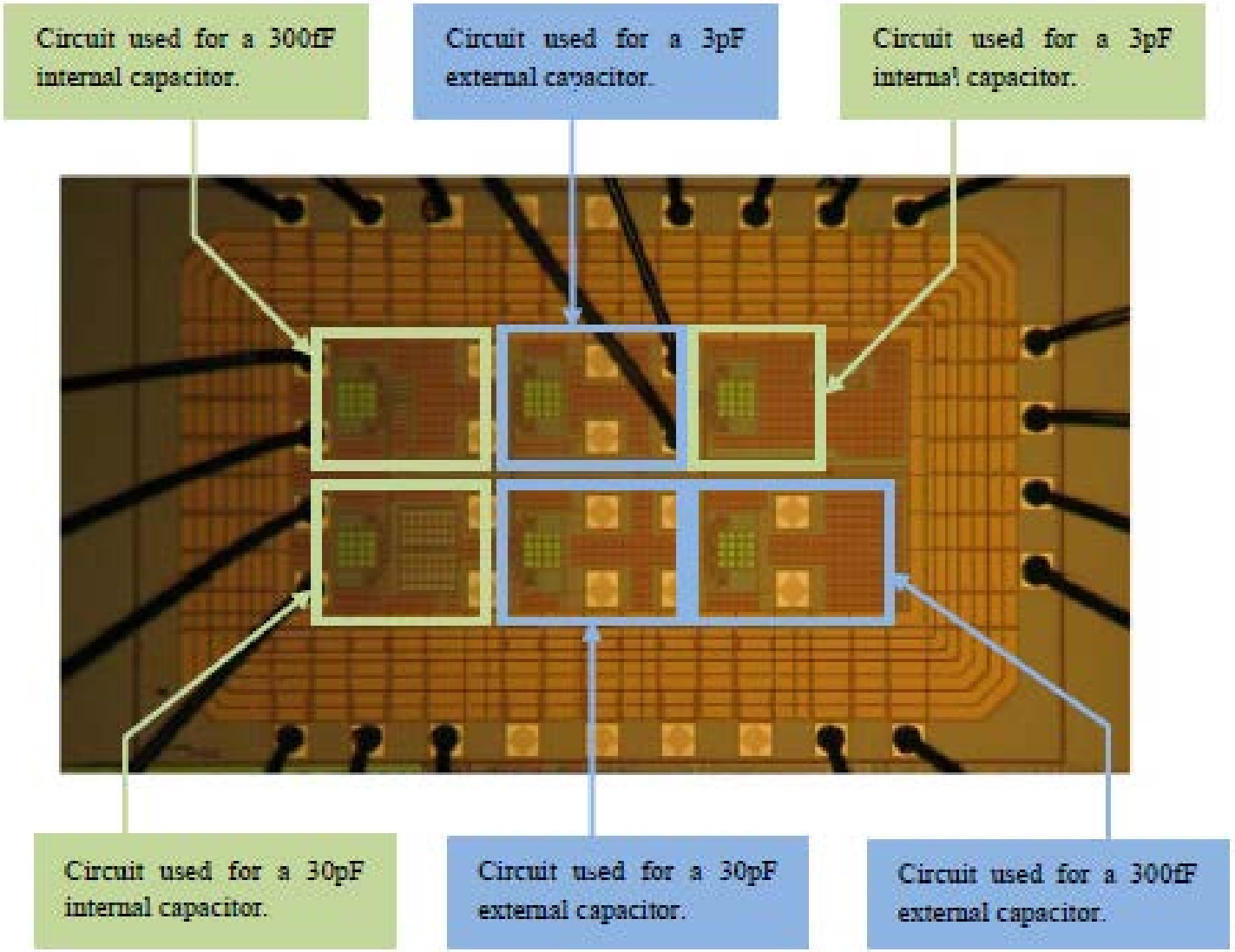
Sensing circuit



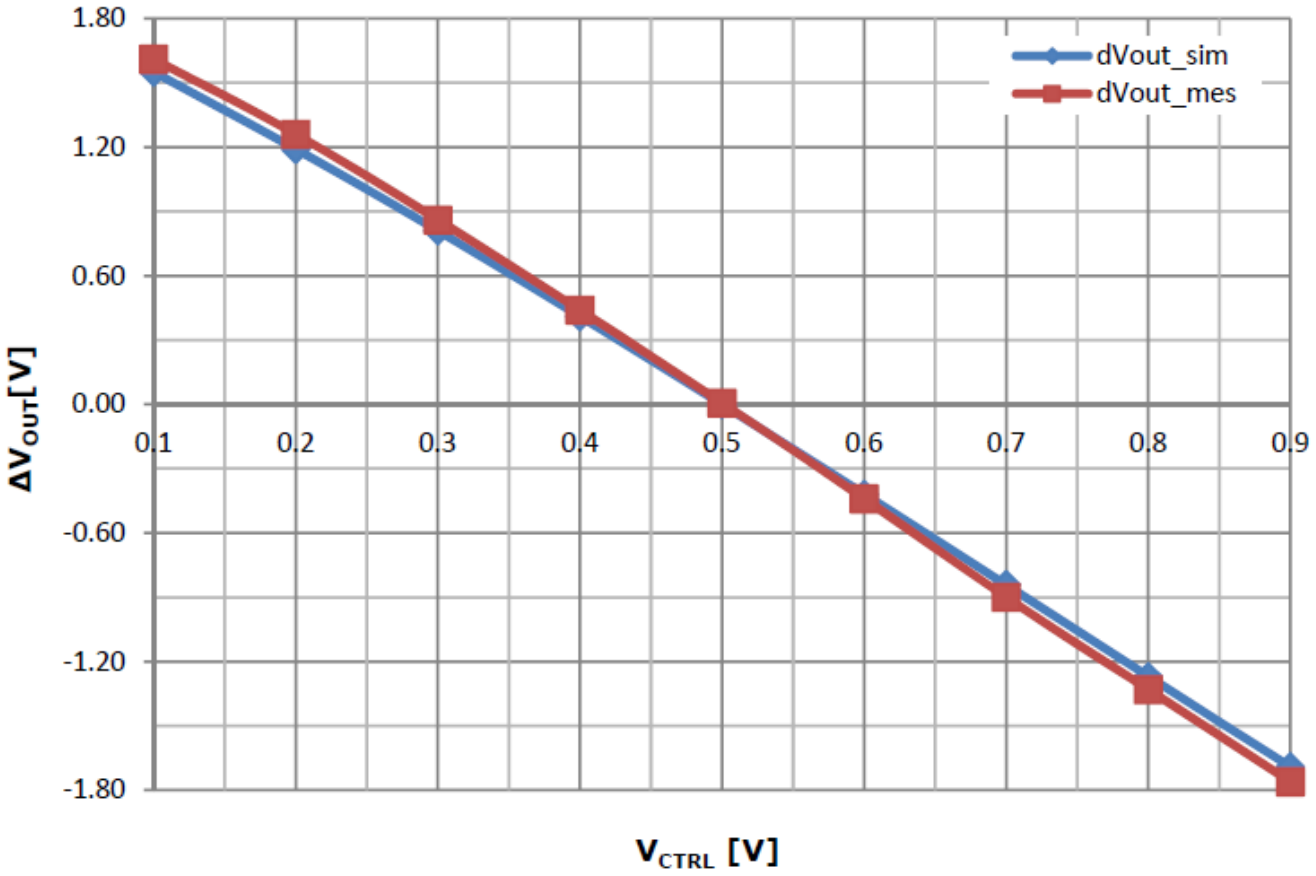
Sensing circuit



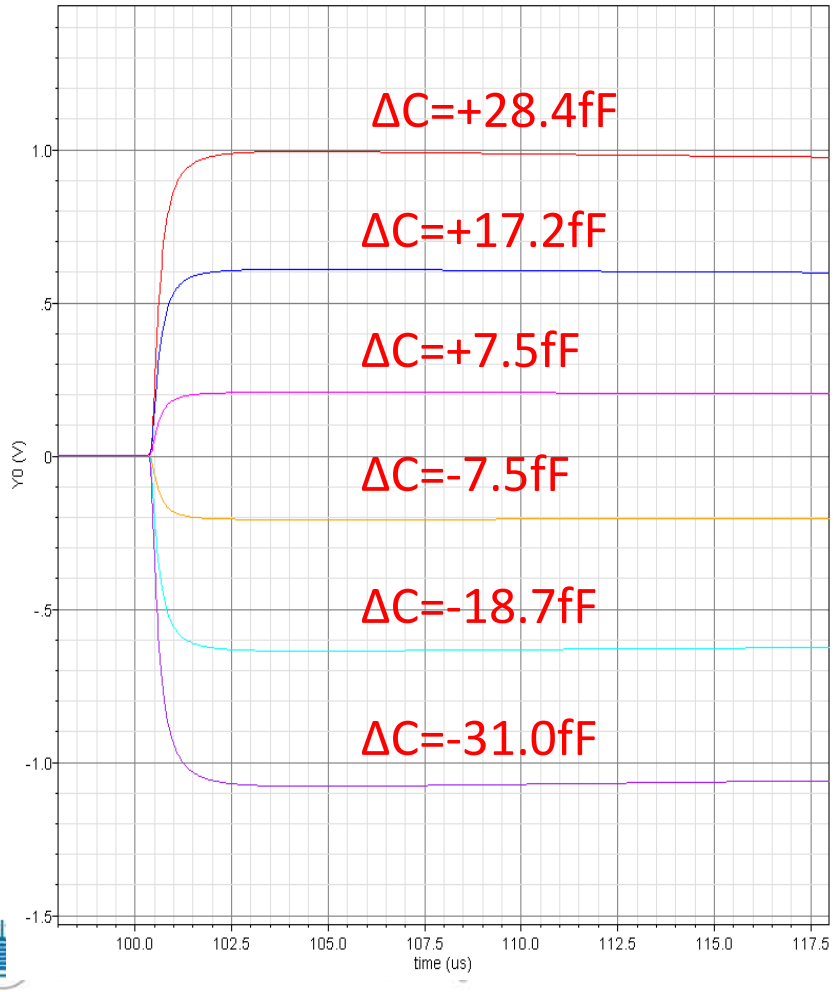
ASIC design

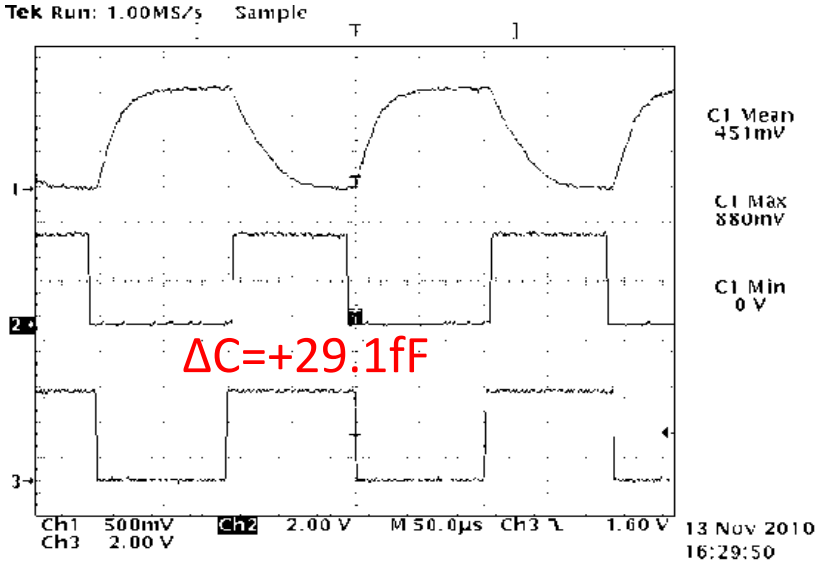

Circuit used for a 300fF internal capacitor.
Circuit used for a 3pF external capacitor.
Circuit used for a 3pF internal capacitor.
Circuit used for a 30pF internal capacitor.
Circuit used for a 30pF external capacitor.
Circuit used for a 300fF external capacitor.

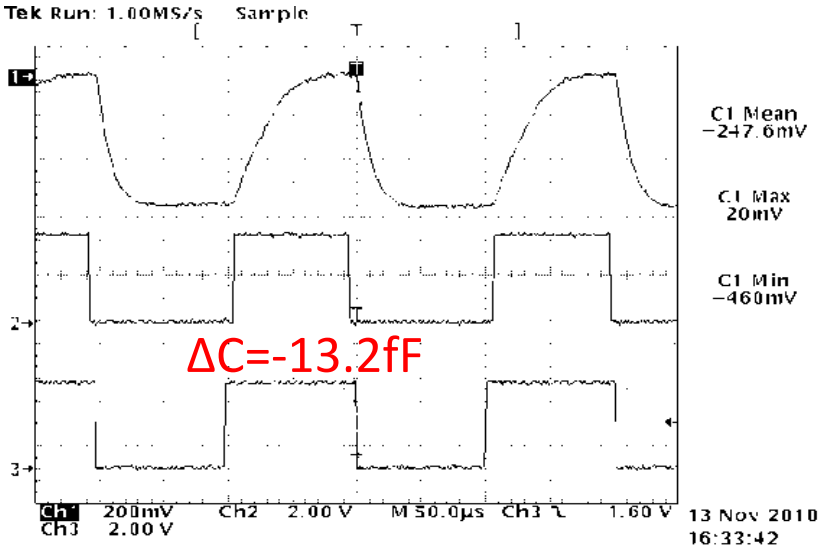
Circuit tests (internal varactor)



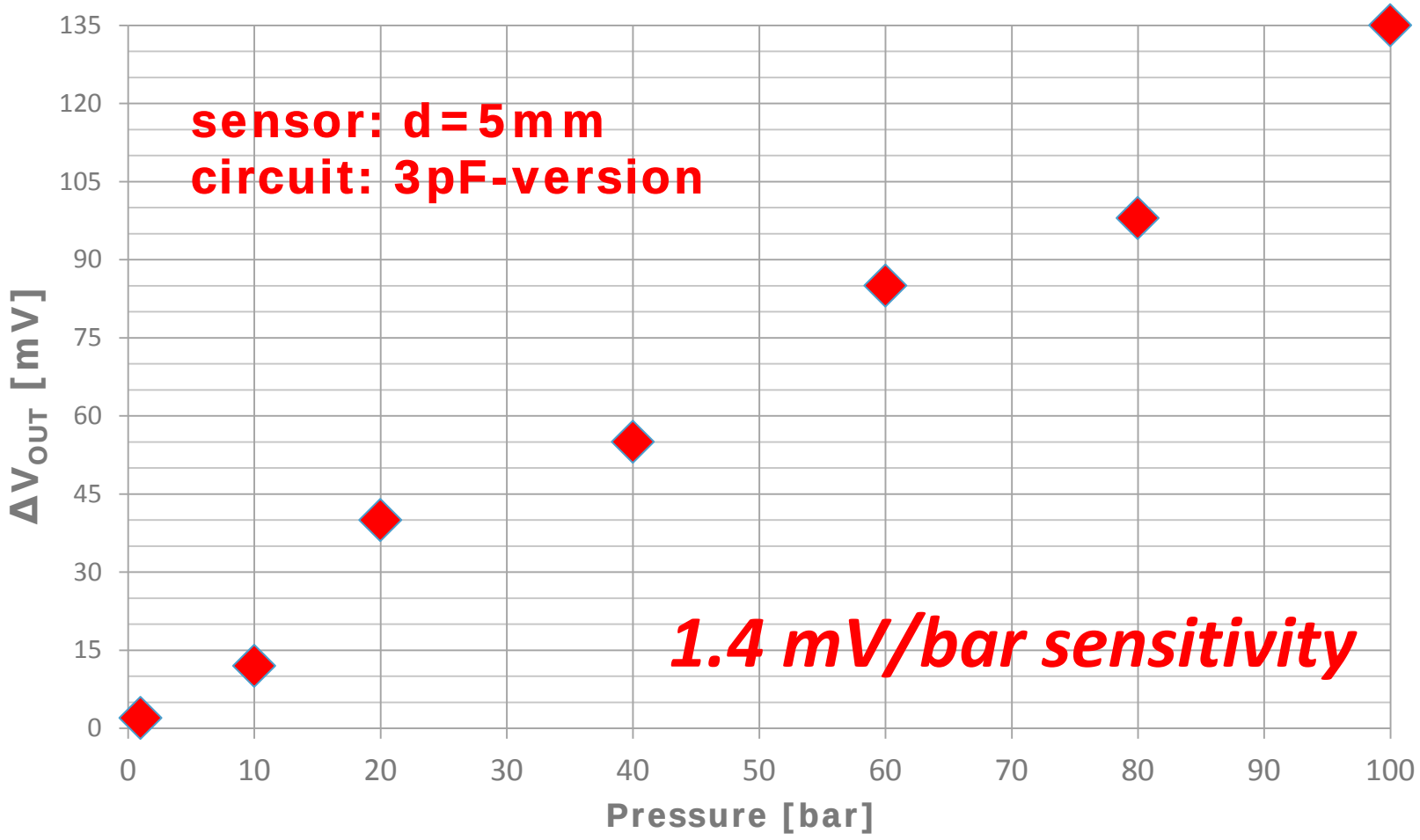
Circuit tests







Circuit performances



Circuit performances

Circuit version	Parameter	Value	Unit
300fF	I_{DD}	38.7	uA
	P_S	127	uW
3pF	I_{DD}	42.5	uA
	P_S	127	uW
30pF	I_{DD}	51.9	uA
	P_S	127	uW

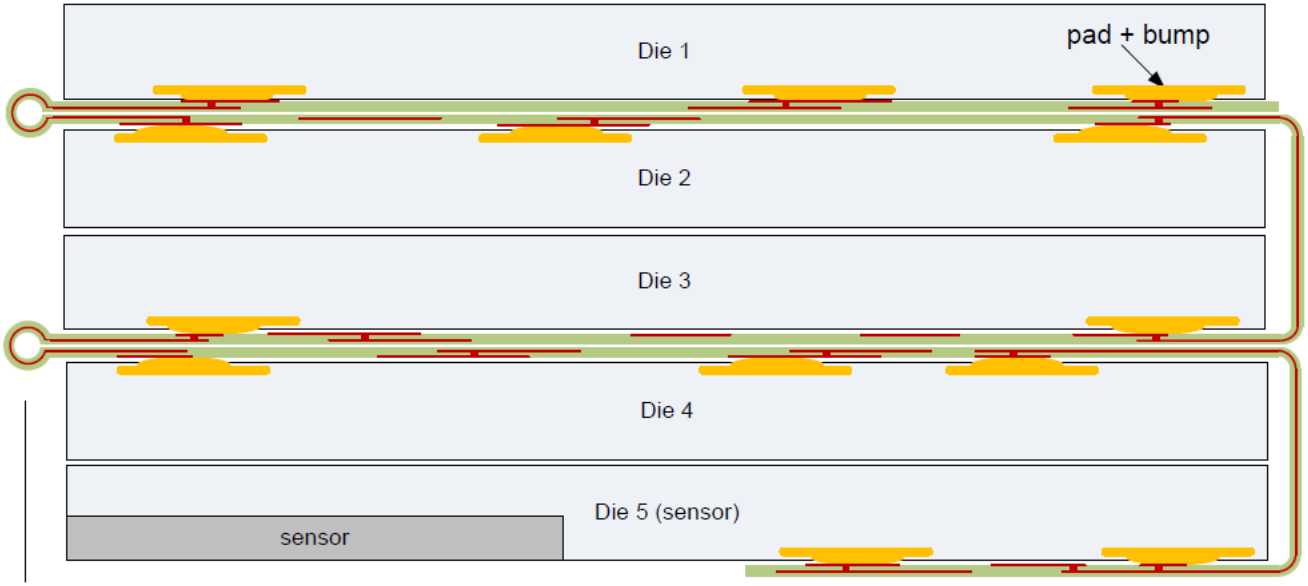
	Circuit version	Simulation	Measure	Unit
Varactor	300fF	30	35	mV/fF
	3pF	33	38	mV/fF
	30pF	37	34	mV/fF
Sensor	300fF	-	-	mV/bar
	3pF	19	1.4	mV/bar
	30pF	126	-	mV/bar

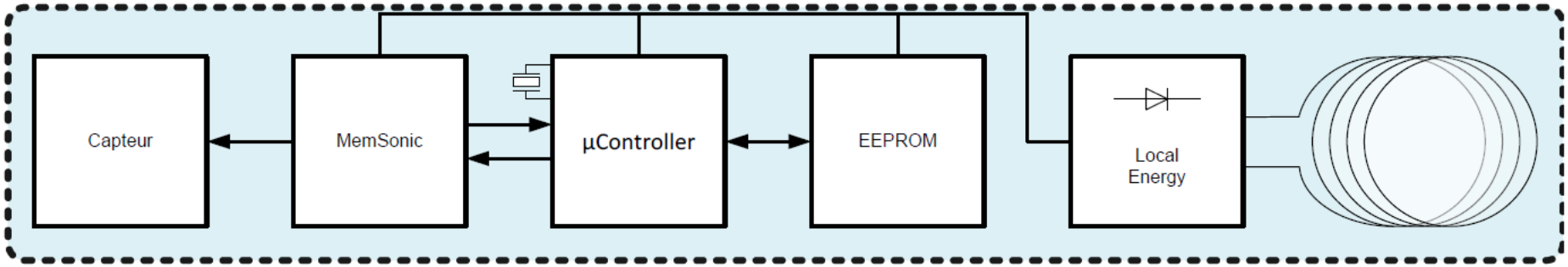
< current leakage ?

On-going work and valorization

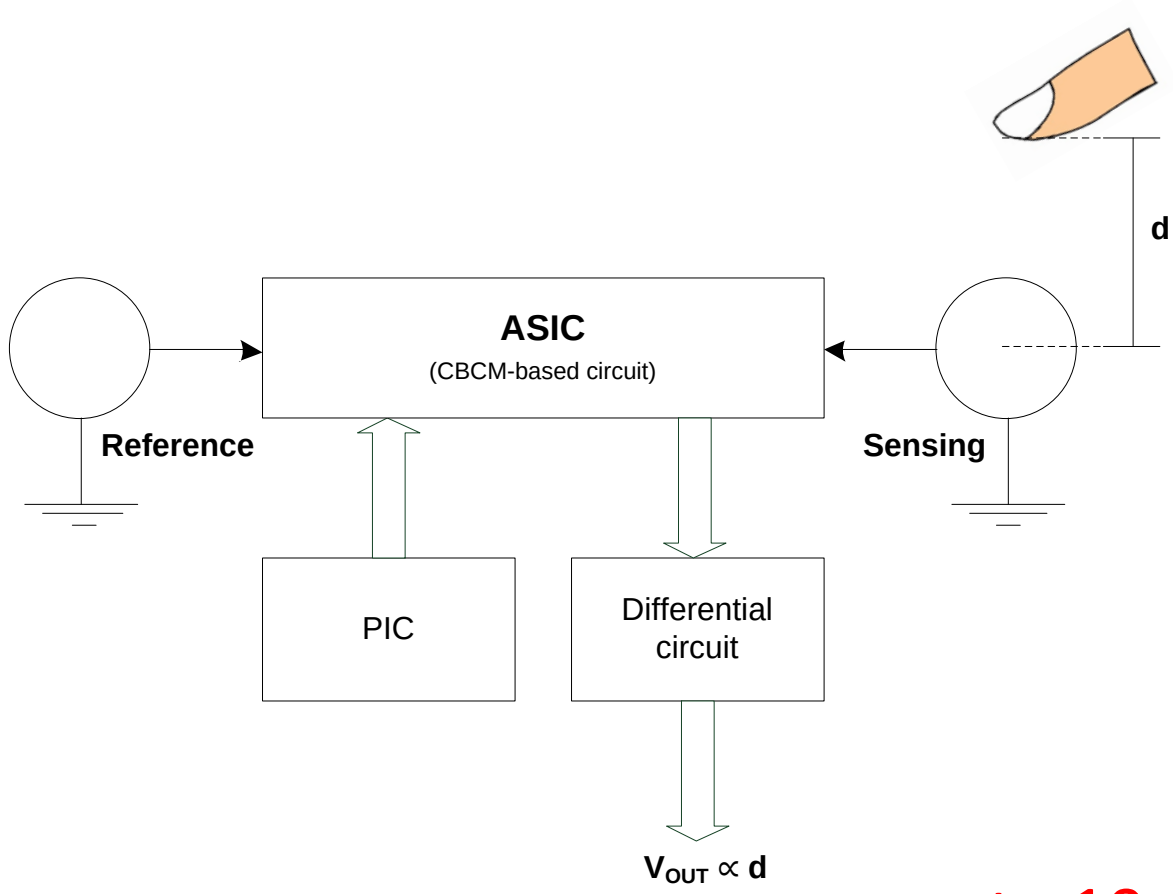
PoUSSyERE

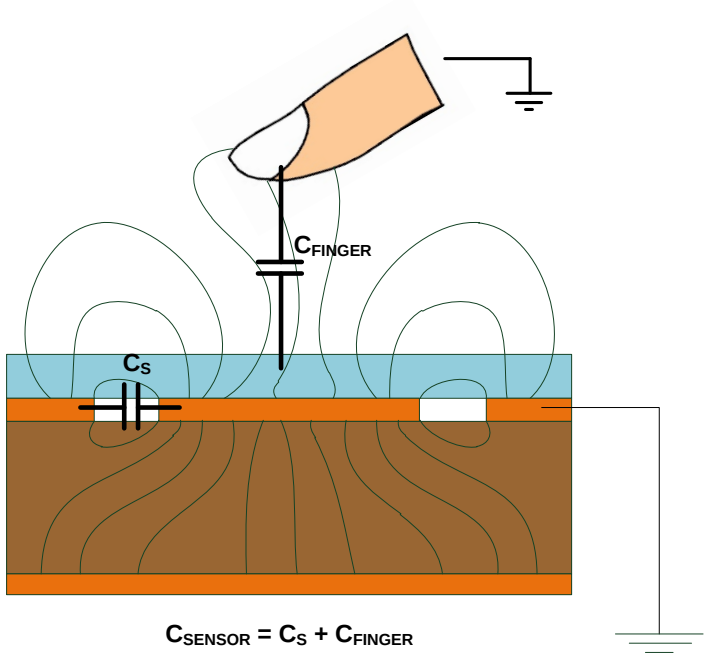
Platform for Ubiquitous Smart Systems for Embedding Recording of Events





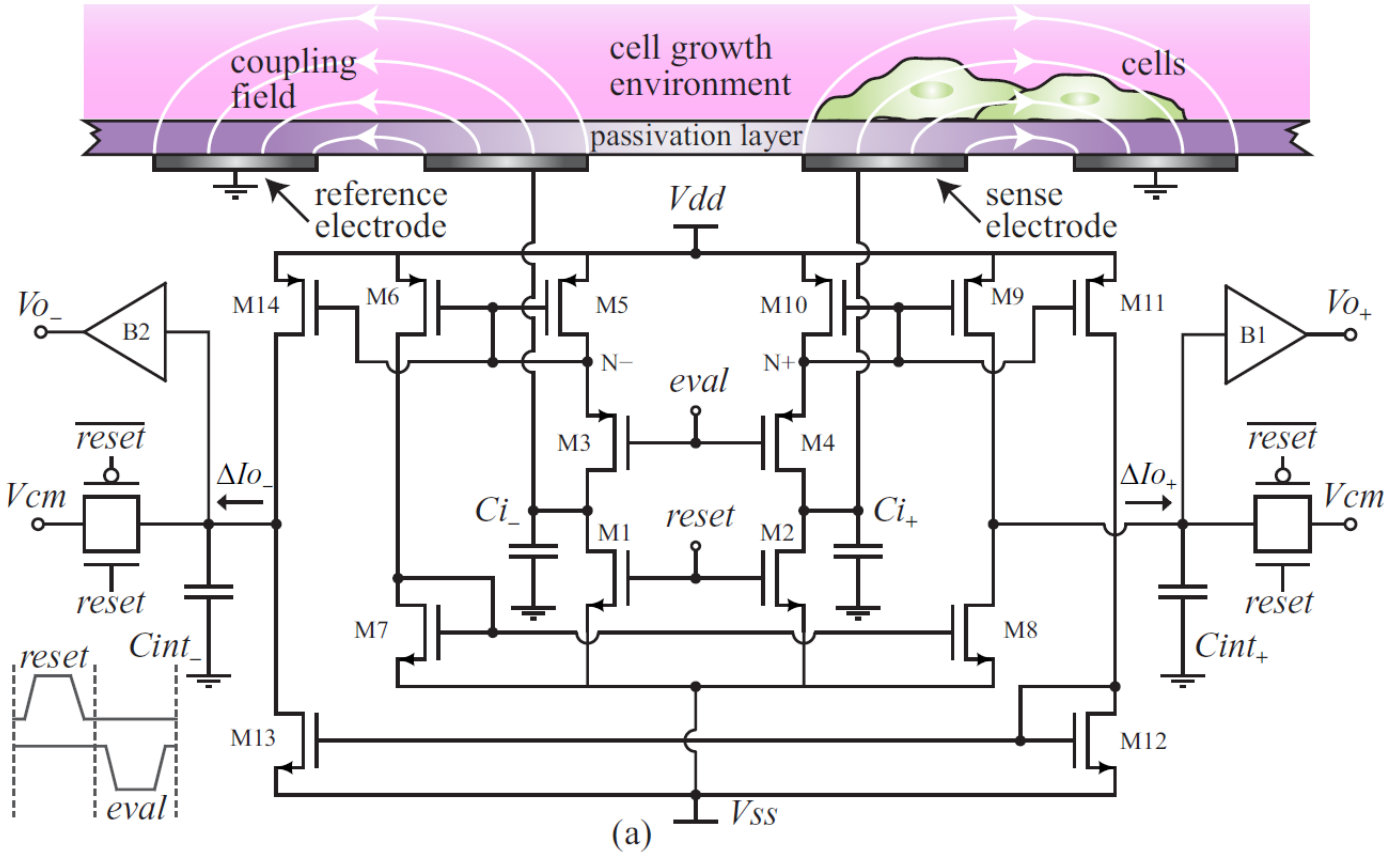
Proximity sensing





up to 10 cm!

Cell sensing



Somashekat et al., "A Fully Differential Rail-to-Rail Capacitance Measurement Circuit for Integrated Cell Sensing", IEEE Sensors 2007.

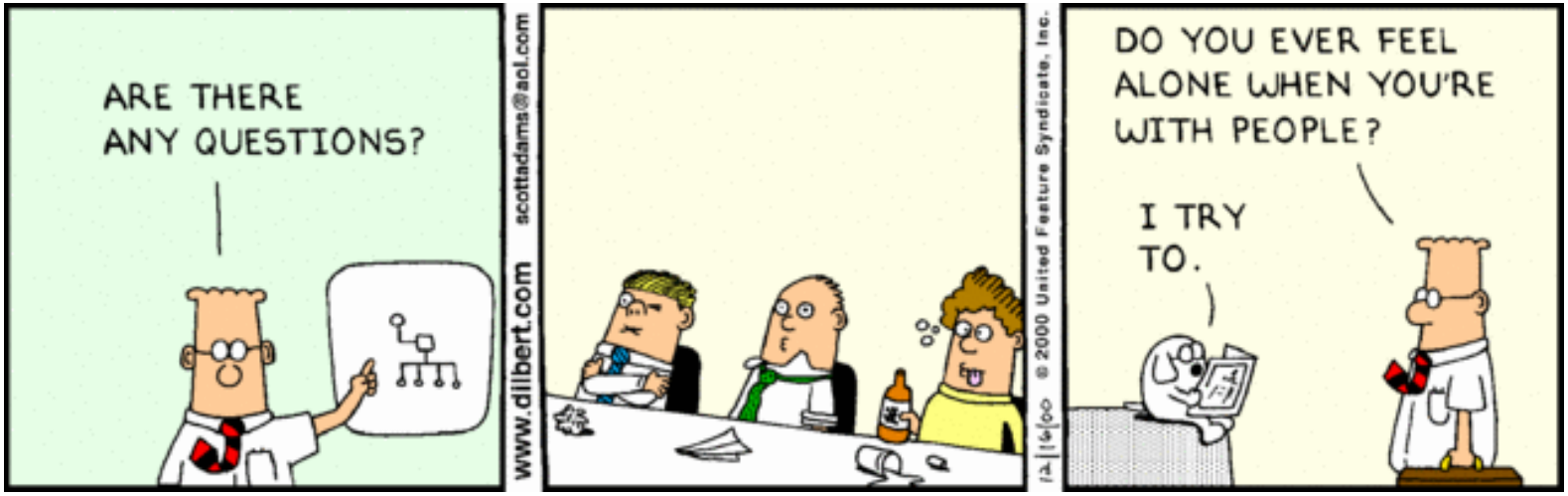
Conclusions

- ✓ An ultra-thin pressure sensor has been designed, developed and tested, matching requirements;
- ✓ CMOS and MEMS have been co-integrated, but still on different substrates, full co-integration feasibility is confirmed;
- ✓ An integrated differential capacitive sensor has been successfully tested and validated as a general platform.

Acknowledgements

- ✓ Prof. Herbert Keppner, prof. Elena-Lavinia Niederhäuser, Lorenzo Pirrami, Benjamin Graf
- ✓ ISYS, a former HES-SO network for supporting the project

Thank you…


ARE THERE ANY QUESTIONS?
www.dilbert.com scottadams@aol.com
© 2000 United Feature Syndicate, Inc.
DO YOU EVER FEEL ALONE WHEN YOU'RE WITH PEOPLE?
I TRY TO.