

## Mikro- og nanoteknologilaboratoriet



(Ref: Dr.ing. N. Peter Østbø)



## microBUILDER

An integrated modular service for microfluidics and mixed technologies

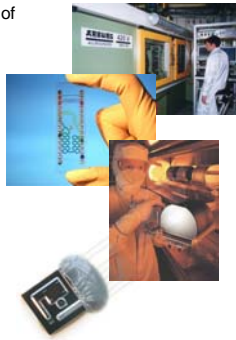
(Ref: Ingelin Clausen)



## Mixed Technologies

■ Combination and interaction of different technologies and competences

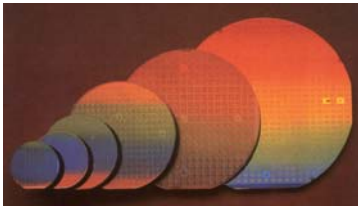
- Moulding of plastics
- Silicon and glass micromachining
- Packaging and system integration
- Actuators
- Electronics
- Surface functionalization and modification



## Produksjon i rene omgivelser



## Startmateriale



- Silisium skiver  $\varnothing$  2 - 8", tykkelse 100  $\mu\text{m}$  - 2 mm
- Restivitet: fra 50 000  $\Omega\text{cm}$
- 25% av jordskorpen er silisium

## Oksidasjon av overflaten: passivering

$\text{SiO}_2$

Silisium skive



- "Tørr" oksid:  $\text{Si} + \text{O}_2 \rightarrow \text{SiO}_2$
- "Vått" oksid:  $\text{Si} + 2\text{H}_2\text{O} \rightarrow \text{SiO}_2 + 2\text{H}_2$
- Temperaturer fra 900 - 1200  $^\circ\text{C}$
- Oksid tykkelse: 2 nm - 2  $\mu\text{m}$

Ovner:

Centrotherm, E1550 HT 260-4



Ovner:

Centrotherm, E1550 HT 260-4



PECVD: AMS200 "I-speeder"



PECVD  
SiO<sub>2</sub>, Si<sub>3</sub>N<sub>4</sub>  
& a-Si



Definere mønster: fotolitografi



- CMOS: 0.18  $\mu\text{m}$  linebredde
- MEMS: > 5  $\mu\text{m}$  (?)

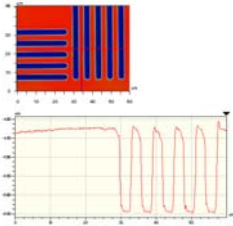
Fotoreisist Coater



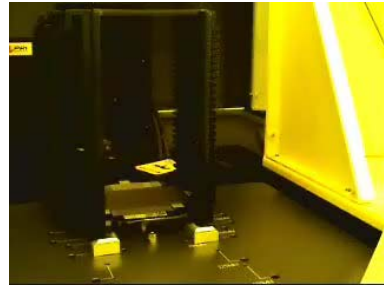
Suss, MA150 CC Aligner



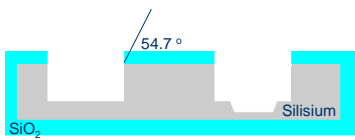
## Fotolitografi



## Automatisk inspeksjon



## Mekaniske strukturer: Etsing



- Etserater: 0.5 - 250  $\mu\text{m}/\text{time}$  F(temp, conc)
- Væsker: EDP, KOH, TMAH
- Gasser: SF<sub>6</sub>, Cl<sub>2</sub>, F<sub>2</sub>

## Våtets



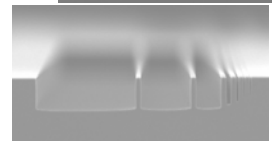
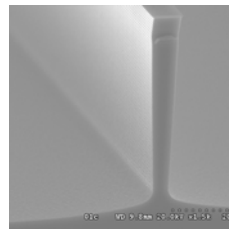
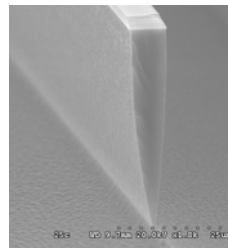
## Tørrets: AMS200 "I-speeder"

Dyp tørrets:  
Bosch og Cryo

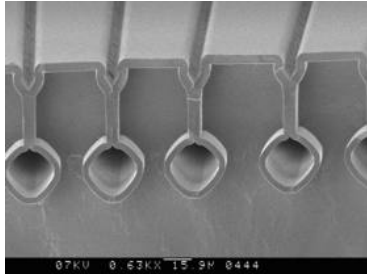
Film tørrets  
SiO<sub>2</sub>, Si<sub>3</sub>N<sub>4</sub>, polySi,  
Al & polyimide



## Tørretsede strukturer

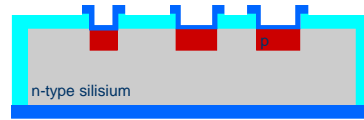


## Begravde kanaler



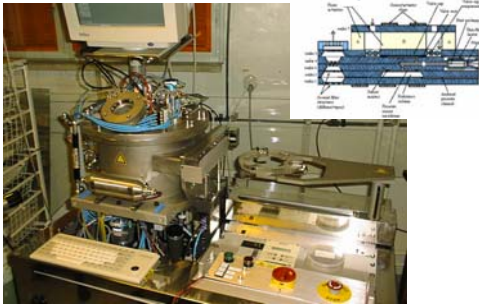
- anisotropisk RIE
- isotropisk RIE
- SiO<sub>2</sub> ets
- SiN LPCVD

## Metall



- Metaller: Aluminium, Gull, Titan, Wolfram
- Diffusjonsbarrierer kan være nødvendig

## 3-D strukturer: skivebonding



## Add-on processes – piezoelectric thin films

- Functional surfaces for resonating elements (cantilevers or diaphragms) or for pumps and actuators
- Attractive for chemical and biochemical sensors
- Piezoelectric film (PZT) on silicon
- To be used as stand-alone or to be combined with lab-on-chip systems

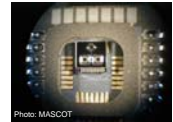
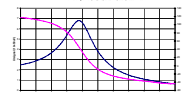


Photo: MASBOT  
Prototype acoustic gas sensor in a ceramic package

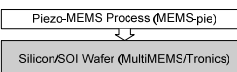


Frequency characteristics of the prototype acoustic gas sensor in CO<sub>2</sub> at room temperature



## Add-on Piezoelectric thin film process I- Wafer Level Processing

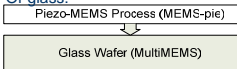
On silicon:



MEMS-pie PZT process steps including Material deposition and patterning

CSC-RTP- PZT (T~650 °C)
Sputter- Pt (T~300 °C)
Sputter- TiO <sub>2</sub> (T~100 °C)
PECVD- SiC <sub>x</sub> (T~300 °C)

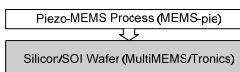
Or glass:



Full integration requires significant Process Development...

## Add-on Piezoelectric thin film process I- Wafer Level Processing

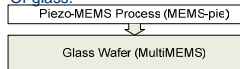
On silicon:



MEMS-pie AlN process steps:

Sputter- Al (T~100 °C)
Sputter- AlN (T~300 °C)
Sputter- Al (T~100 °C)
PECVD- SiC <sub>x</sub> (T~300 °C)

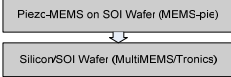
Or glass:



Full integration moderate Process Development...

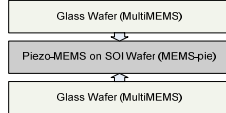
## Add-on Piezoelectric thin film process II- Wafer Level Packaging

Silicon On Silicon:



(Plasma bonding)

Glass-Silicon-Glass:



(Anodic bonding)

## Saging



## Uttesting av ferdige komponenter



## Noen prosjekter

## Application Examples of piezo-MEMS Devices

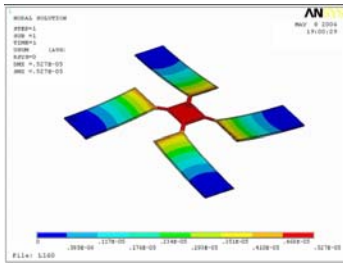


## Automotive Example: SensoNor

- Sensors: Parking, Crash, Gas (Air quality-MASCOT)
- Tire Pressure Sensors
- Energy Harvesters (for wireless sensors)
- FBAR/ SAW-filters (RF) (Ferroelectric Memory)
- pMUTs
  - piezoelectric-micro-Ultrasound Transducers
  - Phased Arrays- phase shifters
- Actuators (micro-pumps, switches,...)
- Tunable optics
  - Micro-focus lenses
  - filters
- Lots of others!



## RF-MEMS switch 1



- Capacitive coupling
- Dielectric
- GHz frequency

Park et al., J. Micromech. Microeng. 16 (2006) 2281–2286

## RF-MEMS switch 2

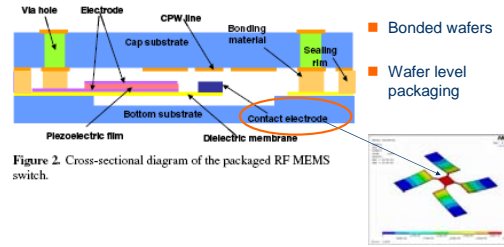


Figure 2. Cross-sectional diagram of the packaged RF MEMS switch.

- Bonded wafers
- Wafer level packaging

Park et al., J. Micromech. Microeng. 16 (2006) 2281–2286

## Gas sensor Example:



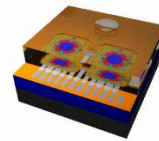
**MASCOT**  
Micro Acoustic Sensor system for CO<sub>2</sub> Tracking

Per Gerhard Gløersen, SensoNor AS  
Beritl Høk, Høk Instrument AB  
Niels Peter Østbo, SINTEF

- Patents pending
- CO<sub>2</sub>
- Humidity
- Piezoelectric Actuator needed!

The MASCOT project was co-financed by the IST programme of the European Commission under grant number IST-2001-32411

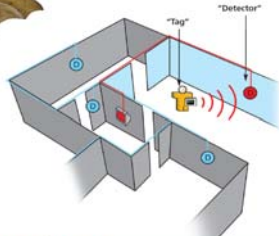
## MASCOT in operation



## Applications Example: Sonitor



Nature gave bats ultrasound for navigation safety in close quarters in the dark...

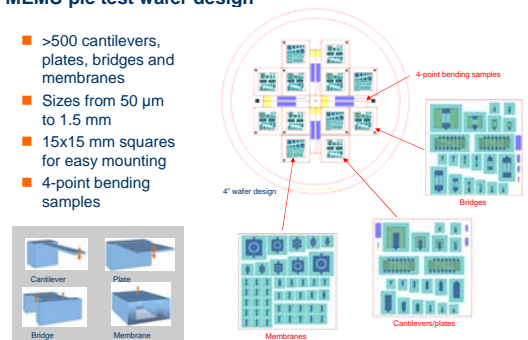


- Ultrasound Transducer: Murata
  - Sonitor-IPS
  - Incl. RF-ID
- (Høk: Gas Sensors)

[www.sonitor.com](http://www.sonitor.com)

## MEMS-pie test wafer design

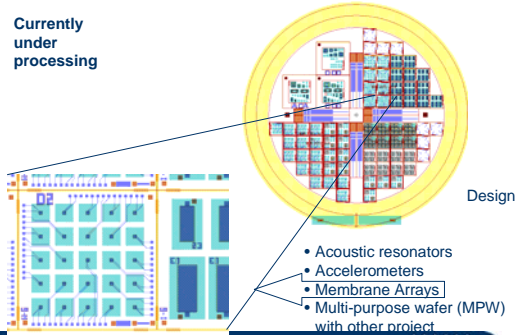
- >500 cantilevers, plates, bridges and membranes
- Sizes from 50 µm to 1.5 mm
- 15x15 mm squares for easy mounting
- 4-point bending samples





**3rd generation test wafer**

Currently under processing



Design

- Acoustic resonators
- Accelerometers
- Membrane Arrays
- Multi-purpose wafer (MPW) with other project

SINTEF IKT

**Noen prosjekter**

SINTEF IKT

**Strålings-detektor**



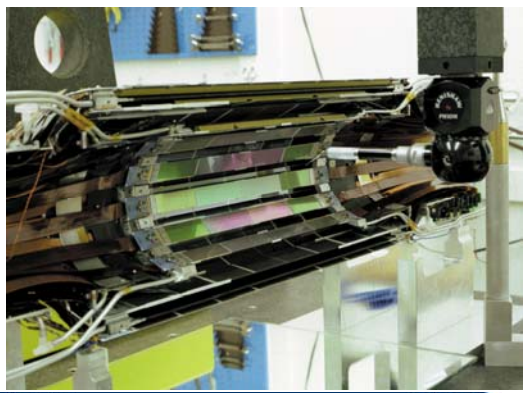
SINTEF IKT

**Sensorer for eksperimenter som avslører naturens innerste hemmeligheter**



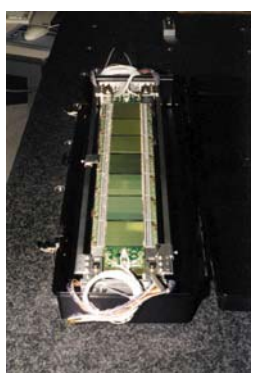
*Alice* CERN Geneve

SINTEF IKT



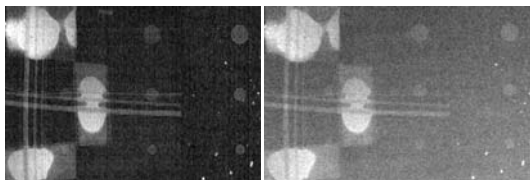
SINTEF IKT

**SINTEFs detektorer er med og jakter på Quark-gluon plasma ved Brookhaven National Lab, USA**



SINTEF IKT

## Silisium detektorer for medisinsk bruk



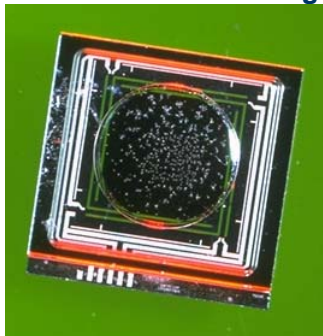
Klarere bilde med silisium pixel detektorer  
(Mammografi, tannrøntgen)



5A.7

Gass sensor:  
Måler CO<sub>2</sub>  
innhold i  
luften i  
klasserommet

## Mikrovekt måler mikrogram



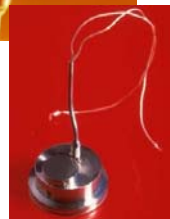
## Trykksensor for 2000 bar, høye trykk



## Sensorer for oljeutvinning



Trykk-sensor som ikke  
påvirkes av  
temperaturforandringer





## Sensorer for målinger i kroppen



SINTEF

IKT

49

## Diagnose-system på en chip

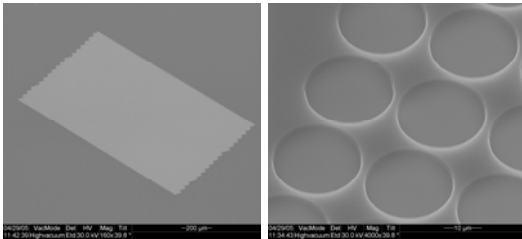


SINTEF

IKT

50

## CMUT. Ultralydtransducer for blodåre



20000 VoltMax Del HV Mag 10  
1.42 50µm/div 10.00V 100.0k/s

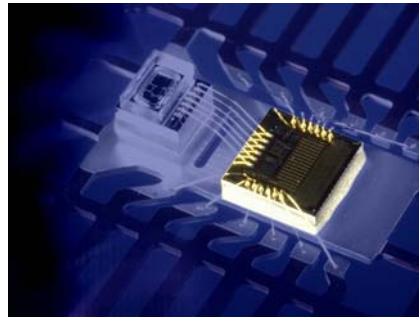
20000 VoltMax Del HV Mag 10  
1.12 50µm/div 10.00V 100.0k/s

SINTEF

IKT

51

## Air-bag vinkelhastighets-sensor.



Ruller  
bilen over  
på siden?

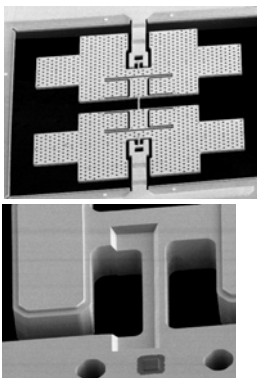
Utløs  
airbag  
fra siden.



SINTEF

IKT

52



Detaljer av  
"gyroskop"

De tynne bjelkene er  
10 mikrometer brede

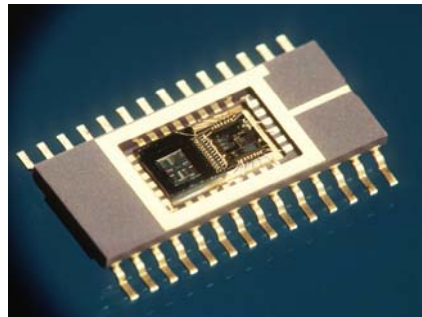


SINTEF

IKT

53

## "Gyroskop" ferdig pakket





SINTEF

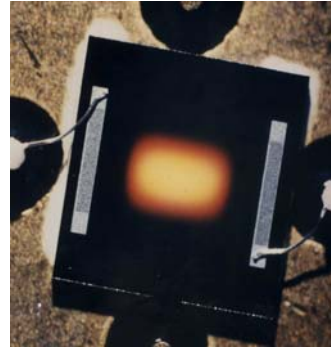
IKT

54



Gass-detektor brukt i Nordsjøen.

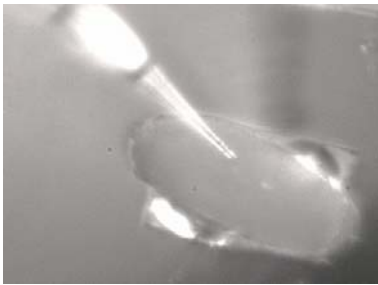
Inneholder infrarød strålingskilde i silisium



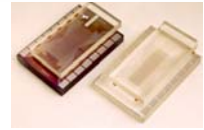
Infrarød strålingskilde i silisium

Stabil i minst 15 år!

### Mikroinjeksjon av DNA i bananflue-embryo samarbeid med Stanford, USA



### PHOTONYX



### Fingeravtrykk sensor



### Diffraktiv optikk

