mini faros

www.minifaros.eu

Biaxial tripod MEMS mirror and omnidirectional lens for a low cost wide angle laser range sensor

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SEVENTH FRAMEWORK PROGRAMME

ICCS VTT Fraunhofer ISIT SICK Sensor Intelligence. VOLVO UNIVERSITY of OULU OULUN YLIOPISTO Škoda SIMPLY CLEVER

Introduction

Central ideas of the MiniFaros project:

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- development of a sensor with almost omnidirectional view

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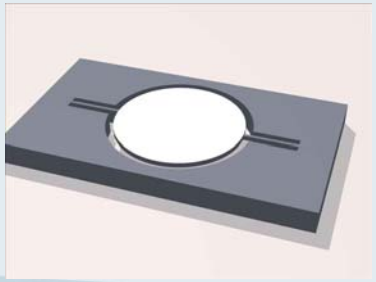
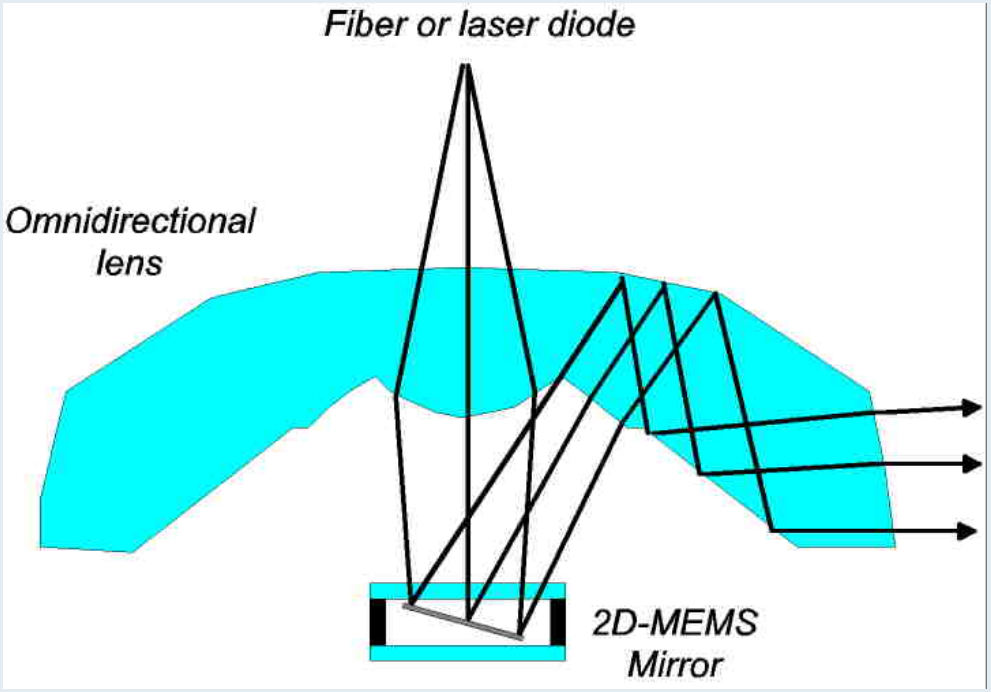
- compact size
- mass-producible at low cost

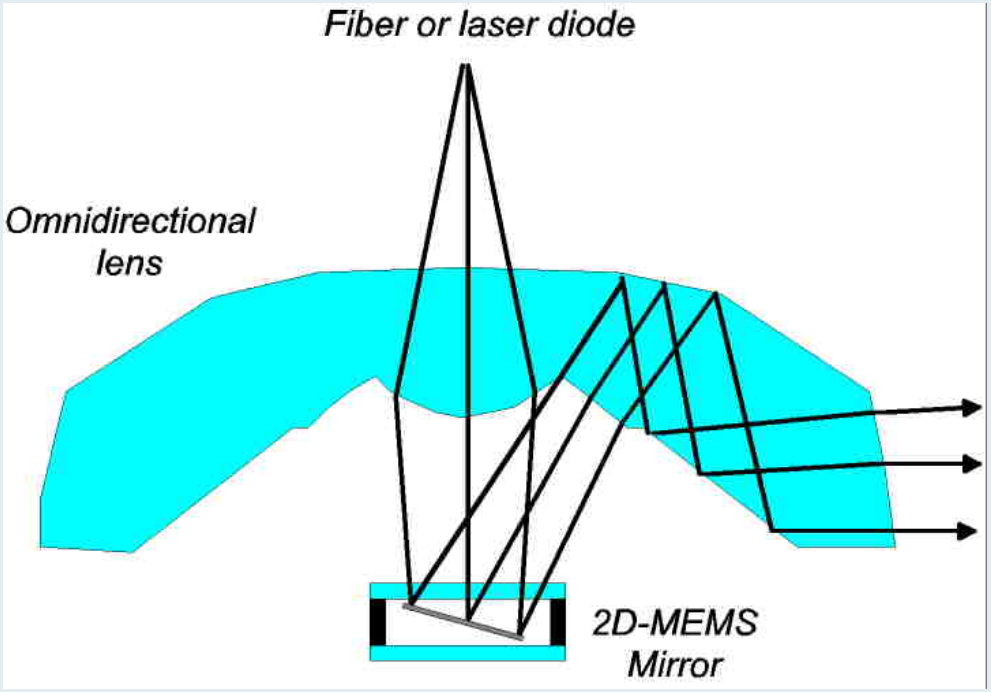
=> MEMS scanning mirror technology + replicable plastic optics



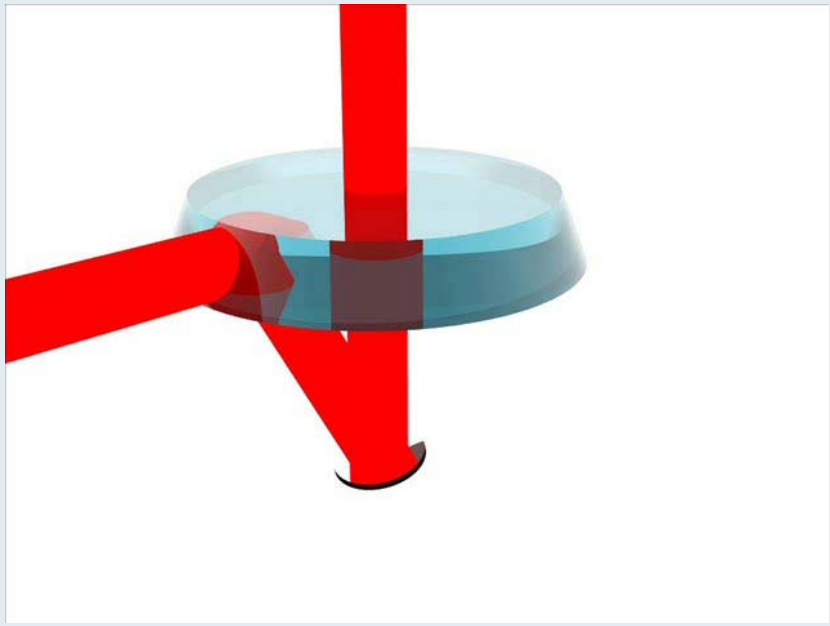
Omnidirectional scanning concept



Omnidirectional scanning concept



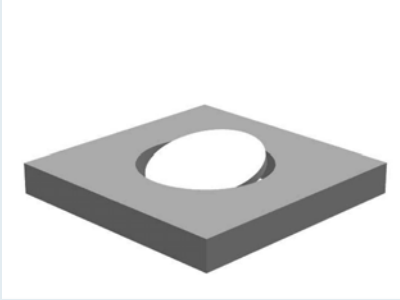
Omnidirectional lens



2D-MEMS Mirror

MEMS mirror requirements

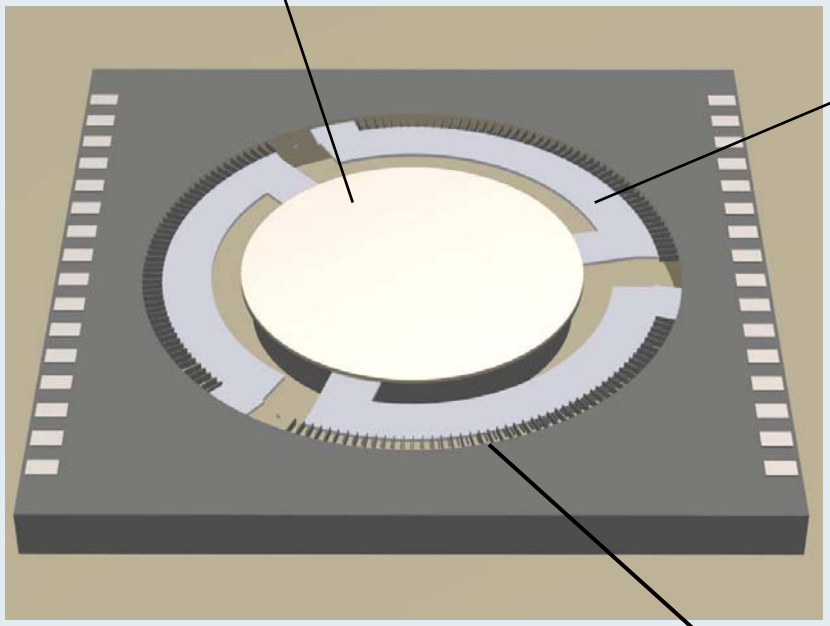
1. large mirror aperture size of 7mm
2. circular scan pattern => two axes of identical scan frequency
3. large tilt angle of 15 degrees in both axes



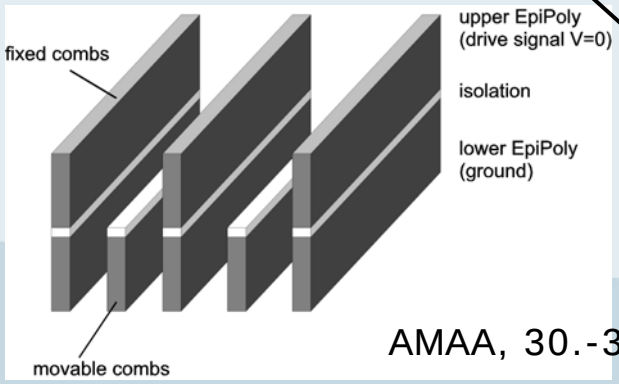
Tripod MEMS mirror design

mirror plate (diameter 7mm, thickness 500 µm)

circular bending springs
(thickness 40 µm)

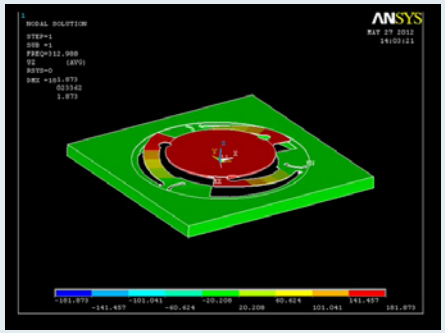


- identical resonant frequencies in xy
- minimum footprint
- circular springs enable large tilt angle
- advantageous eigenmode spectrum

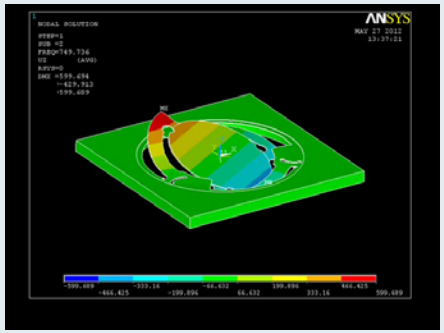


stacked vertical comb electrodes
for electrostatic driving
and capacitive position sensing

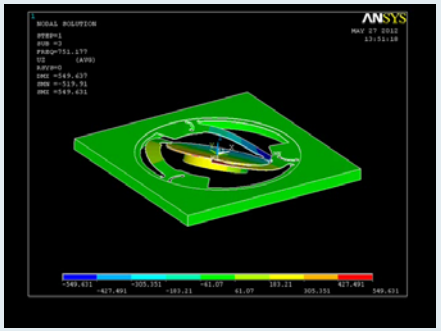
FEM modal analysis



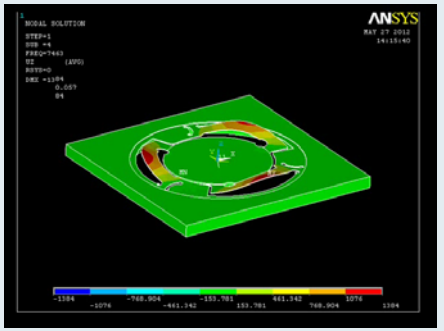
1st mode:
parasitic piston mode
@ 310 Hz



2nd mode:
first scan axis
@ 750 Hz

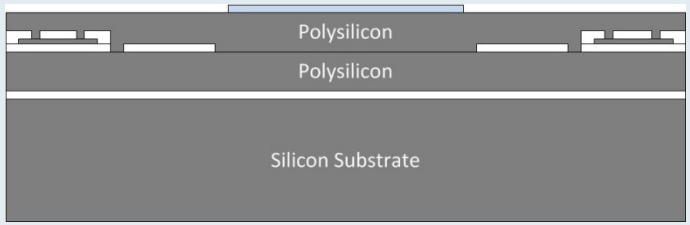


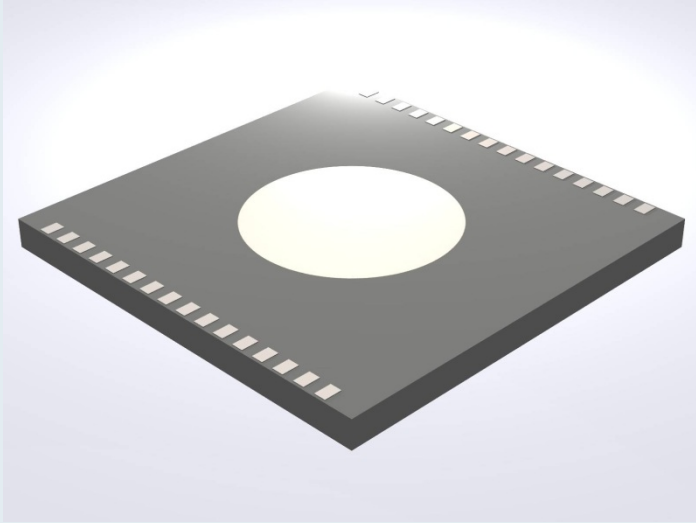
3rd mode:
second scan axis
@ 750 Hz



4th mode:
parasitic mode
@ 7.4 kHz

Tripod MEMS mirror fabrication process





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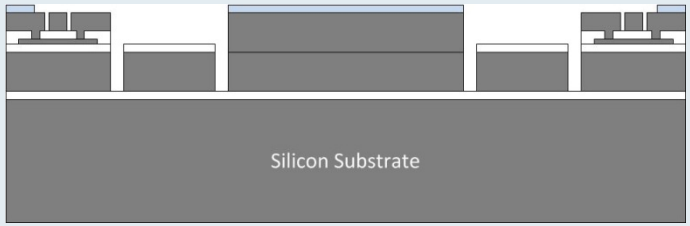

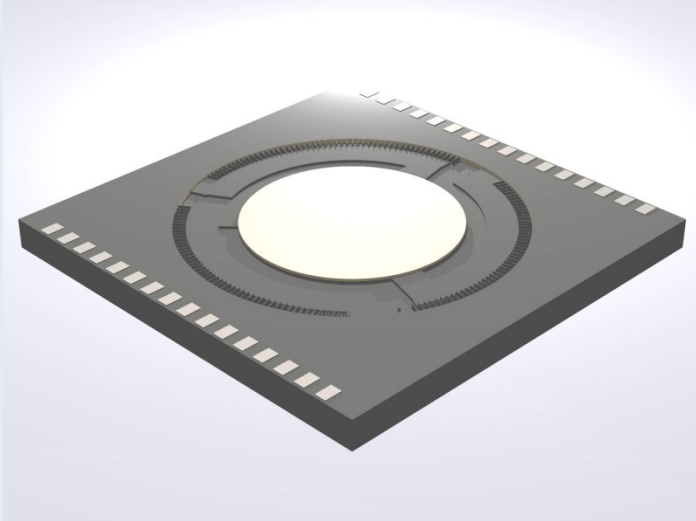

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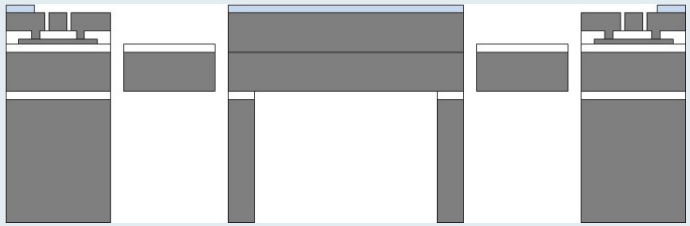
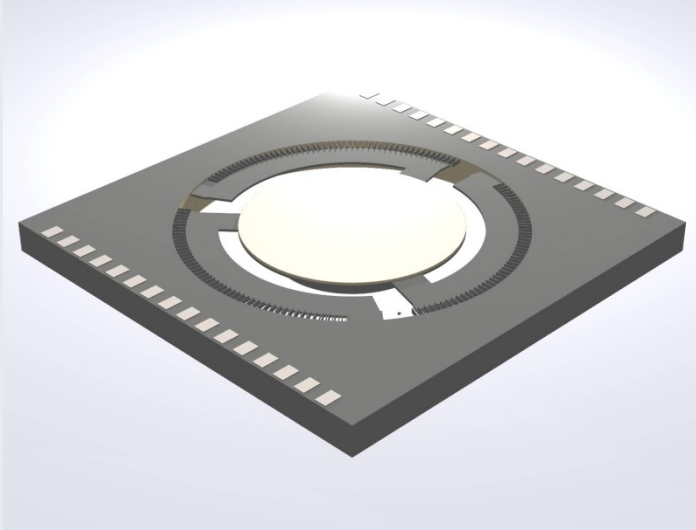


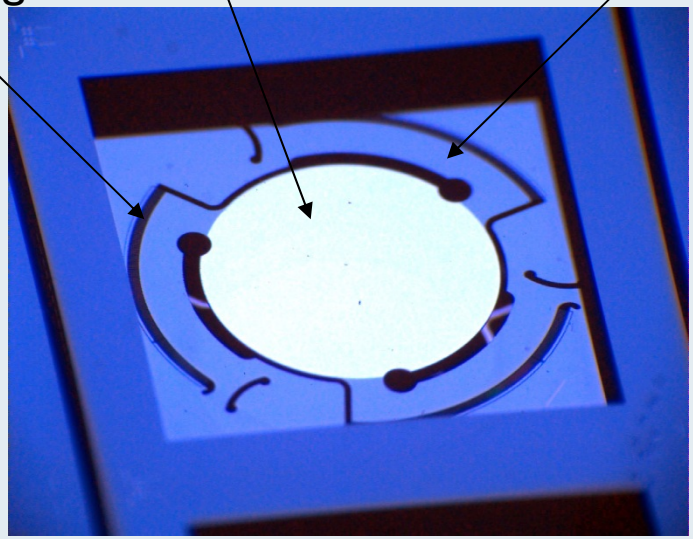


Fabricated tripod MEMS mirrors

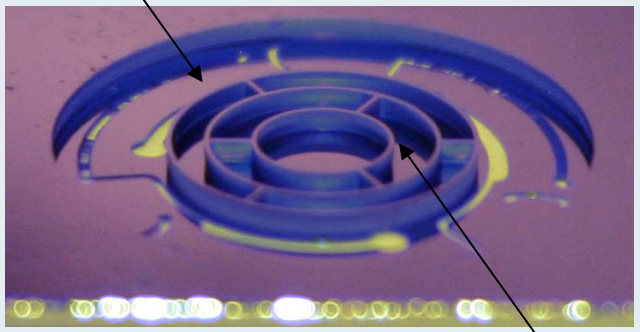
comb drive electrodes

mirror

circular suspension

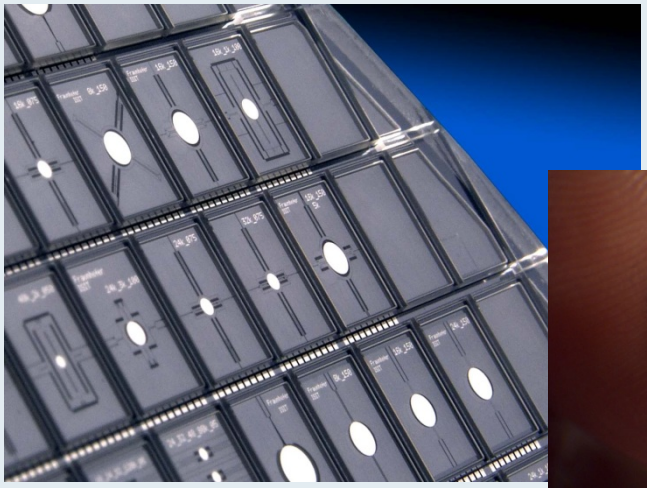


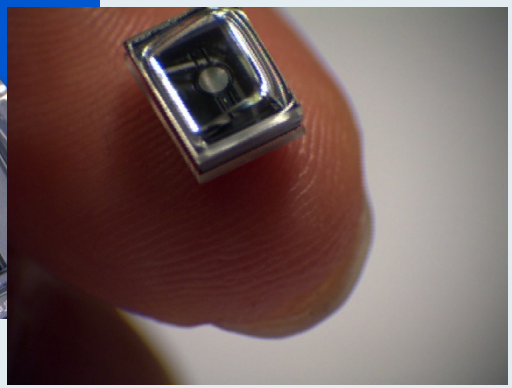
rear side of the mirror

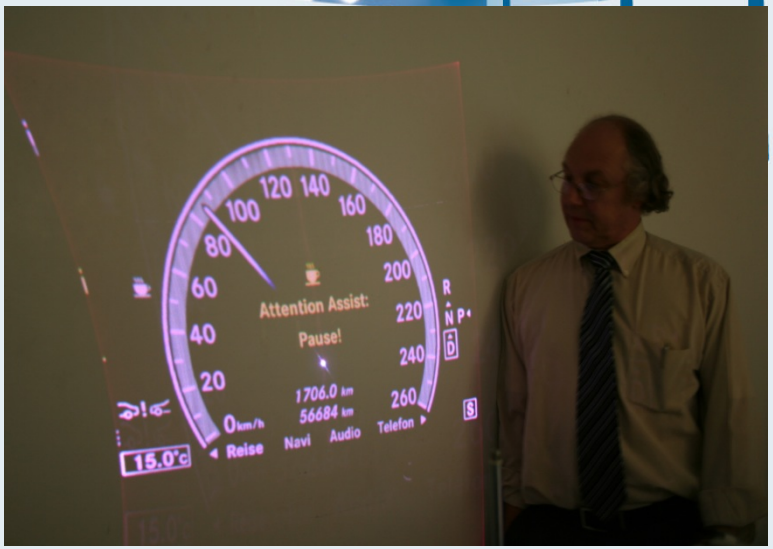


stiffening rings

How to enable the large tilt angles ?







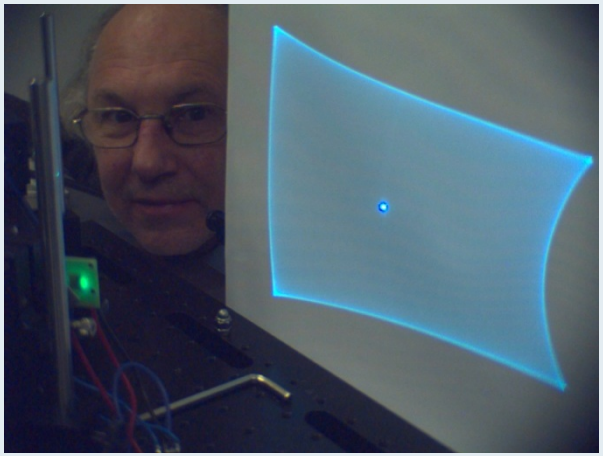
only possible by a vacuum package

1. minimum damping
2. maximum scan angle
3. low driving voltage
4. effective protection against contamination

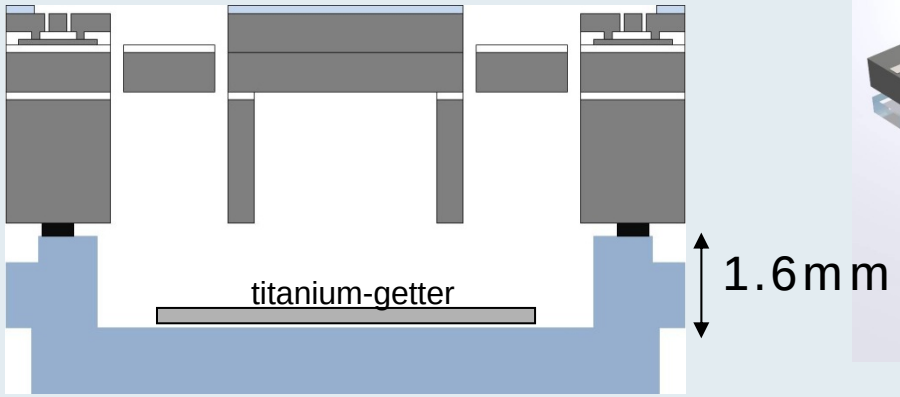
Benefit of vacuum encapsulation

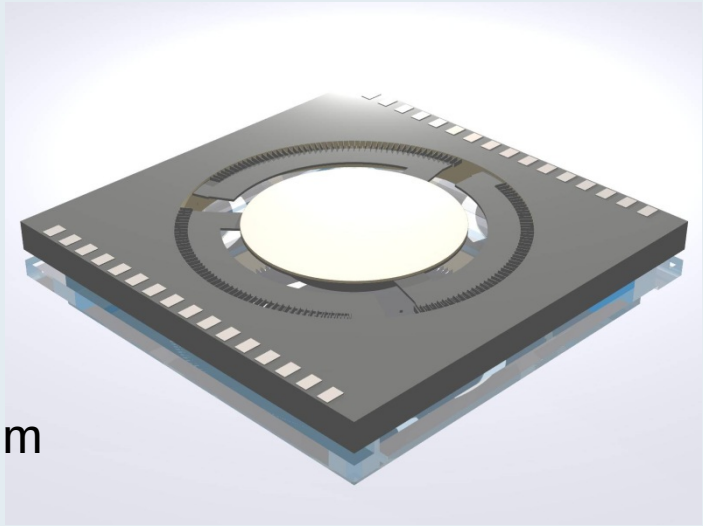
in atmosphere

in vacuum

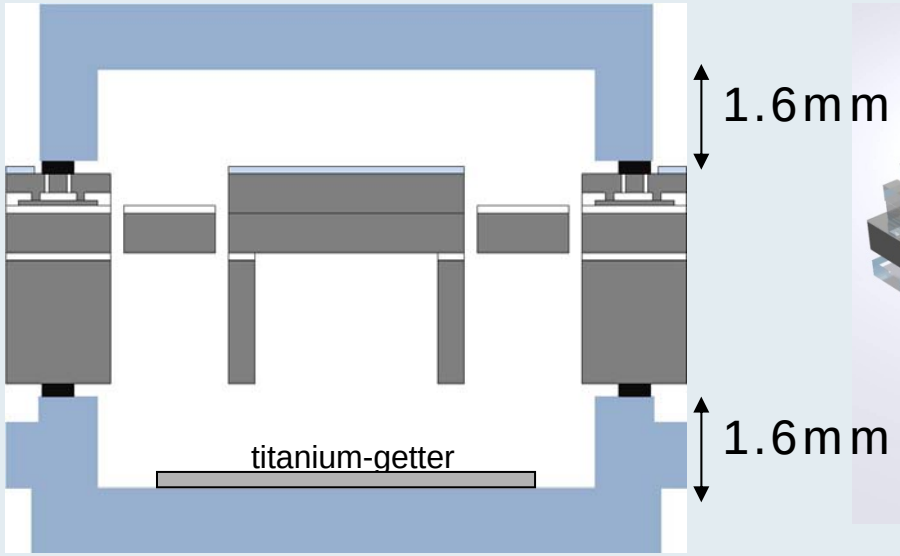


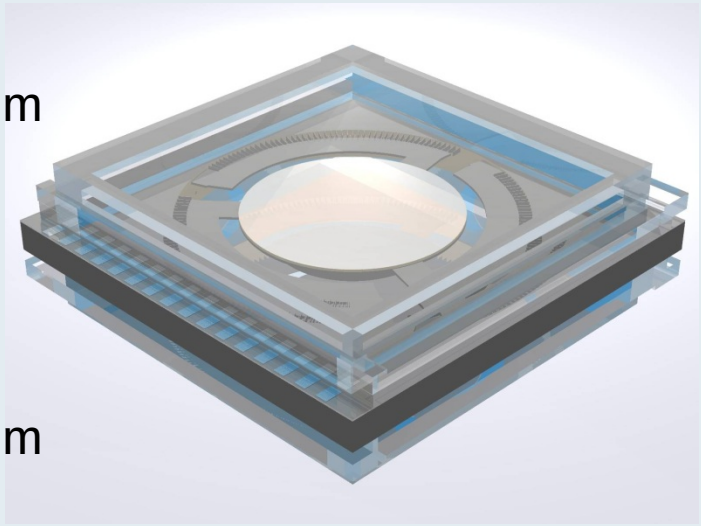
Wafer level vacuum packaging





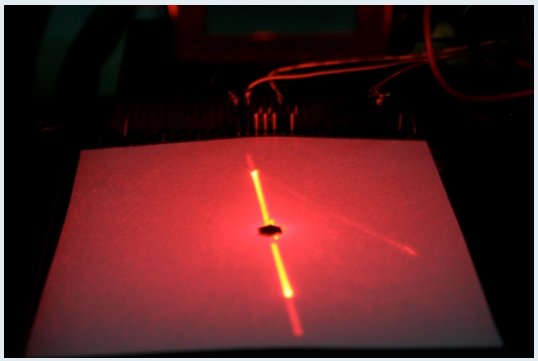
Wafer level vacuum packaging



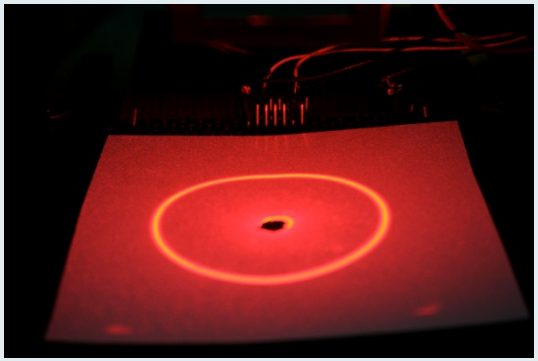


Vacuum encapsulated MEMS mirror wafer

Proof of concept of tripod MEMS design



single axis excitation

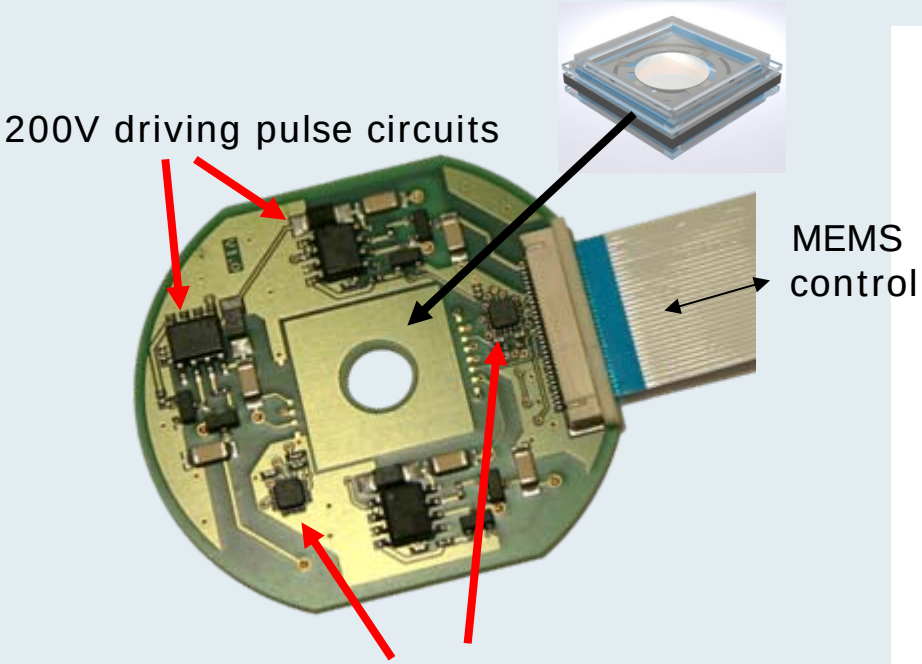


dual axis excitation

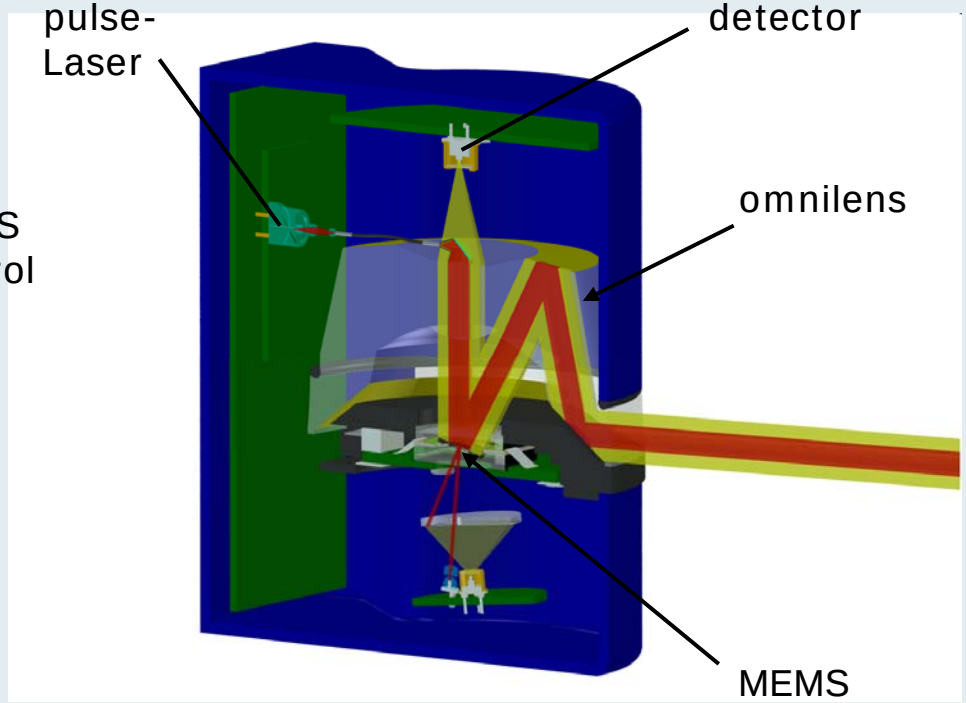
single electrode excitation
f = 800 .. 865 Hz

Electronic control of tripod mirror

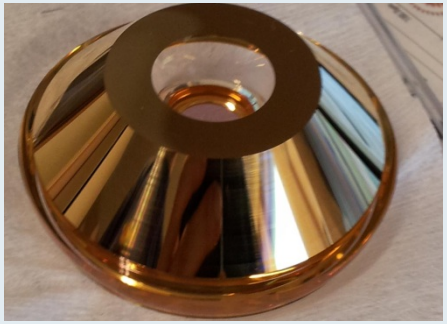
MEMS mirror pcb



coaxial LIDAR sensor

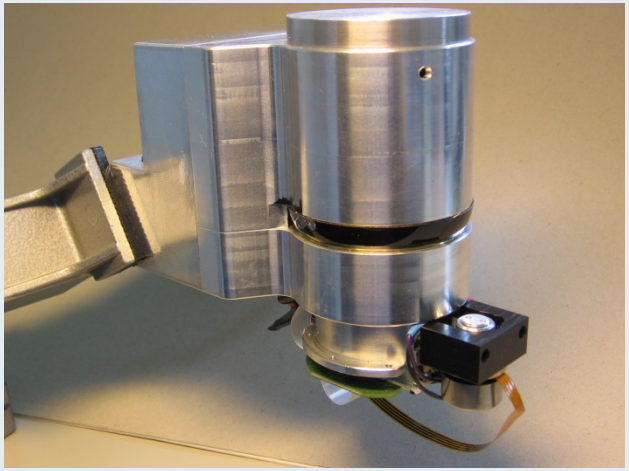


Sensor prototypes with omnilenses



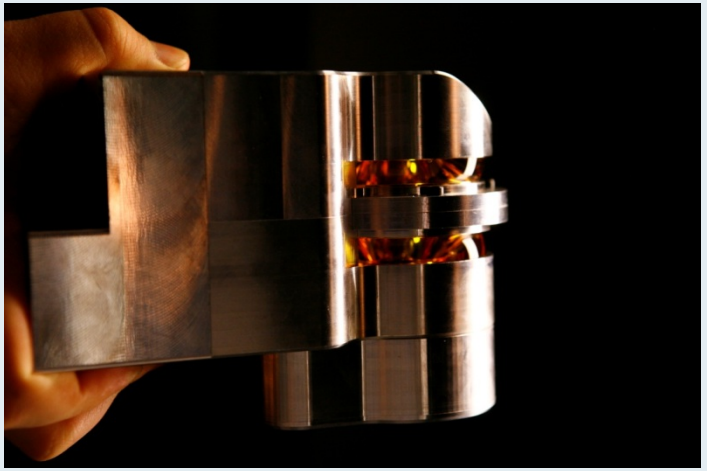
omnidirectional lens designed by VTT Finland

coaxial sensor



combined transmitter
and receiver paths

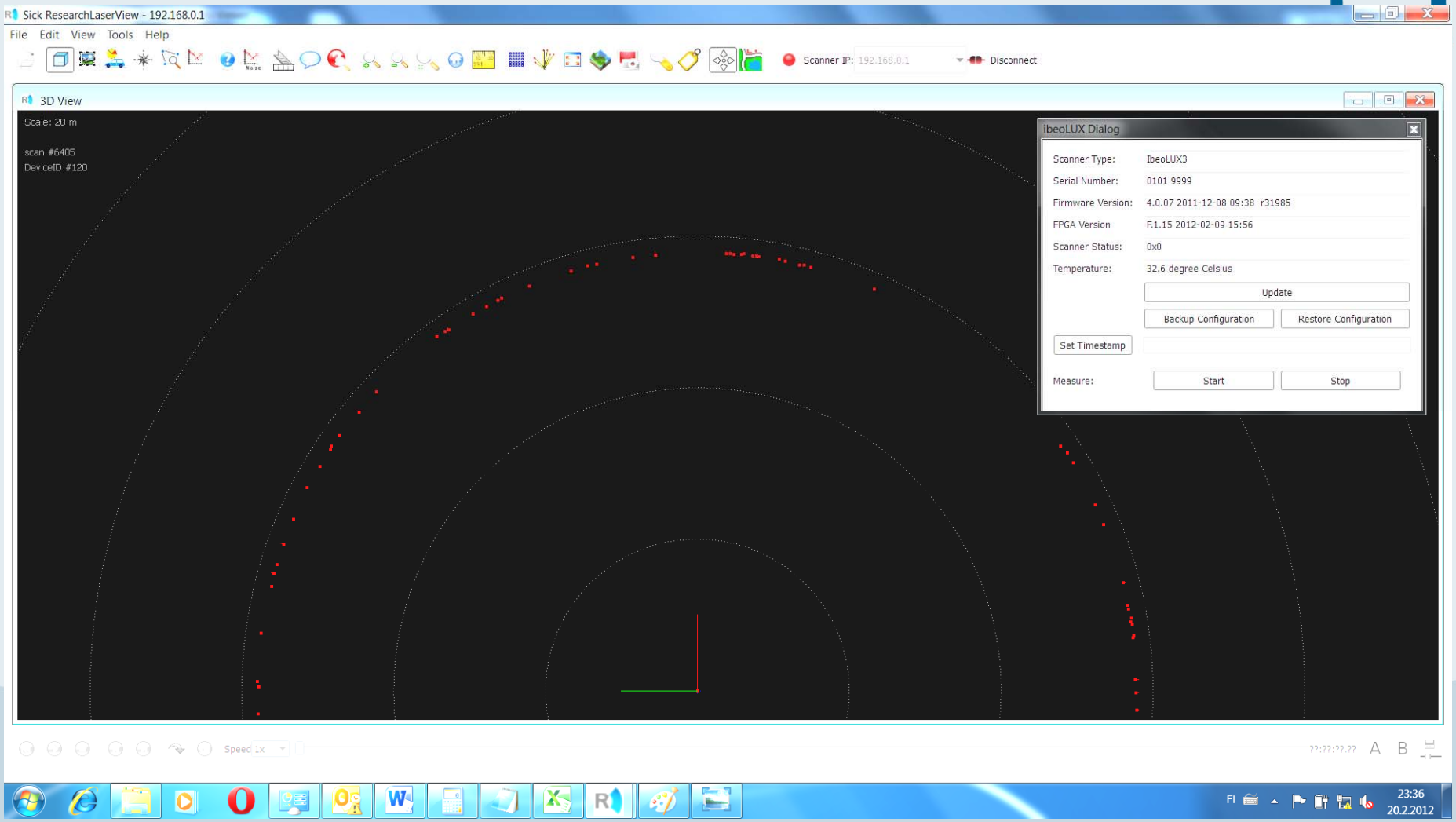
biaxial sensor



separate transmitter
and receiver paths

First result of biaxial sensor

58 meter range to a half specular, half diffuse reflective target



Acknowledgement

MiniFaros is part of the 7th Framework Programme, funded by the European Commission.

The partners thank the European Commission for supporting the work of this project.