Characterization of Crosstalk in CMUTs

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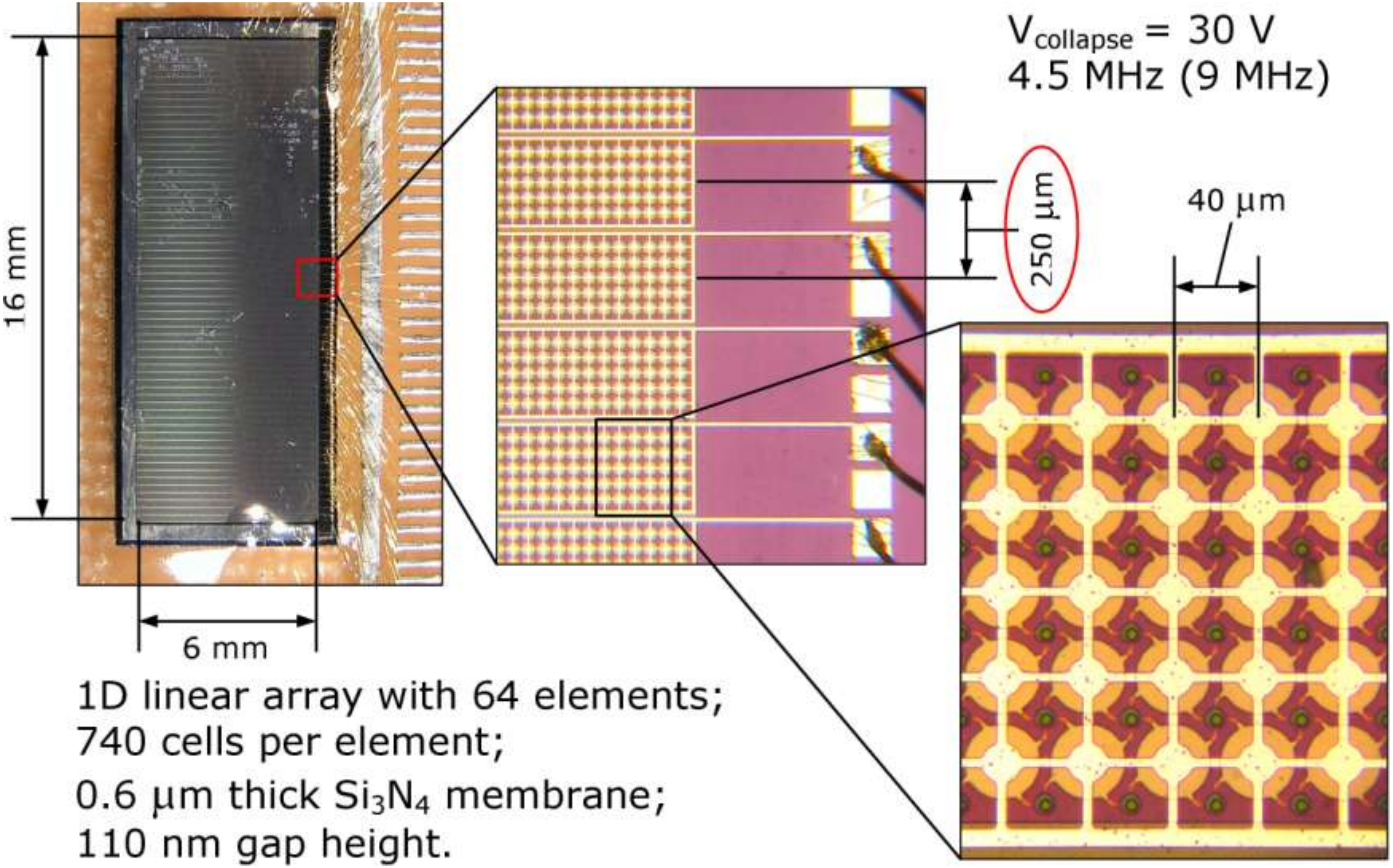
1. CMUT specifications, measurement setup and two methods (optical vs. electrical) to measure crosstalk signals.

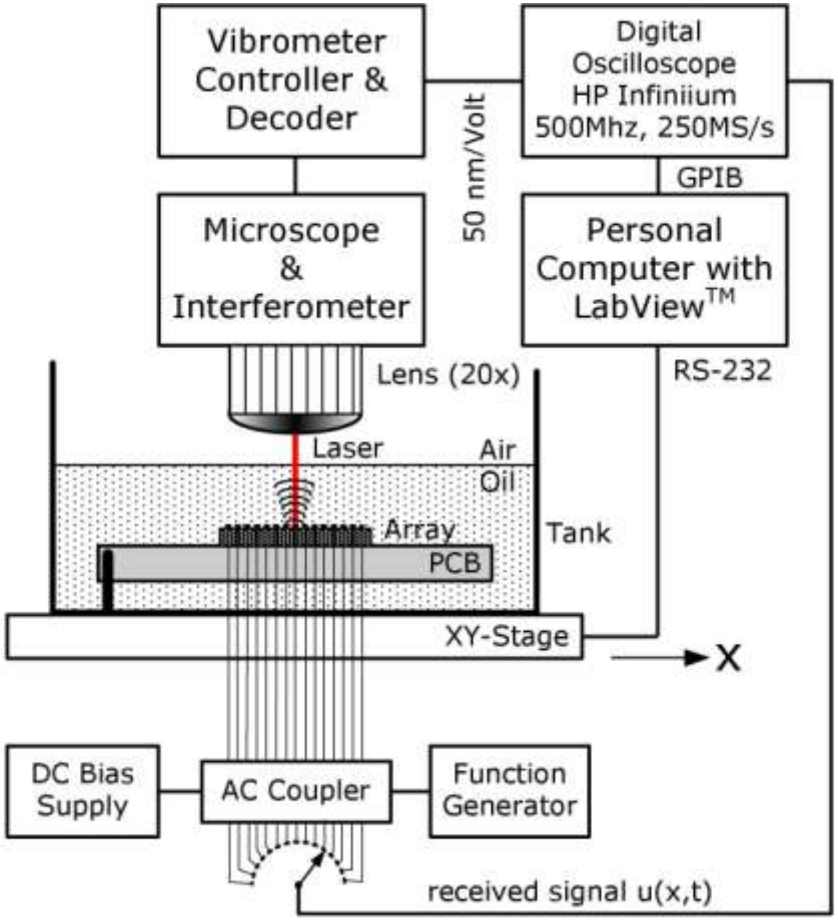
2. Crosstalk analysis in wavenumber-frequency domain:
    - Identification of different crosstalk contributions;
    - Conventional operation mode with/ without PDMS;
    - Collapse operation mode with/ without PDMS.

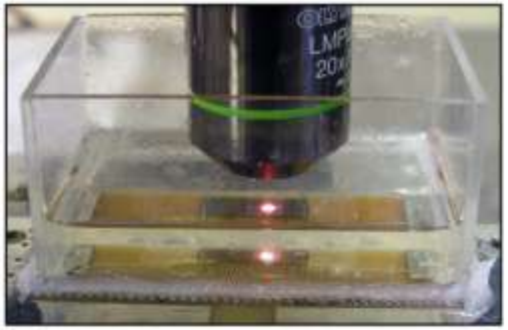
A 1D-linear CMUT array was used for crosstalk characterization



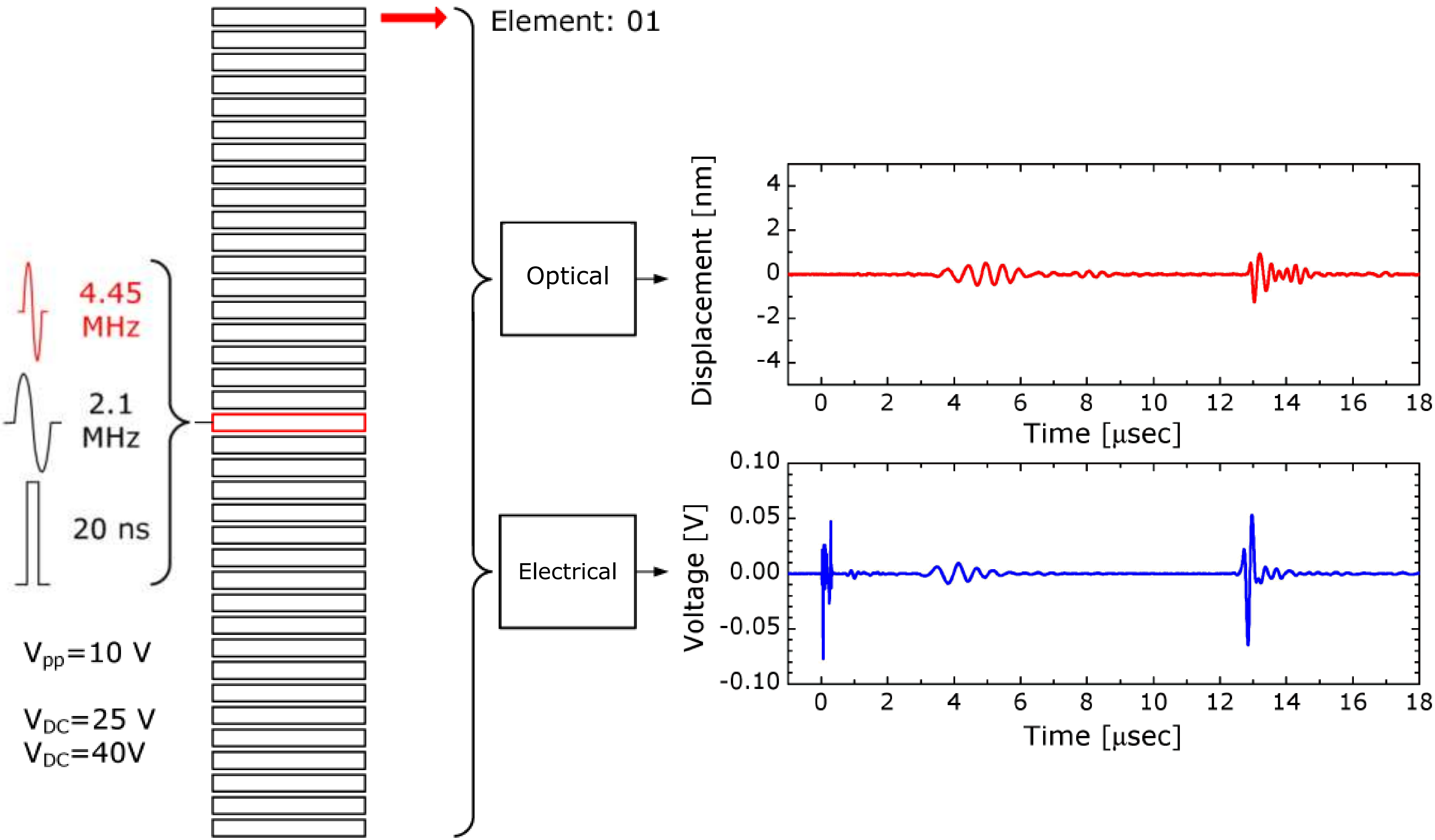
1D linear array with 64 elements;
740 cells per element;
0.6 µm thick Si_3N_4 membrane;
110 nm gap height.

Optical interferometry versus measuring the received voltage of each element of the array immersed in oil (Verification)





Center element was excited; the electrical and optical measurements were performed simultaneously



Direct comparison of optical and electrical signal shapes (crosstalk) show good agreement

Displacement of one cell in element 10.

Received signal of **all** cells in element 10.

CMUT array was immersed in oil

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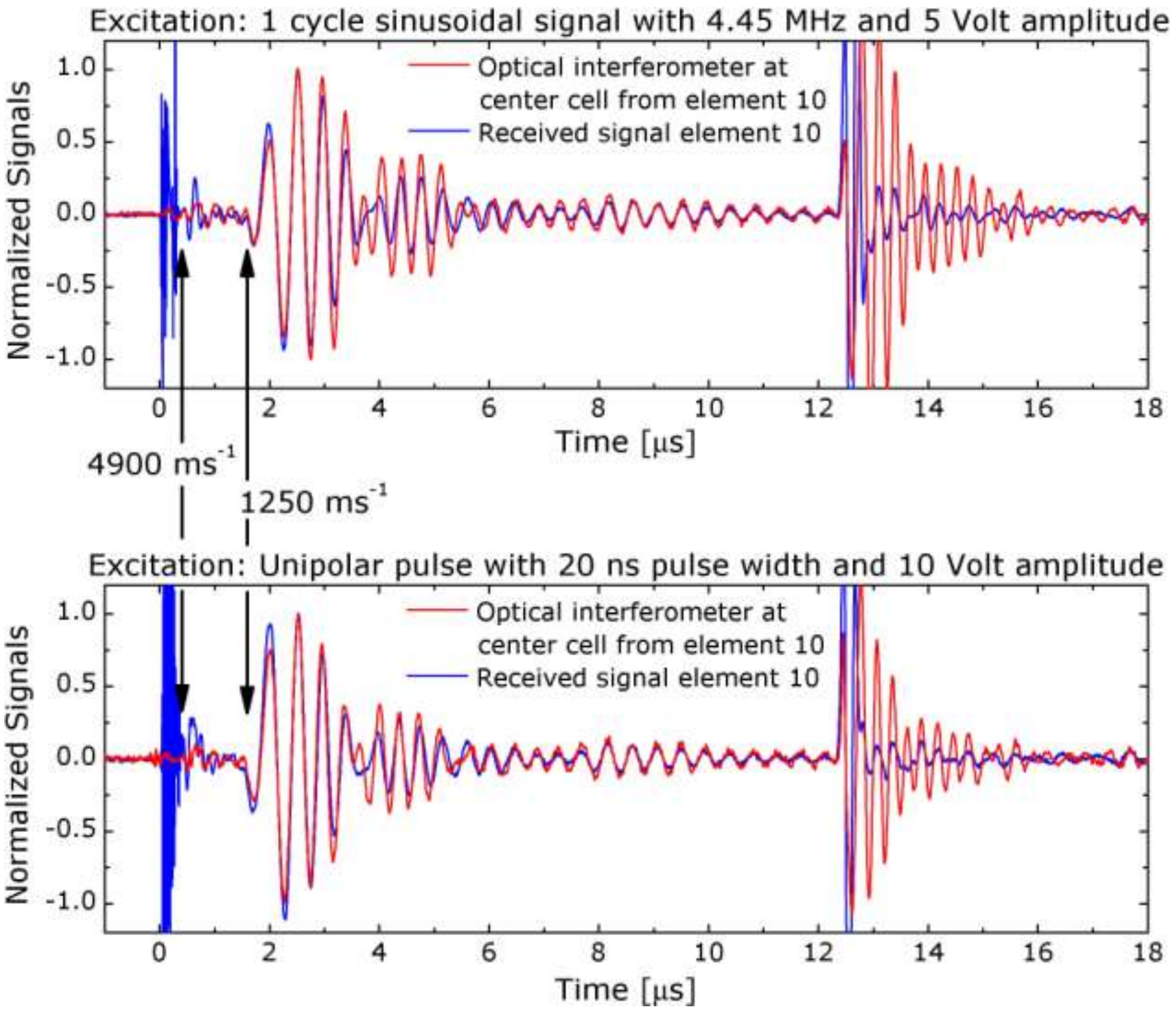
Corrections for
- refractive index;
- acousto-optic effect

are required.



In the 2D time-spatial domain different wave velocities are evident

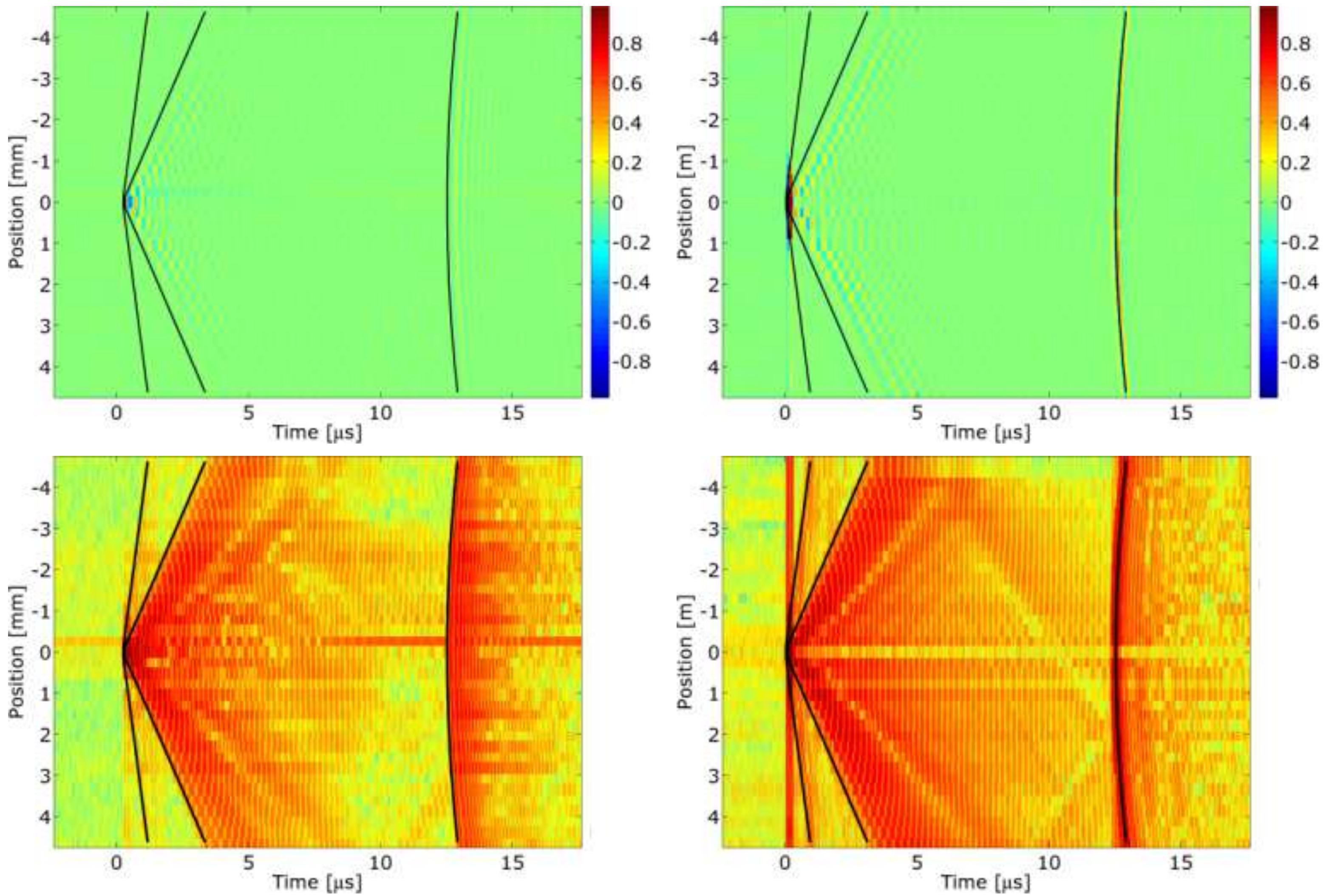
Displacement (optical) | Received signal (electrical)

Excitation:

1 cycle sinusoidal signal, 4.45 MHz, 5 Volt

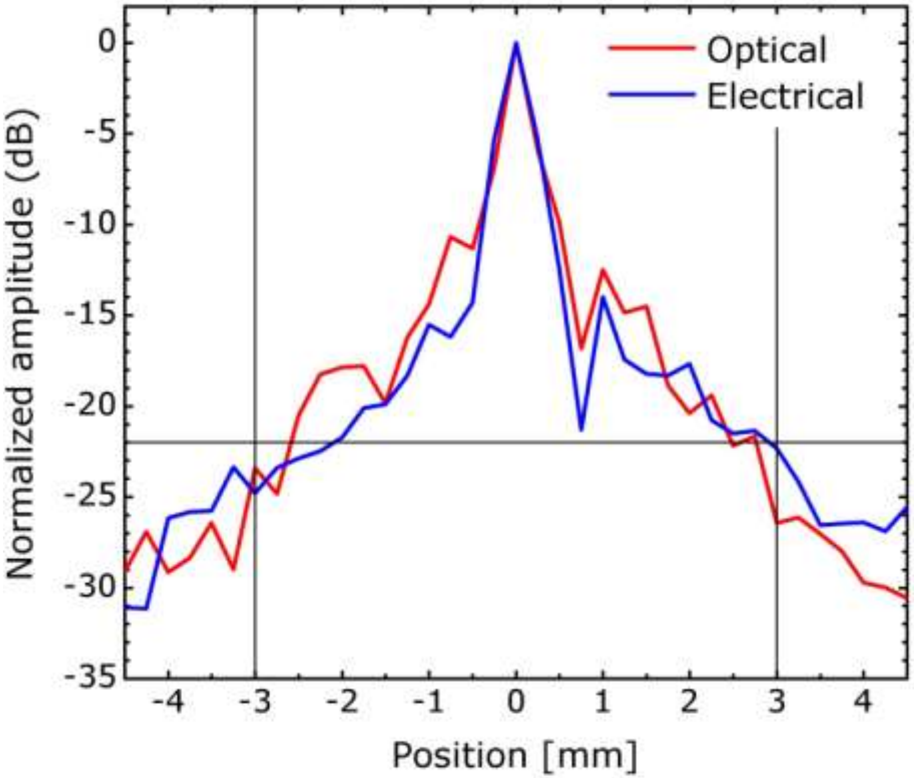
V_{DC}=25V

Log scale

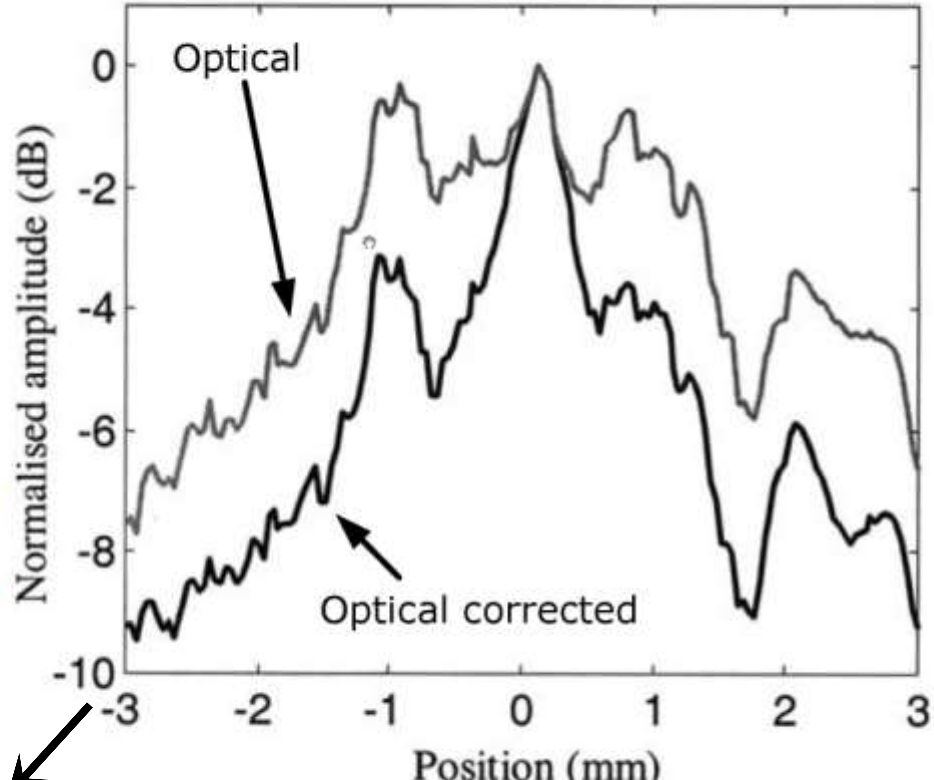


Compared to an array of piezoelectric composite material the CMUT seems to show less crosstalk

CMUT array
(4.45 MHz, 250 μm pitch)



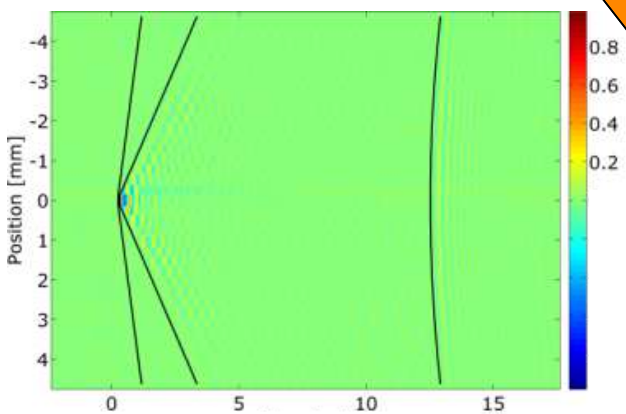
Array of piezoelectric
composite material
(3.5 MHz, 330 μm pitch)



D. Certon, et al, *Influence of acousto-optic interaction on the determination of the diffracted field by an array obtained from displacement measurements*, Ultrasonics, vol. 42, pp. 465-471, 2004.

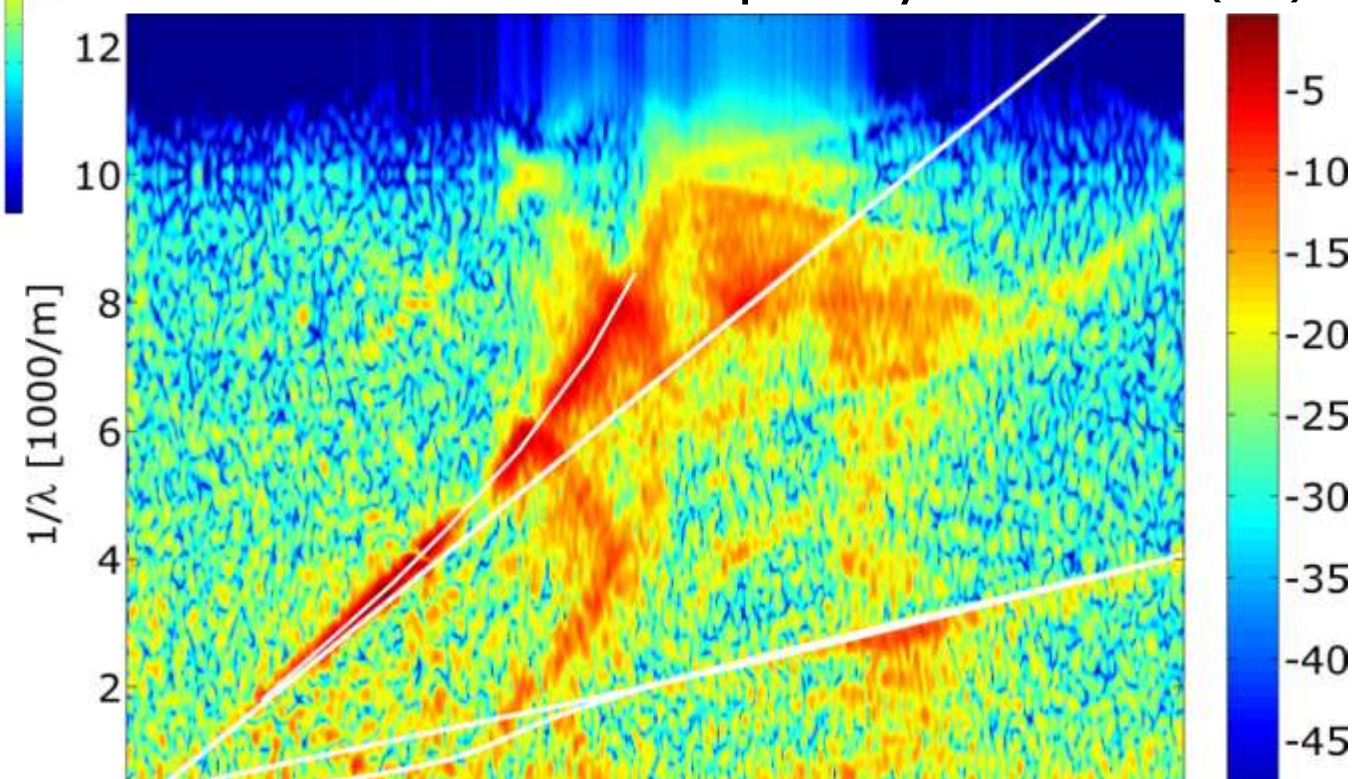
The k-ω domain provides a powerful analysis of the propagating multimode waves

Displacement (optical)



2-D FFT

Wavenumber-frequency domain (dB)



Excitation:

Unipolar pulse with 20 ns pulse width with 10 V amplitude

V_{DC}=40V

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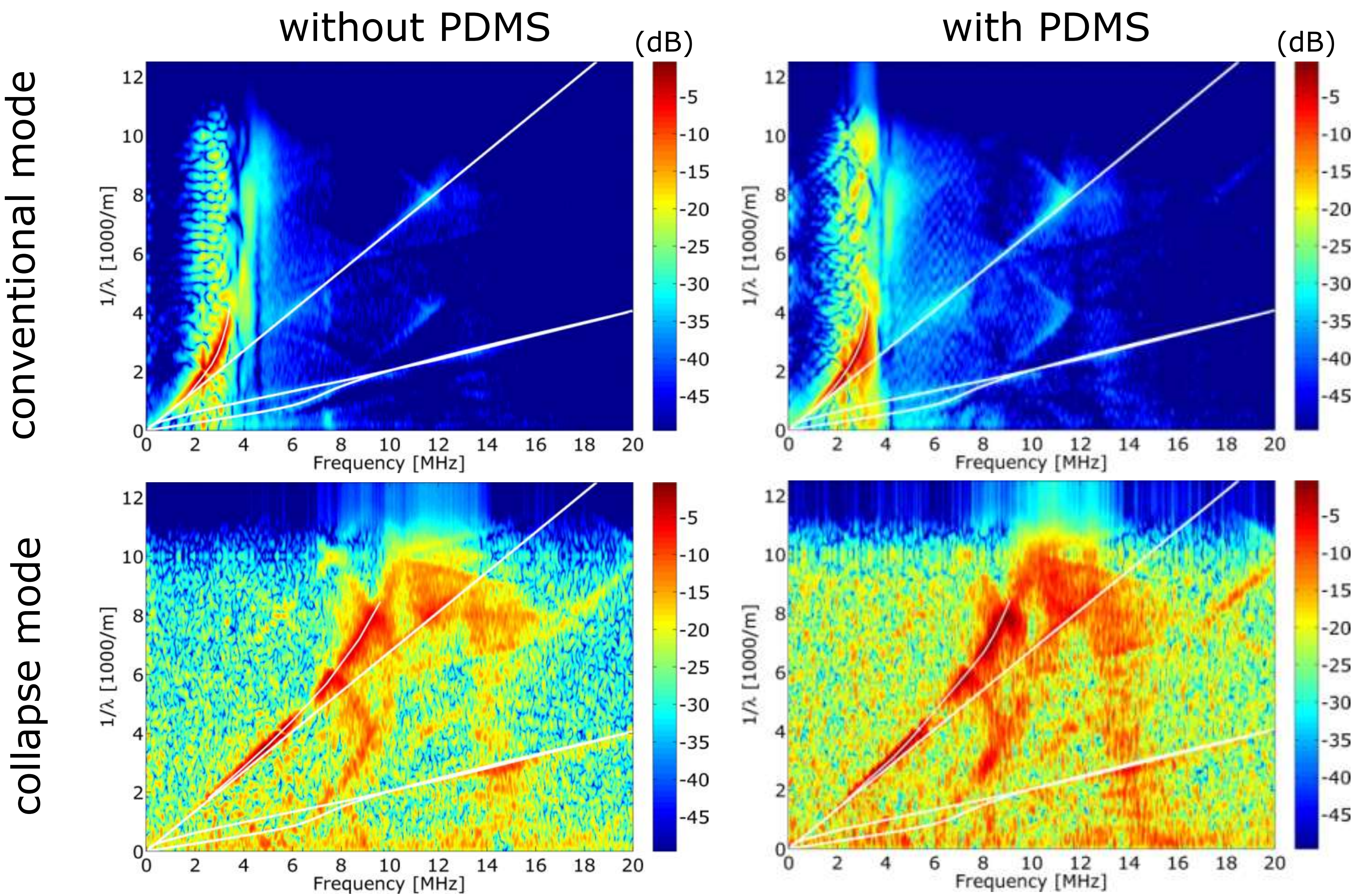
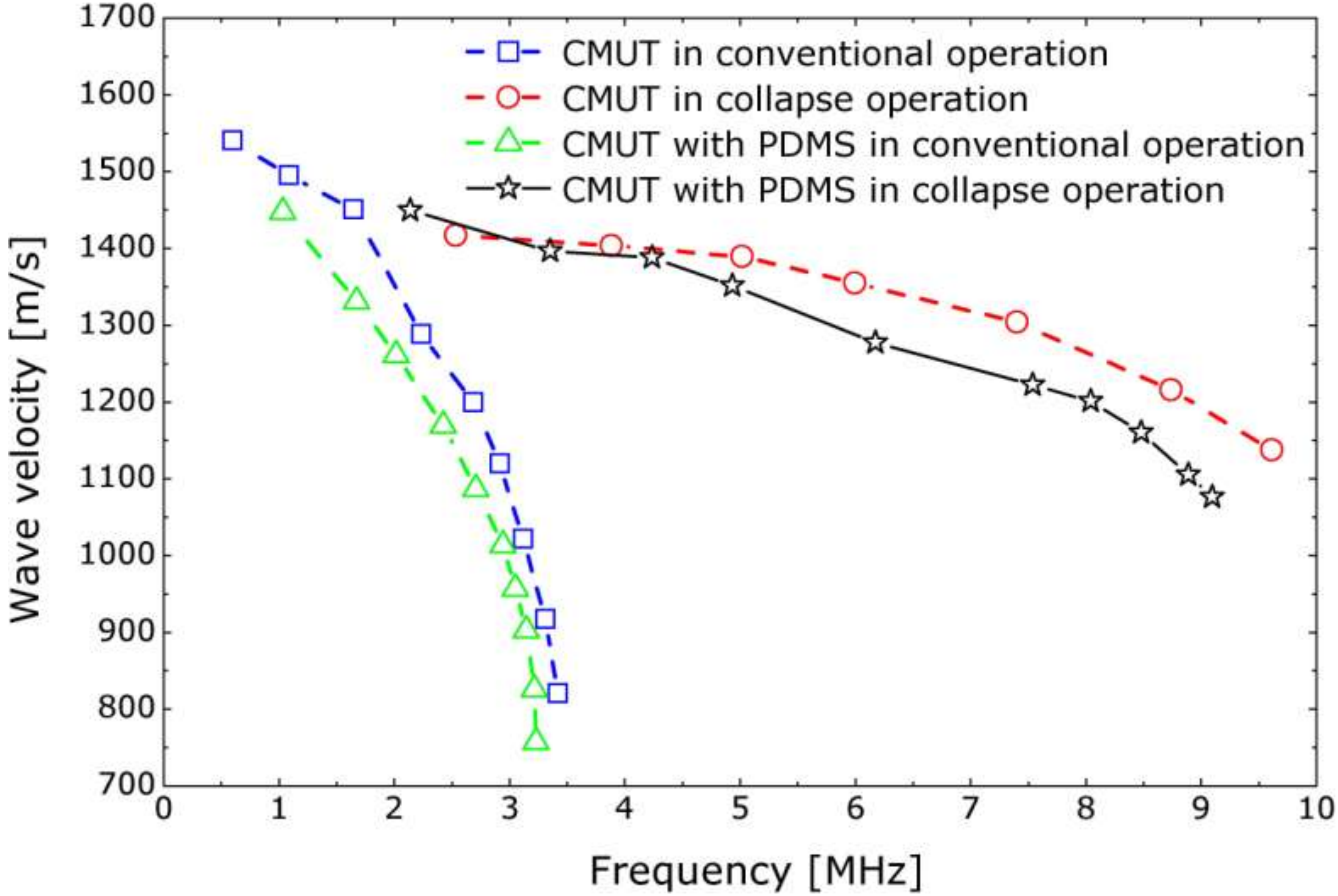
M. Wilm, et al, *Three-dimensional modelling of micromachined-ultrasonic-transducer arrays operating in water*, Ultrasonics, vol. 43, pp. 457-465, 2005.

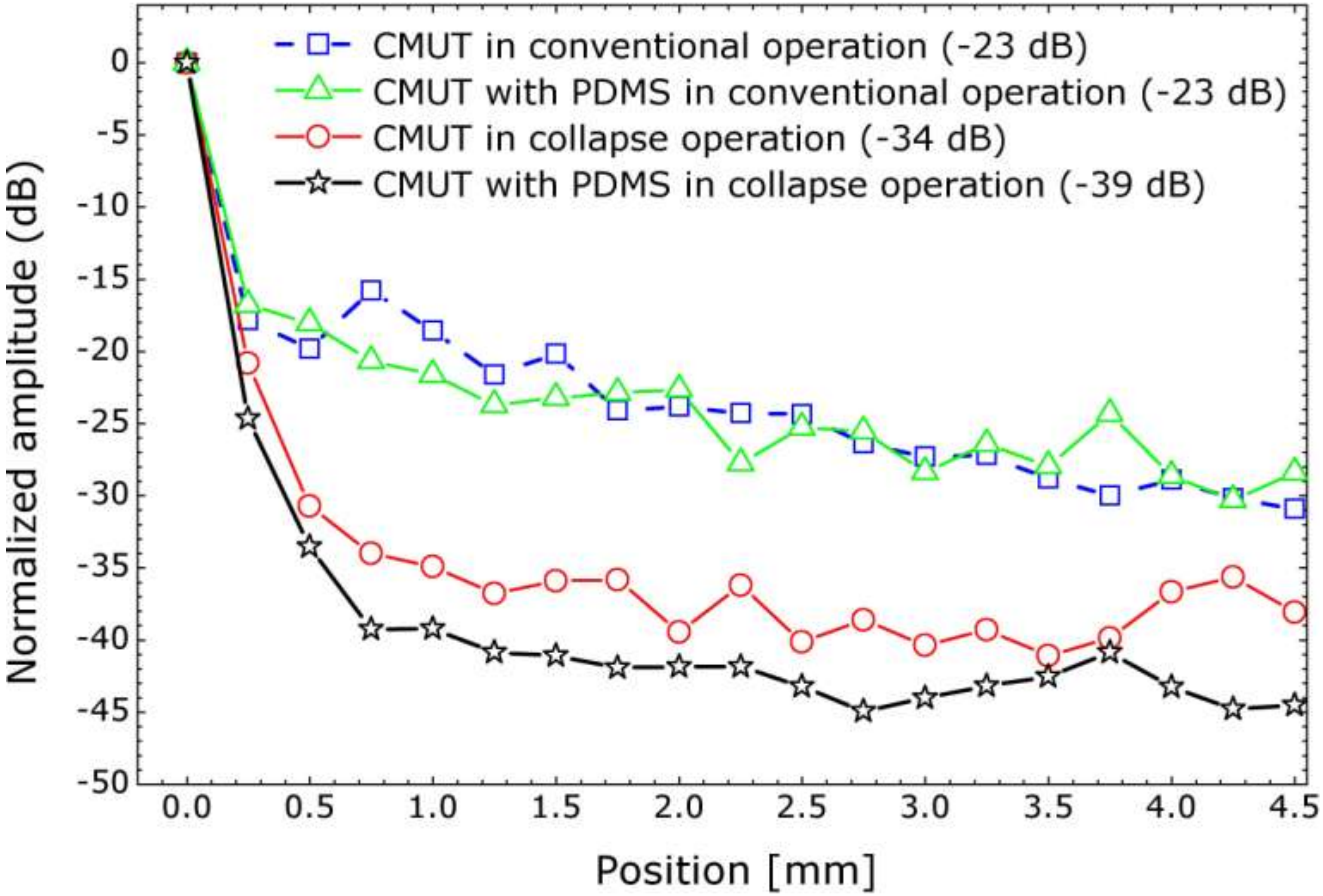
What is the effect of a 5-μm thick PDMS layer ?



Changing from conventional to collapse operation mode mainly affects the dispersive guided mode



A CMUT array covered with a 5-μm thick PDMS layer, operated in collapse operation mode, shows superior crosstalk supression



Conclusion

- Dispersive guided modes (1500 - 800 m/s) are the main reason for crosstalk in CMUT arrays

- Interface and surface waves do not play a significant role concerning crosstalk effects in CMUTs.

- Collapse operation mode reduces crosstalk, especially when the CMUT is covered with a PDMS layer.