Half Wavelength Contact Acoustic Microscopy (HaWaCAM): a novel metrology technique for semicon

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I. Introduction

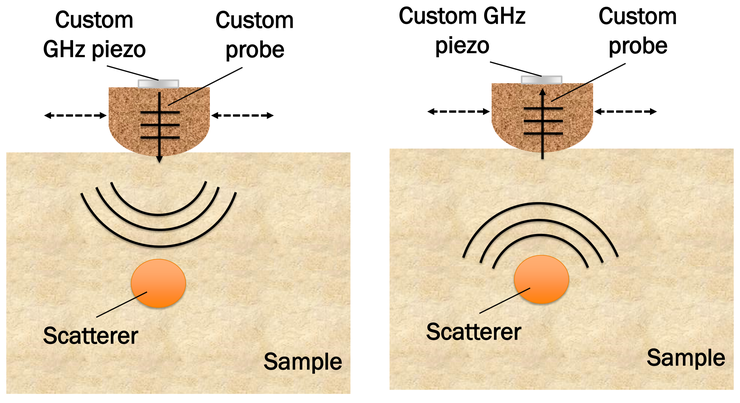
- Ever more functionality and processing power is integrated on the same semiconductor area.
  - To do so the device structures have become 3D,
  - and 3D NAND stack heights keep increasing.
- Cost effective device fabrication at high throughput requires metrology.
- The current non-destructive metrology workhorse for semicon is optics based.
- Optical metrology typically features 0.2 – 1.5 µm resolution and is limited by:
  1. optically opaque layers,
  2. a low penetration depth (O(1 µm)).
- Acoustic microscopy may solve these limitations.
- However, its resolution is limited > O(3 (PMMA) – 6 (SiO_2) µm) in samples
- Acoustic microscopy uses a geometric lens and a coupling liquid to couple the acoustic waves into the sample and to enable good lateral resolution [1].
- Acoustic frequency (resolution) limited by attenuation in coupling layer

GOAL:

- To present a novel high frequency acoustic metrology technique entitled Half-Wavelength Contact Acoustic Microscopy (HaWaCAM), which does not require a liquid coupling layer.

II. HaWaCAM measurement concept

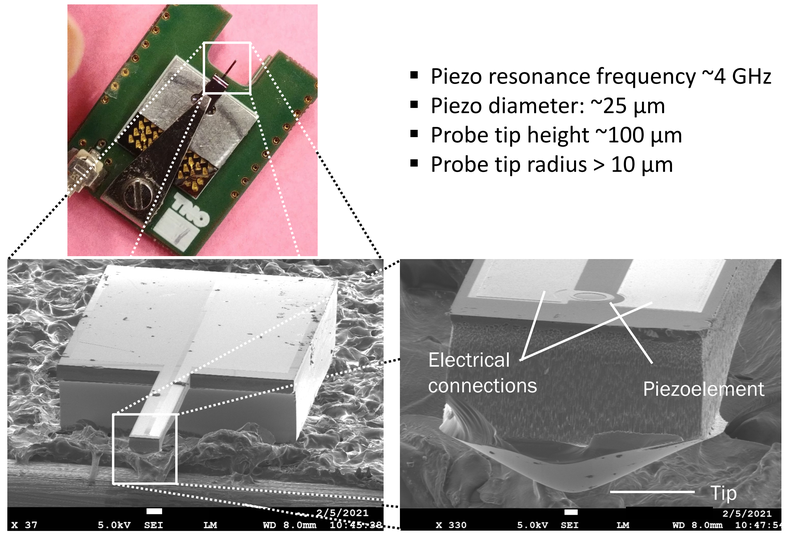
- HaWaCAM marries a probe with GHz piezotransducers
- Image contrast depends on acoustic impedance differences
- Tip – sample contact diameter ~half wavelength
- Tip – sample contact: linear



HaWaCAM characteristics:

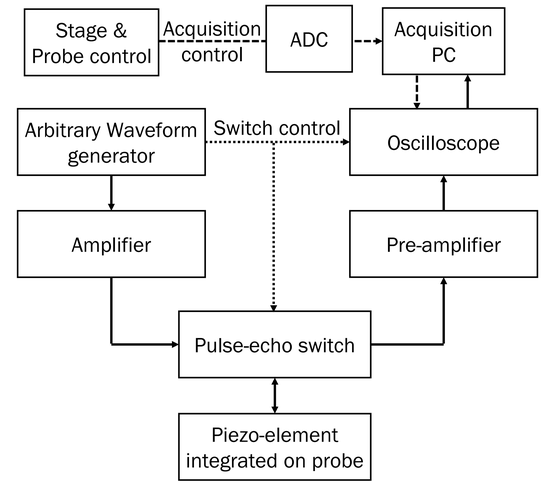
- No coupling layer (contact mode)
- Frequency >>1 GHz → not limited by attenuation in coupling layer
- Currently implemented: 4 GHz – wavelength 0.75 µm in PMMA, 1.5 µm in SiO2
- Penetration O(10s of µm)
- Non-destructive/nondamaging
- Ability to image through opaque layers

III. Custom GHz probe

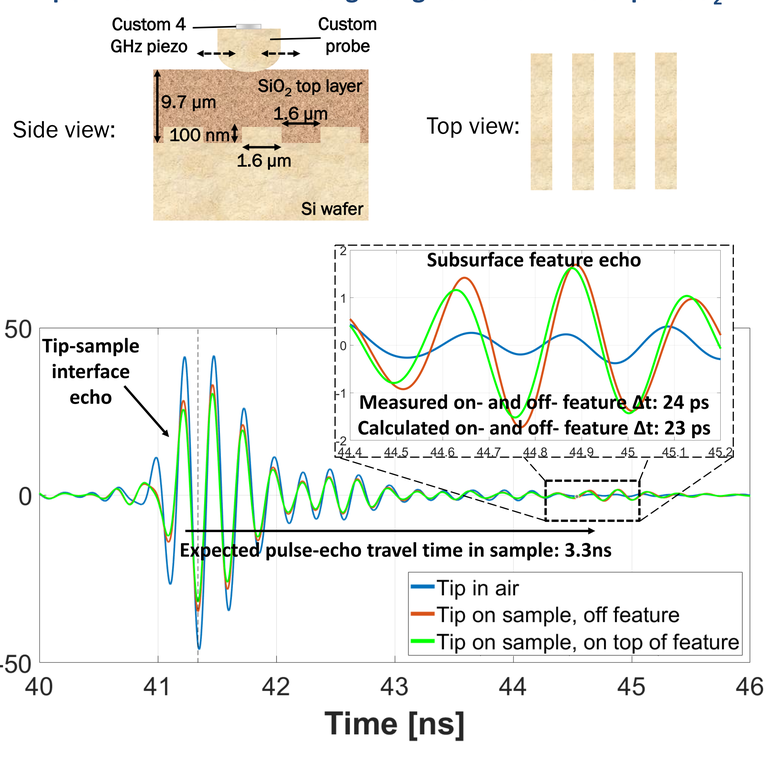


- Piezo resonance frequency ~4 GHz
- Piezo diameter: ~25 µm
- Probe tip height ~100 µm
- Probe tip radius > 10 µm

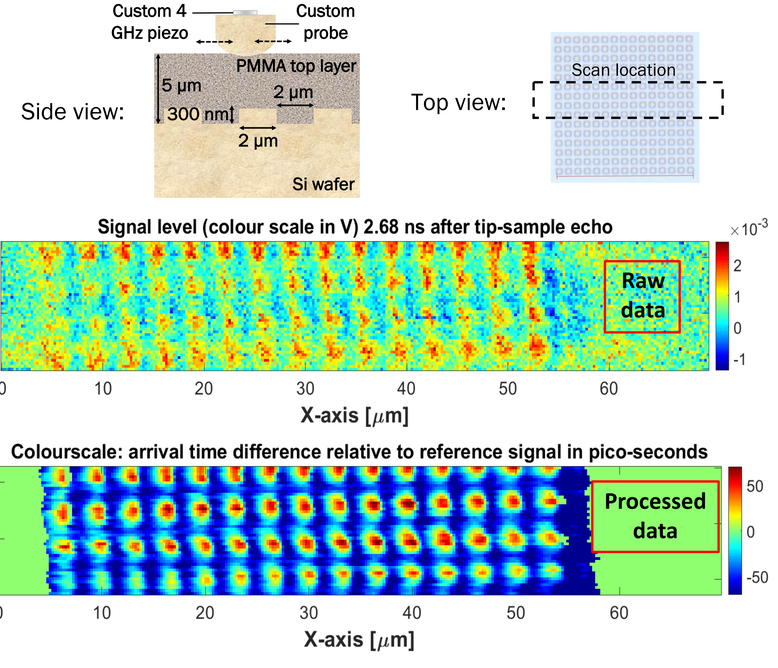
IV. Experimental setup



V. Experimental results: linear grating buried below 9.7 µm SiO_2



VI. Experimental results: matrix grating buried below 5 µm PMMA



VII. Discussion/Conclusion

- A novel high frequency acoustic metrology technique entitled Half-Wavelength Contact Acoustic Microscopy (HaWaCAM) was presented
- Current center frequency: 4 GHz, wavelength: 0.75 µm (PMMA), 1.5 µm (SiO_2)
- Picosecond arrival time accuracy
- Current acoustic measurement time/point: 0.4 ms

References
[1] Weiss, Lemor et al., IEEE Trans. Ultrason. Ferroelectr. Freq. Contr., 54(11), 2257-2271 (2007).