Modulated Scatter Array Measurements and Signal Processing from UHF to THz

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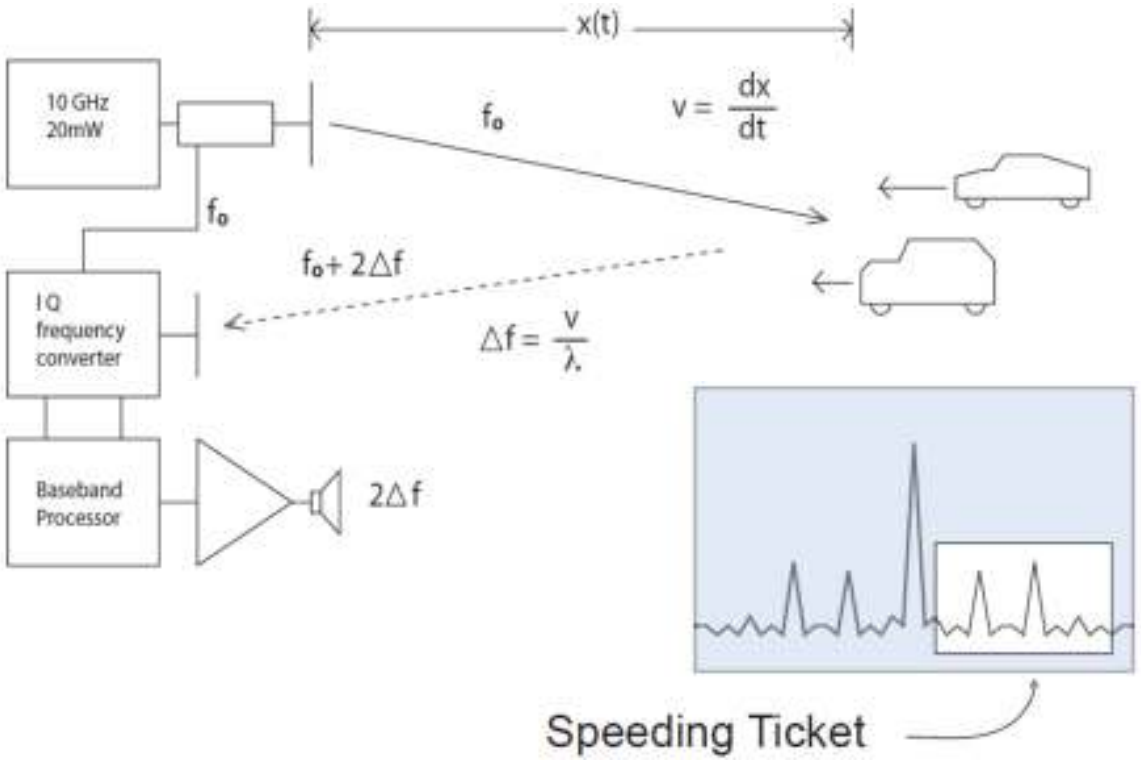
What is Modulated Scattering?



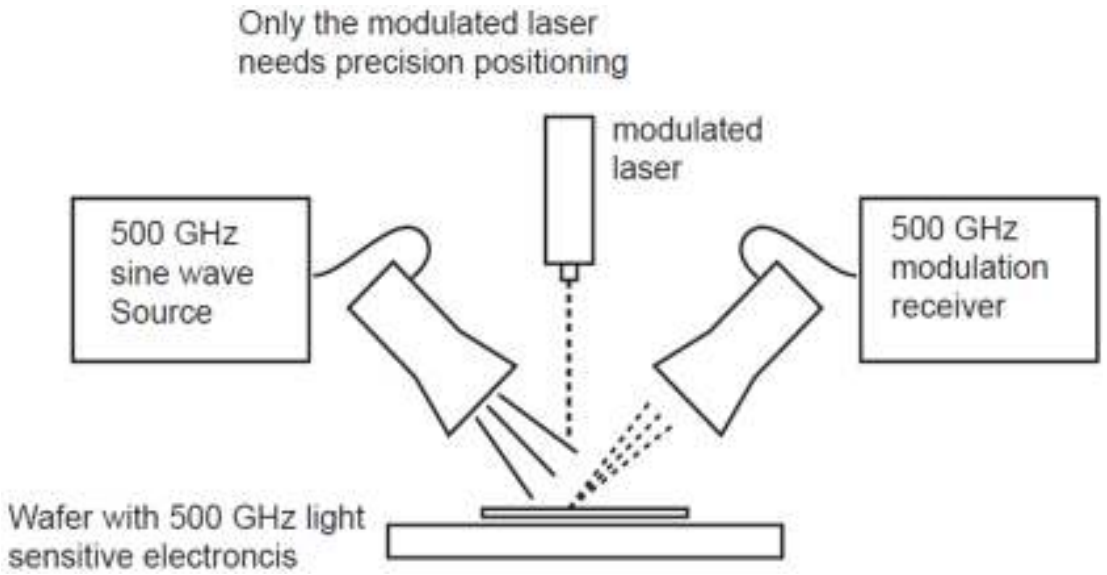
Important Basics

Modulation is slow: Hz and kHz, not THz

Modulation gives a particular target a unique signature

Profound signal to noise advantage

Proposed On Wafer Measurement Application



All semiconductor junctions may be modulated with light, so even things that aren't designed for modulated scatter measurements might be tested.

Really Cool Stuff

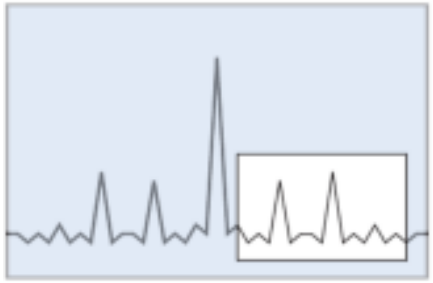
Size of modulation target: how well can you focus and position the laser?

At 500 GHz λ/4 is 150 µm so easy to get good scattering from on-chip structures

No mechanical contact to wafer

The modulator picks the target, so the RF source and receiver may have broad antenna beamwidths

Really Hard Stuff



Receiver needs to reject specular reflection and just see modulated beam kHz away

Receiver and source need to have the same reference for frequency stability

Even if the receiver and transmitter have the same reference, phase noise will kill you

This may now be feasible above 100 GHz

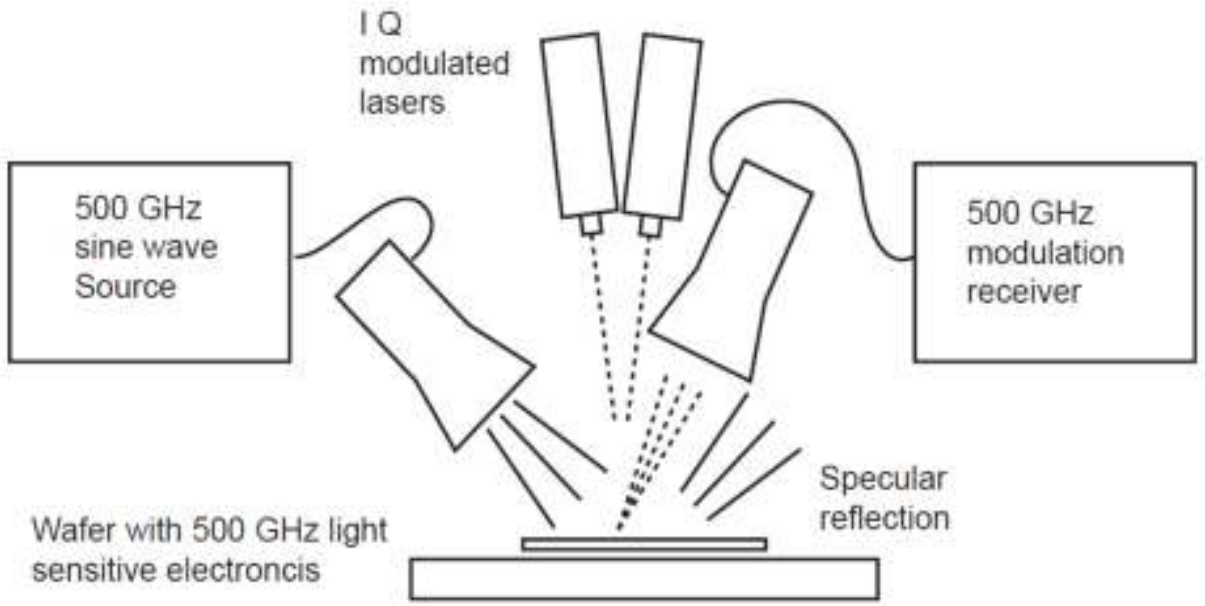
An enhancement: What if...

The departure angle of the modulated scatter signal could be different from both the arrival angle and the unmodulated specular reflection?

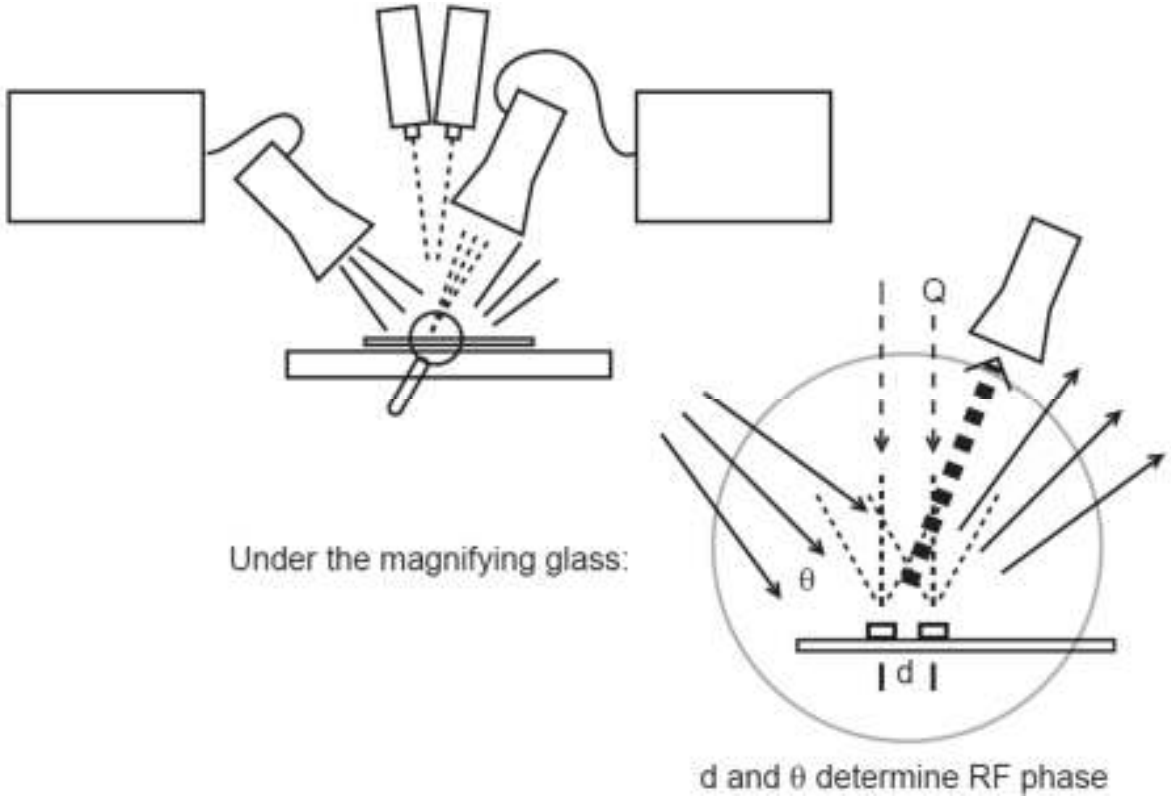
“Space-angle modulation”

Our current work in the PSU lab

Possible On-Wafer Implementation



Detail



Theory is good, sketches look nice, but...

We need a proof of concept experiment

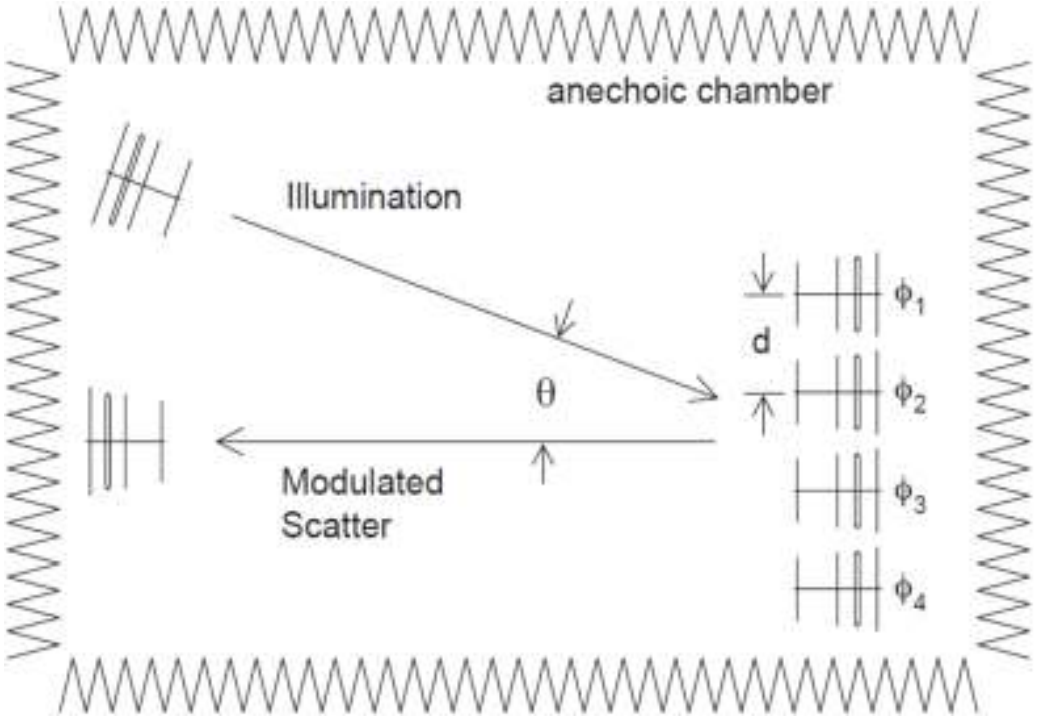
First, a scale model:

500 GHz to 500 MHz

Multiply all dimensions by 1000

1 mm scales to 1 m

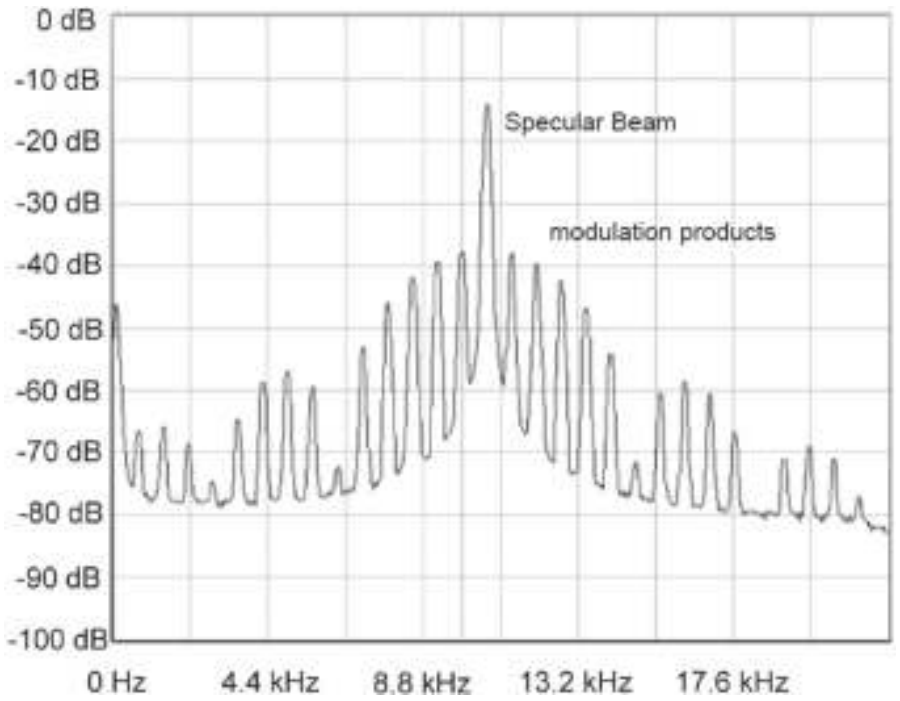
Instead of on-wafer, in Anechoic Chamber



4 element 432 MHz array in Chamber

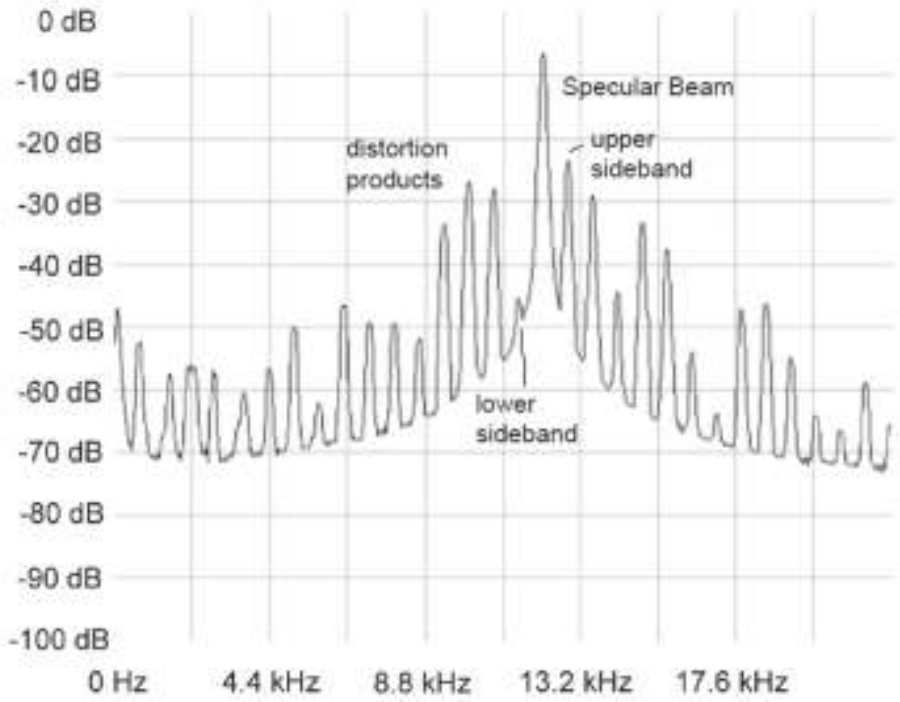
Each element has a single diode turned on and off by baseband audio I Q signals

Modulation from a single element



Measured data, November 2017

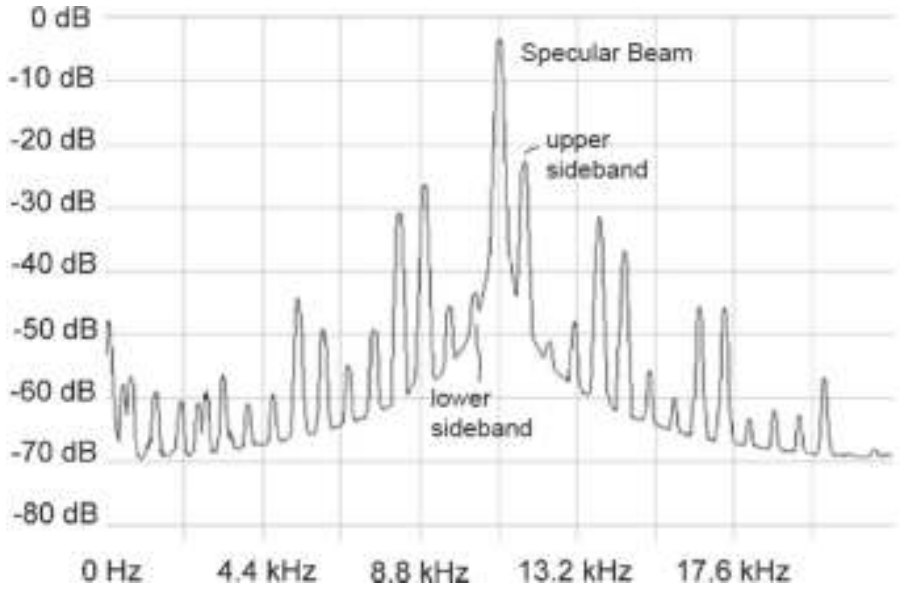
Modulation from a single element



4 element Upper Sideband Modulator

4 phase: I, Q, inverse I, inverse Q

Note cancellation of even order distortion



Can do lots more elements in array

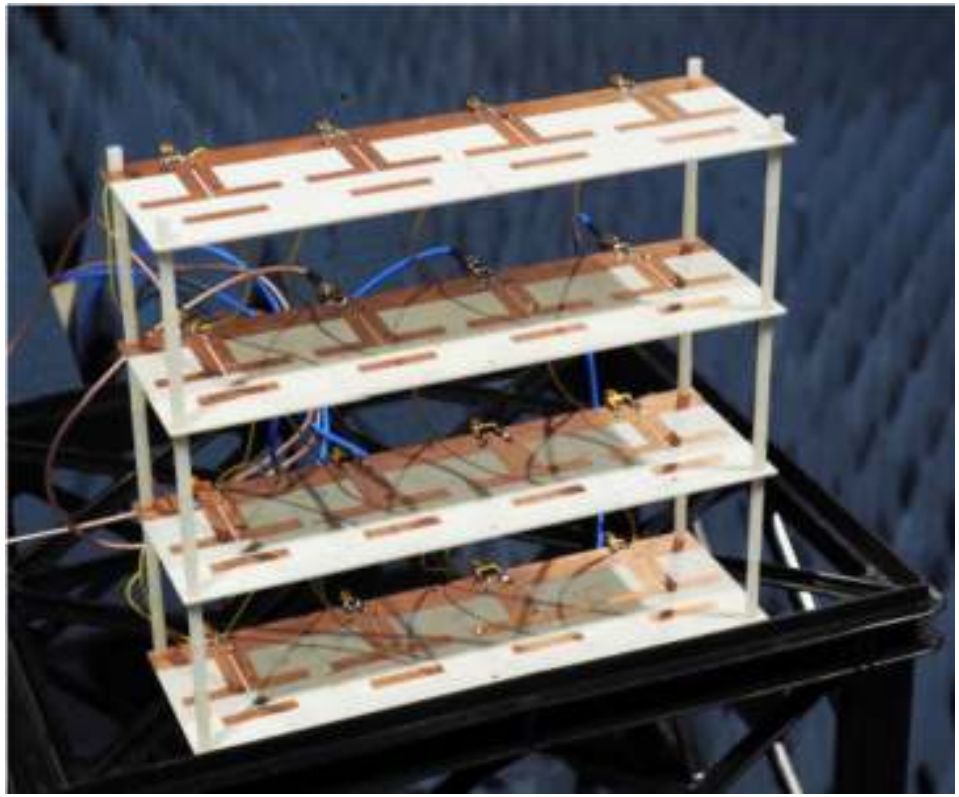
Fourier Theory, the more elements, the narrower the desired beam,

and/or the lower the distortion products

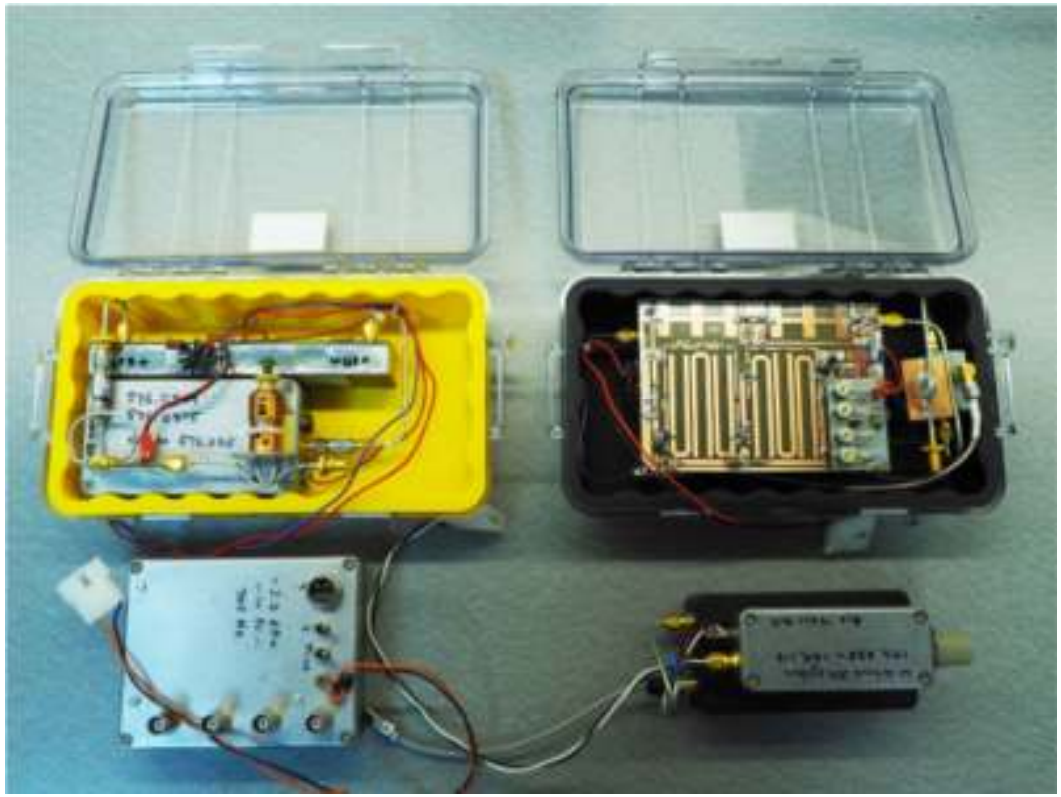
Note: specular beam and all other products are present, they just radiate in different directions. "Space-Angle Modulation"

Now, work up the frequency spectrum until dimensions are wafer scale

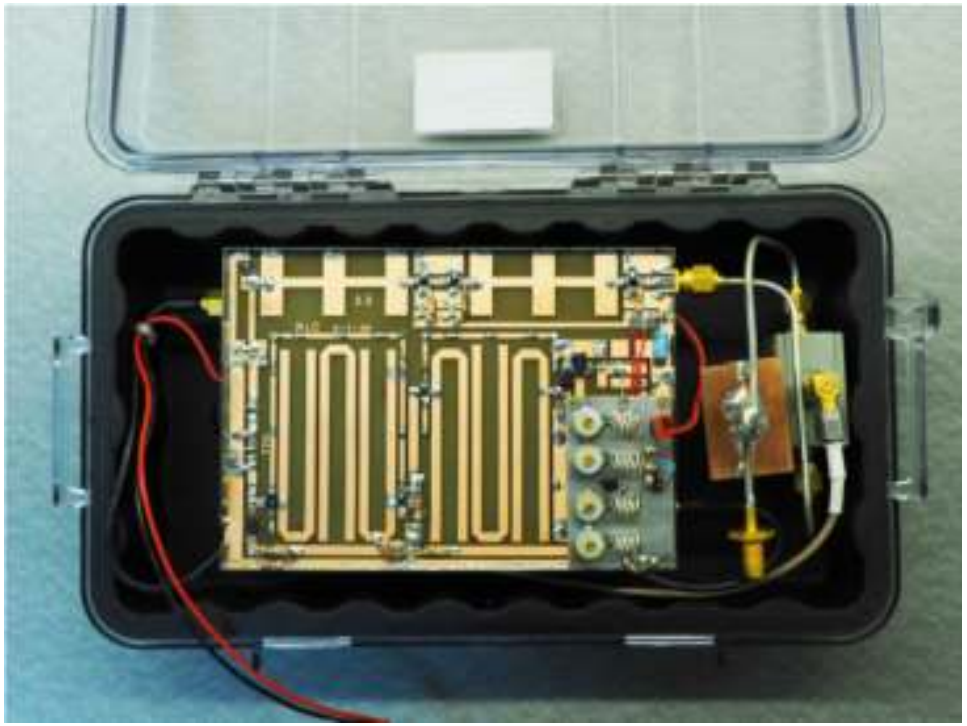
Next Step: scale to higher frequency: 2.3 GHz



Requires all new RF to Baseband hardware



Most of our work is not on wafer, some outdoors

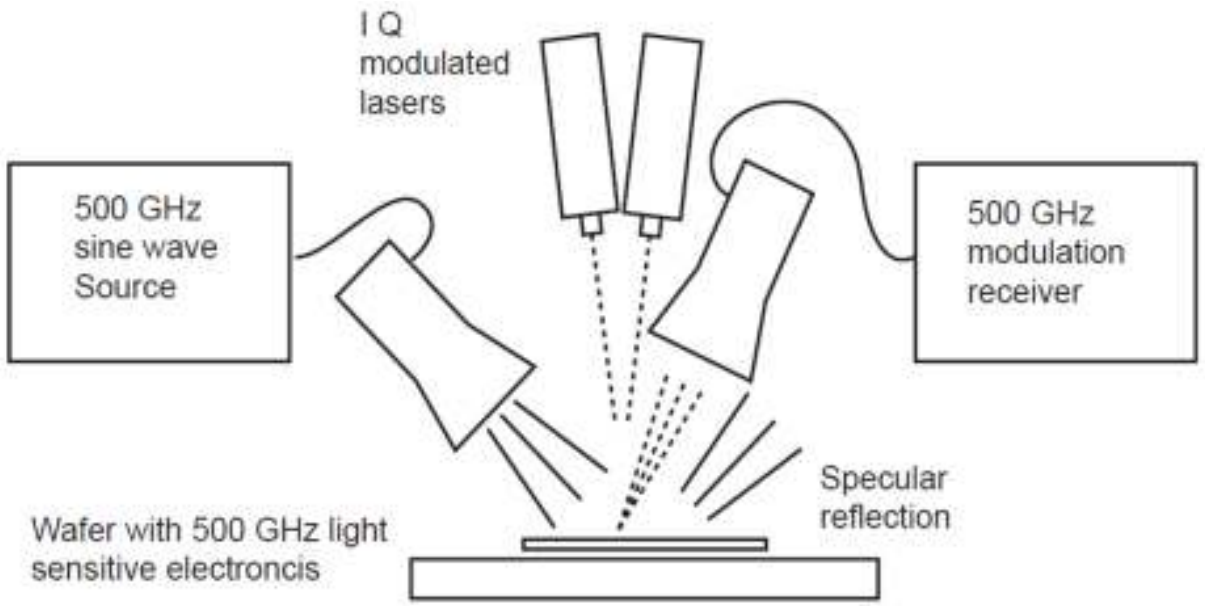


marine environment instrumentation packaging

Next

Scale Model proof-of-concept experiments completed at 432 MHz and 2.3 GHz

Next:



Thank you to you all, and special thanks to

Nasr Alkhafaji

Finishing his PhD, who built and measured all the 2.3 GHz arrays and made the measurements

Madeleine Roche

Finishing her MS, who worked on all the 432 MHz arrays and has been an essential part of the 2.3 GHz team