Ultrafast Electronic Probe with Ultrafine Spatial Resolution

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Ultrafast electronics probe with Ultrafine spatial resolution

To meet the measurement needs of:

- The IC industry where standard production will incorporate 100 nm line dimension by 2007.
- The scientific community where high-speed, high-efficiency devices will be working with reduced dimensionality nanostructures.
Properties of LT- GaAs grown near 200°C

- femtosecond carrier lifetime

- resistivity $> 10^7$ ohm-cm

- responsivity 1 to 100 mA/W

- MSM gates with $< 10$ fF capacitance
Principle: Photoconductively gated sampling

- provide direct contact of photoconductive gate to devices for maximum sensitivity
- sense voltage waveforms using a picosecond gate with low parasitics

Material: Low-Temperature GaAs & metal contacts

- define probe by conventional etch processes
- define contact tip by self-terminating lift-off
- utilize subpicosecond carrier lifetime in to achieve temporal resolution with low parasitics
- utilize sub-100 nm tip radius to scan and contact surface structures
Probe processing

- grow layered structure
- etch front side
- pattern metal electrodes
- form tip by self-terminating lift-off
- pot front side in black wax
- thin and etch to remove substrate
- mount probes for scanning probe microscope
MSM capacitance

The elliptic integral of the first kind, defined as:

\[ K(k) = \int_{0}^{\frac{\pi}{2}} \frac{d\phi}{\sqrt{1-k^2\sin^2\phi}} \]

The capacitance, C, of an interdigital MSM structure with area, \( A \), finger width, \( w \), and center-to-center finger spacing of, \( d \), is

\[ C = \frac{K(k)}{K(k')} \epsilon \left( 1 + \frac{\epsilon}{\epsilon'} \right) \frac{A}{d} \]

where,

\[ k = \tan^2 \left( \frac{\pi w}{4d} \right) \]

\[ k' = \sqrt{1 - k^2} \]
Image acquired by fiber-supported probe
Conclusions

- A high sensitivity probe of picosecond electrical signals with nanometer spatial resolution has been demonstrated.

Future work

- Probes will be adapted to the cryogenic environment and used to sample signals on quantum wire structures.
- Testing of multi-chip-modules will be performed.
- Applications of the probe to VLSI testing will be developed.