2.5D Technology based on Vertically Aligned Carbon Nanotubes for MM-Waves Passive Devices

IMS
Connecting Minds. Exchanging Ideas.

The Coolest Ideas Under the Sun
SAN DIEGO 2023

Simon Chun Kiat Goh, Chun Fei Siah, Joseph De Saxce, Zhikai Ng, Li Lynn Shiau, Lucas Lum Yun Xiang, Chong Wei Tan, Edwin Hang Tong Teo, Philippe Coquet, Dominique Baillargeat, Beng Kang Tay

CiNTRA, xlim, Nanyang Technological University Singapore, THALES

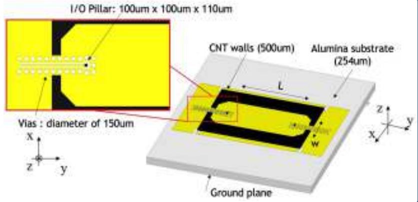
CONTEXT

- ✓ Beyond 5G and 6G: (sub) millimeter operating frequency
- ✓ Use of such high frequency bands results in more design challenges of RF circuits and heterogeneous integrations, in a 3D approach in general
- ✓ Need for a new type of low-cost, high performance, integrated passive devices to compete respectively electrical performances and cost of fabrication of 2D and classical 3D technologies.

OBJECTIVES

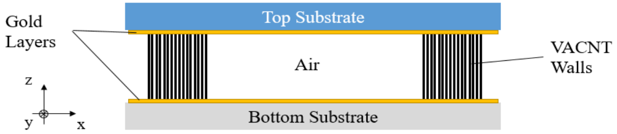
To propose an alternative and disruptive 2.5D technology based on VACNTs

- ✓ ease in fabricating patterned CNTs based structures, with
  - ➢ *any type of geometry and high resolution,*
  - ➢ *together CNTs' superior* optical, mechanical, thermal and electronic properties
- ✓ A proof of concept of a VACNTS-based AFWG for 5G backhaul applications in the 81-86 GHz band



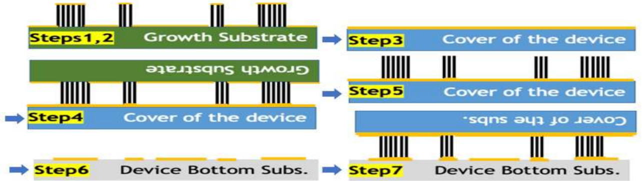
TEST STRUCURE FABRICATION

Air-Filled WG



- ✓ replacing classic lateral metal walls of WG structures with CNTs) walls
- ✓ CNT low temperature transfer technology to solve the mechanical limitation
- ✓ using air as the propagation medium to reduce the dielectric losses.

Transfer process < 300° , CMOS compatible

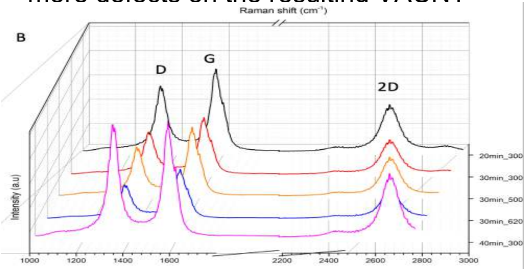


1. Growth of the VACNTs that will make the walls and pillars; 2. Deposition of a gold layer by evaporation on top of the as-grown CNTs; 3. Manufacture of the cover by depositing a gold layer on a Si substrate; 4. Bonding of the gold plated VACNTs on the cover using thermo-compression bonding (TCB); 5. Separation of the growth substrate and cover of the device, leaving the VACNTs on the cover; 6. Manufacture of the GCPW lines on the bottom substrate using classical processes; 7. TCB of the cover with the CNTs and the bottom substrate for the realization of the AFWG.

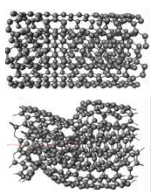
CNTS COMPRESSIVE DEFORMATION EFFECTS

Axial compression on CNTs during the transfer process

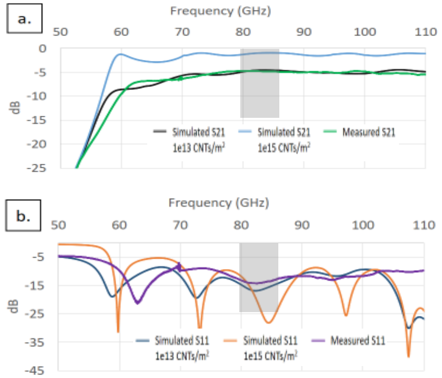
- ✓ I_D/I_G ratio corroborates with the fact that higher compression ratio, would induce more defects on the resulting VACNT
- ✓ Molecular dynamics simulation under progress



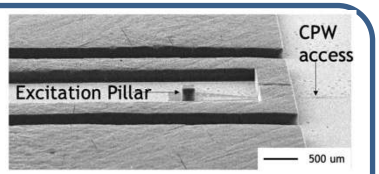
Raman shift of grown VACNT (20, 30 and 40 mins growth time) and height of compression limiting spacers (300, 500 and 620 μm).



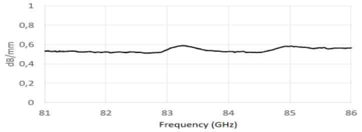
S-PARAMETERS



Experimental S-parameters



Fabricated CNT-based AFWG



Experimental attenuation constant

For the first time, an experimental AFWG based on VACNTs is fabricated and tested with success in the 81-86 GHz band.