COMPOUND SEMICONDUCTOR MICROMACHINING
(10 years of collaboration between FORTH & IMT)

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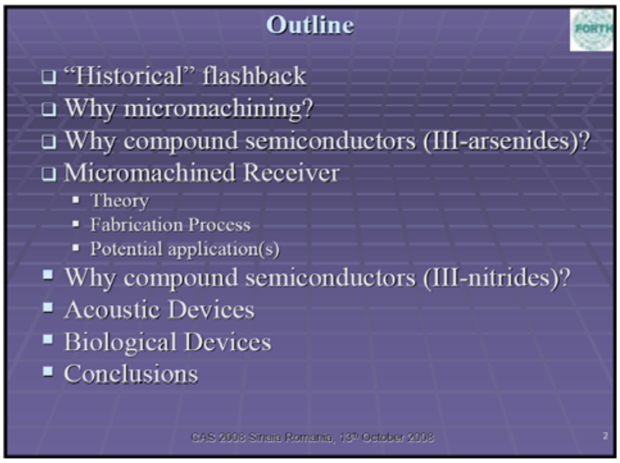
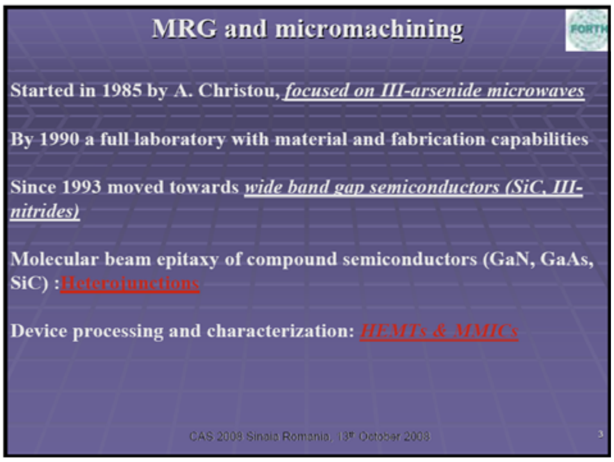
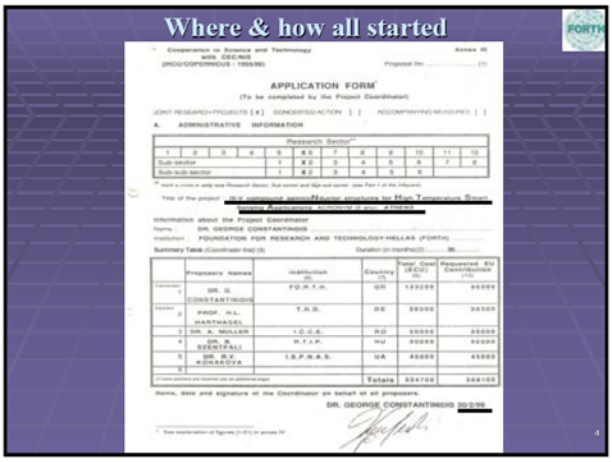
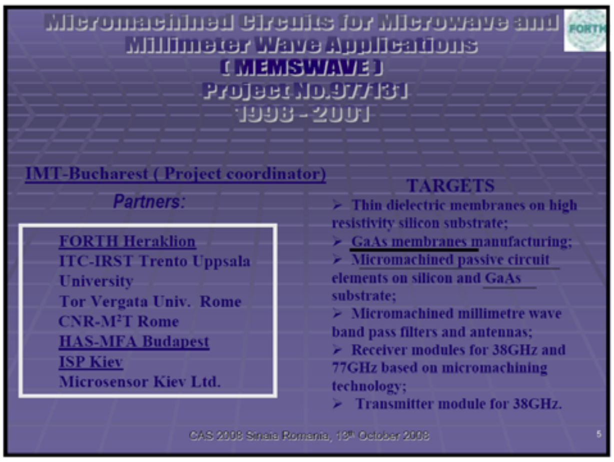
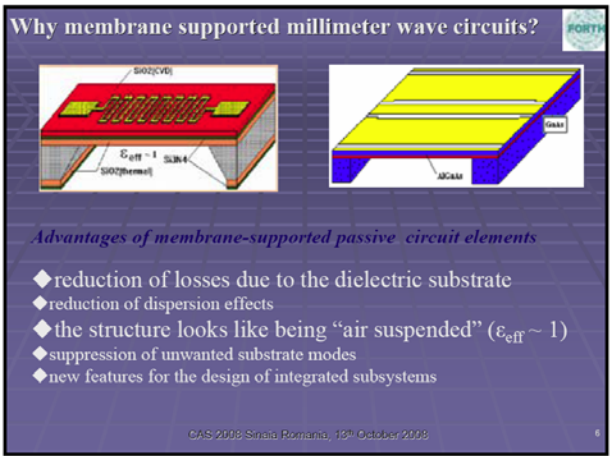
Institute of Electronic Structure &Lasers (IESL)
Foundation for Research & Technology Hellas (FORTH)

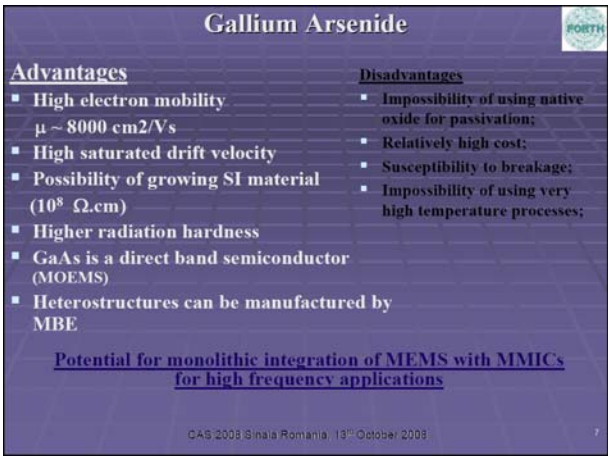












GaAs millimeter wave micromachined circuits

The research of applications of micromaching techniques at ultrahigh frequencies such as sub-millimeter waves and THz

The development of innovative new devices and systems required such as miniaturized THz sources, amplifiers and transceivers which presently are missing in these frequency range though a wealth of applications especially in medicine, biology molecular chemistry, security environmental control and communication.

The development of new concepts such a MMID by integrating micromaching devices with active circuits, sensors and RF MEMS

Process flow general issues

- Substrate (GaAs)
- Epitaxial material (MBE)

FABRICATION

- Photolithography
- Metallizations (active, interconnects, bridges, vias)
- Micromachining - etching (sacrificial material, selectivity,wet, dry)
- Passivation
- Packaging

Wet etching of GaAs

⇒ (zincblende) GaAs→ anisotropic etching

⇒(100) most common direction

⇒**Various inclinations may be unsuitable for metallisations**

⇒Undercutting under the etch mask

Ohmic contacts to GaAs

⇒ **Small contribution to parasitic resistance**

⇒ For n GaAs various metals have been used (Si, Ge, Sn, Se, Te) but Ge dominates

⇒ Used with Au and usually there is a system based on (Ge/Au) Ni and Au

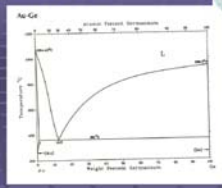
Mechanism (upon annealing around 360C-410C)

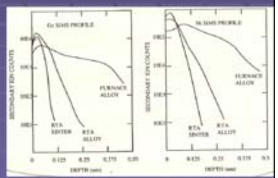
⇒ Au attracts Ga atoms

⇒ Ge goes to the Ga vacancies. This acts as n++ doping

⇒ Ni assists the diffusion of Ge

⇒ Also the top Au helps for the connection to the "outer world"





Reactive Ion Etching (RIE)

⇒ Chlorine based chemistry (BCl_3, Cl_2, CCl_2F_2, $SiCl_4$)

⇒ **Selectivity issues between arsenides (GaAs, AlGaAs)**

⇒ Typical reaction

⇒ $2BCl_3 \longrightarrow B_2Cl_4 + 2Cl \longrightarrow \frac{1}{4} Al_2Cl_6 + 1/4 Ga_2Cl_6 + \frac{1}{4} As_4$

⇒ Gaseous byproducts removed

⇒ Monitoring processes

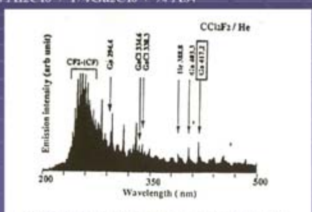


FIG. 2. Emission spectrum of CCl_2F_2/He plasma produced while etching GaAs.

Back side III-arsenide technology (from MMICs)

Substrate lapping down to 100μm

Initial substrate thickness 400μm (2-inch) ή 600μm (3inch)

Polishing of final surface

Final thickness 100 μm ± 10 μm

Via hole technology

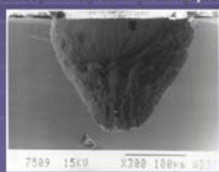
Incorporation of an AlGaAs etch stop layer to the buffer layer of the structureς

A two step RIE

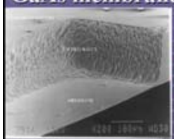
➔ GaAs with CCl2F2 (rate 1.2μm/min)

➔AlGaAs with BCl3 (rate 0.12μm/min)

RIE with tuned conditions for walls with positive slope



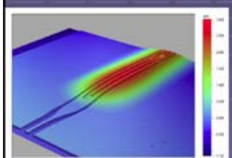
GaAs membranes as support for millimeter wave filters



Etched walls of the structure

The AlGaAs/GaAs heterostructure

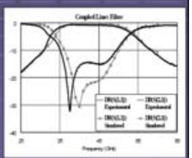
77 GHz cascaded open end series stubs CPW filter on GaAs membrane



WLI of the 77 GHz filter

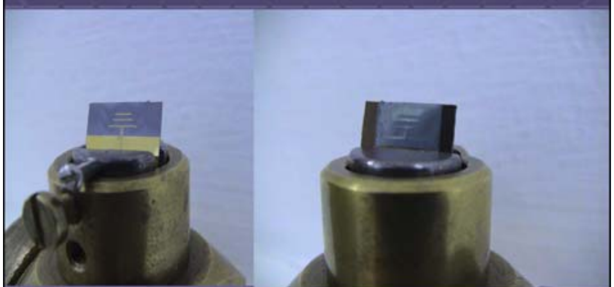
Journal of Micromechanics & Microengineering 11, p.305, (2001)

GaAs membrane supported coupled line filter for 45 GHz

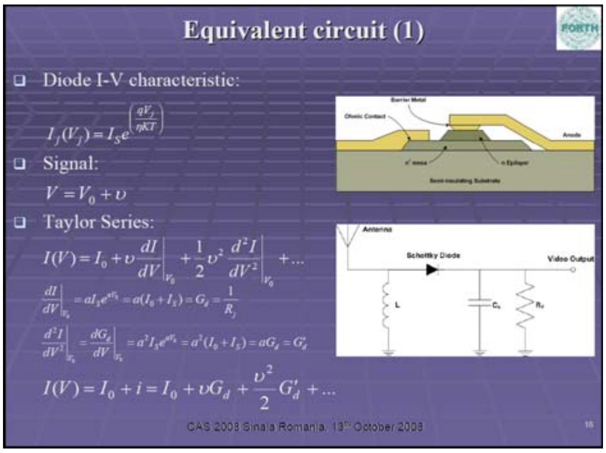


S parameter measurements for the new coupled line filter structure

Realised devices/GaAs



Front side of GaAs based Yagi-Uda   Back-side of GaAs based Yagi-Uda


Equivalent circuit (1)
Diode I-V characteristic:
$I_j(V_j) = I_S e^{\left(\frac{qV_j}{\eta KT}\right)}$
Signal:
$V = V_0 + \upsilon$
Taylor Series:
$I(V) = I_0 + \upsilon \frac{dI}{dV}\Big|_{V_0} + \frac{1}{2}\upsilon^2 \frac{d^2I}{dV^2}\Big|_{V_0} + \ldots$
$I(V) = I_0 + i = I_0 + \upsilon G_d + \frac{\upsilon^2}{2} G'_d + \ldots$
Antenna
Schottky Diode
Video Output
CAS 2008 Sinaia Romania, 13th October 2008
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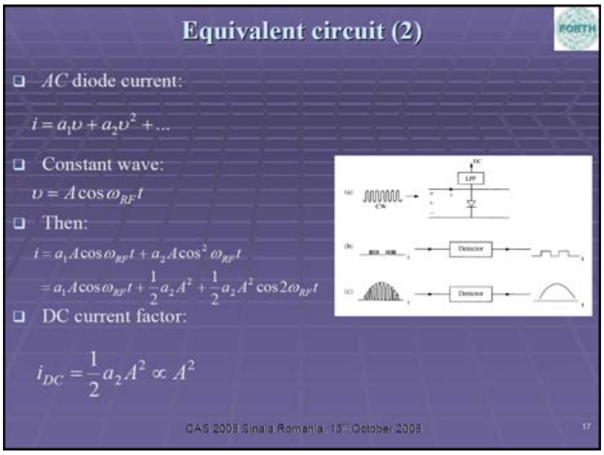
Equivalent circuit (2)
AC diode current:
$i = a_1\upsilon + a_2\upsilon^2 + \ldots$
Constant wave:
$\upsilon = A\cos\omega_{RF}t$
Then:
$i = a_1 A\cos\omega_{RF}t + a_2 A\cos^2\omega_{RF}t$
$= a_1 A\cos\omega_{RF}t + \frac{1}{2}a_2A^2 + \frac{1}{2}a_2A^2\cos 2\omega_{RF}t$
DC current factor:
$i_{DC} = \frac{1}{2}a_2A^2 \propto A^2$
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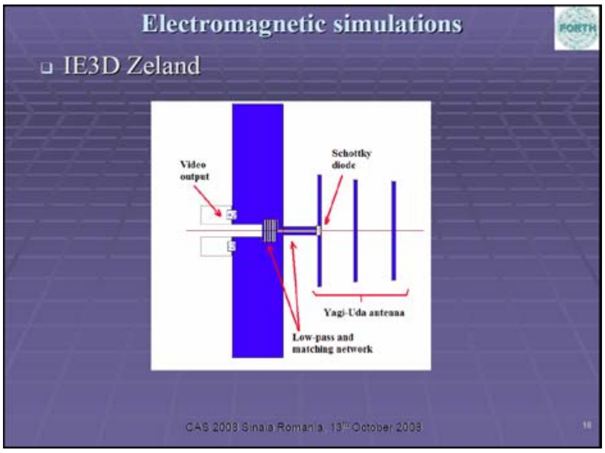
Electromagnetic simulations
IE3D Zeland
Video output
Schottky diode
Yagi-Uda antenna
Low-pass and matching network
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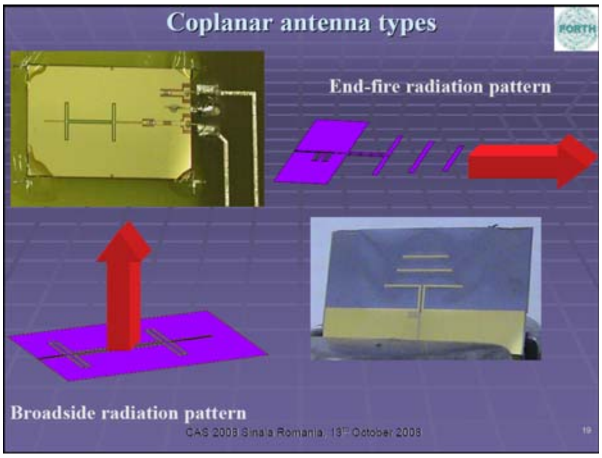
Coplanar antenna types
End-fire radiation pattern
Broadside radiation pattern
CAS 2008 Sinaia Romania, 13th October 2008
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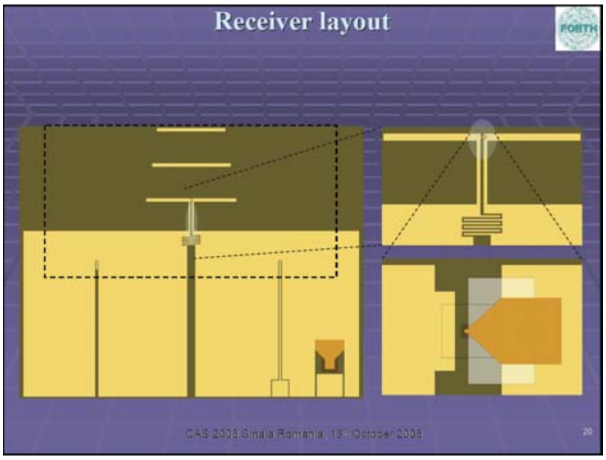
Receiver layout
CAS 2008 Sinaia Romania, 13th October 2008
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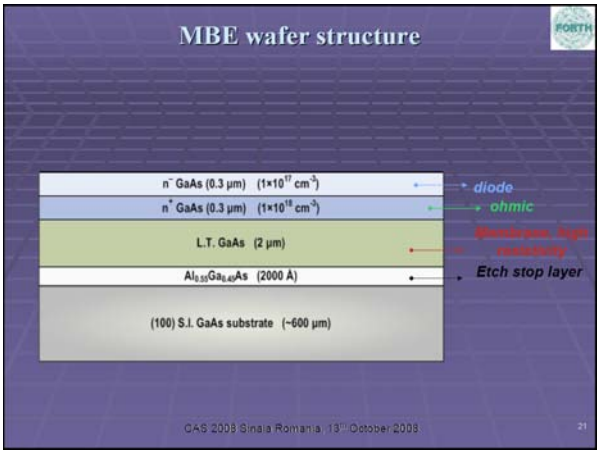
MBE wafer structure
n⁻ GaAs (0.3 μm) (1×10¹⁷ cm⁻³)
n⁺ GaAs (0.3 μm) (1×10¹⁸ cm⁻³)
L.T. GaAs (2 μm)
Al0.55Ga0.45As (2000 Å)
(100) S.I. GaAs substrate (~600 μm)
diode
ohmic
Etch stop layer
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Yagi-Uda receiver fabrication
8 fabrication stages
1st mesa formation
2nd mesa formation
Ohmic contacts metallization and RTA
Overlay metallization over ohmic contacts
Polyimide deposition
Metallization for bridge formation and Schottky contact diode
Front etching for later device dicing
Back side membrane formation
CAS 2008 Sinaia Romania, 13th October 2008
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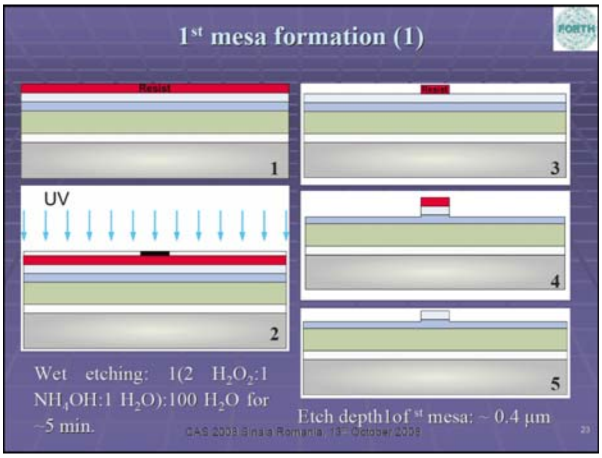
1st mesa formation (1)
Resist
Resist
1
3
UV
4
2
5
Wet etching: 1(2 H_2O_2:1 NH_4OH:1 H_2O):100 H_2O for ~5 min.
Etch depth1of st mesa: ~ 0.4 μm
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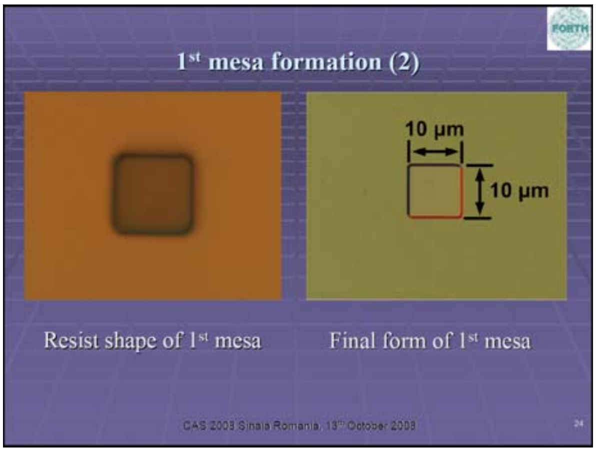
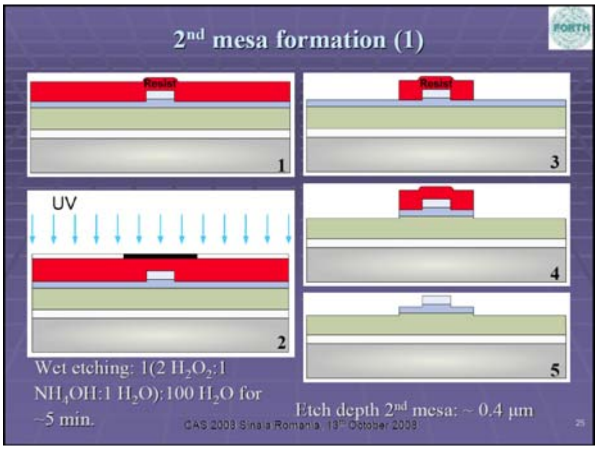

1st mesa formation (2)
10 µm
10 µm
Resist shape of 1st mesa
Final form of 1st mesa
CAS 2008 Sinaia Romania, 13th October 2008
24


2nd mesa formation (1)
Resist
UV
Wet etching: 1(2 H2O2:1 NH4OH:1 H2O):100 H2O for ~5 min.
Etch depth 2nd mesa: ~ 0.4 µm
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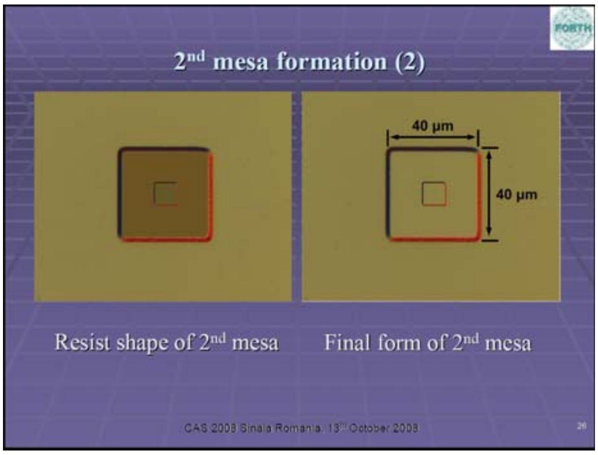
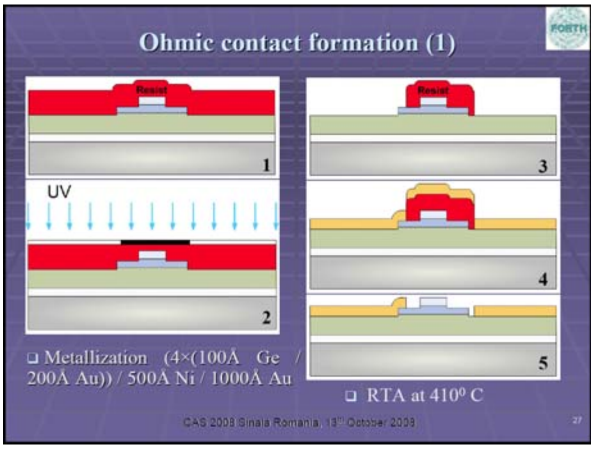
25


2nd mesa formation (2)
40 µm
40 µm
Resist shape of 2nd mesa
Final form of 2nd mesa
CAS 2008 Sinaia Romania, 13th October 2008
26


Ohmic contact formation (1)
Resist
UV
Metallization (4×(100Å Ge / 200Å Au)) / 500Å Ni / 1000Å Au
RTA at 410° C
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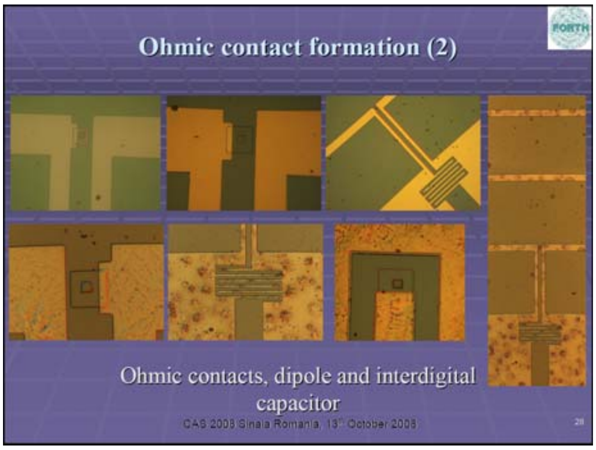
Ohmic contact formation (2)
Ohmic contacts, dipole and interdigital capacitor
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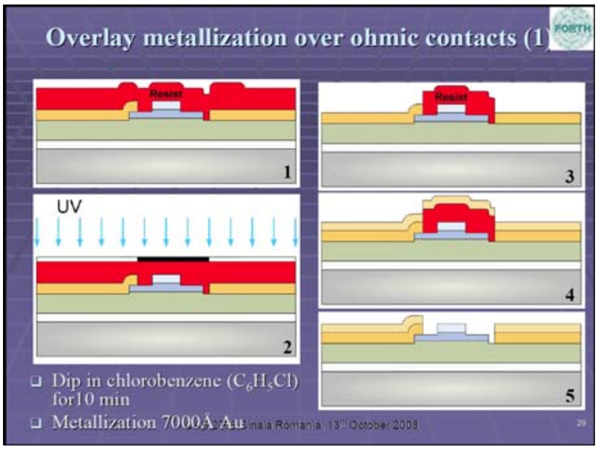
Overlay metallization over ohmic contacts (1)
Resist
UV
Dip in chlorobenzene (C6H5Cl) for10 min
Metallization 7000Å Au
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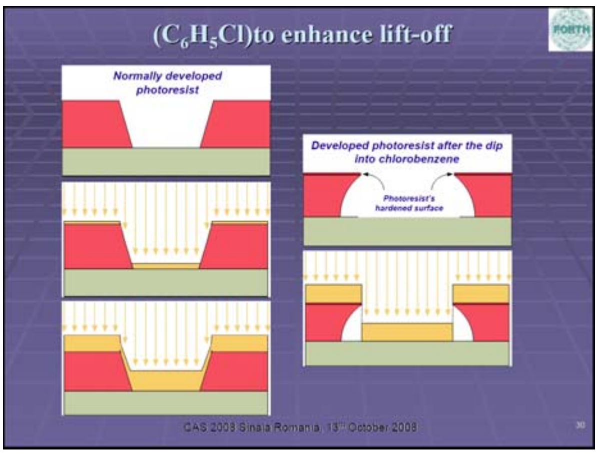
(C6H5Cl)to enhance lift-off
Normally developed photoresist
Developed photoresist after the dip into chlorobenzene
Photoresist's hardened surface
CAS 2008 Sinaia Romania, 13th October 2008
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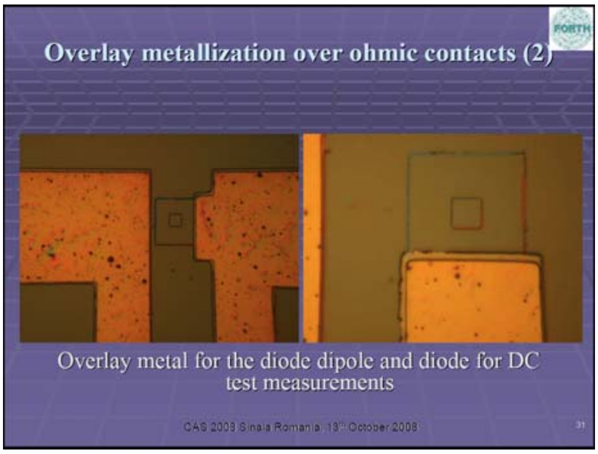
Overlay metallization over ohmic contacts (2)
Overlay metal for the diode dipole and diode for DC test measurements
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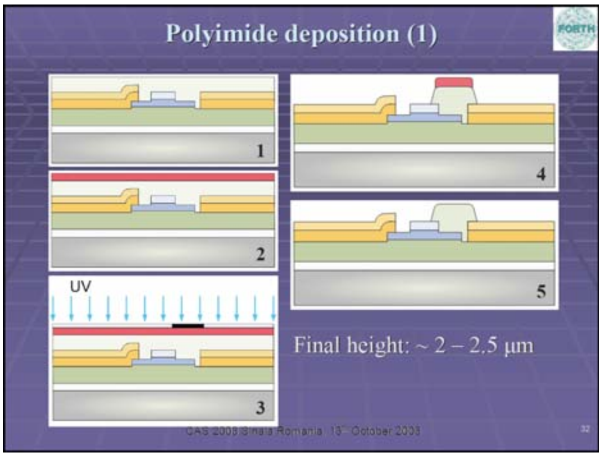
Polyimide deposition (1)
UV
1
2
3
4
5
Final height: ~ 2 – 2.5 μm
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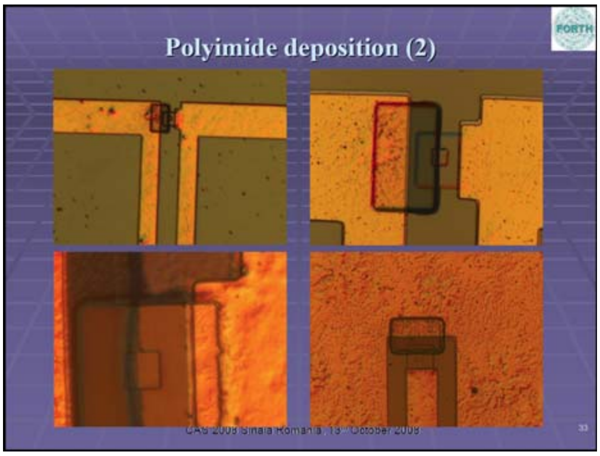
Polyimide deposition (2)
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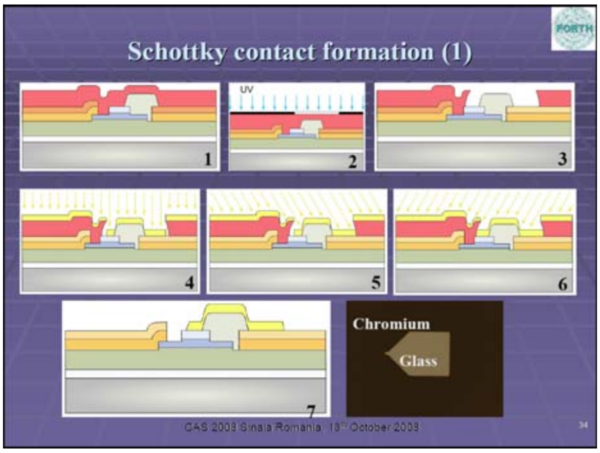
Schottky contact formation (1)
UV
1
2
3
4
5
6
7
Chromium
Glass
CAS 2008 Sinaia Romania 13th October 2008
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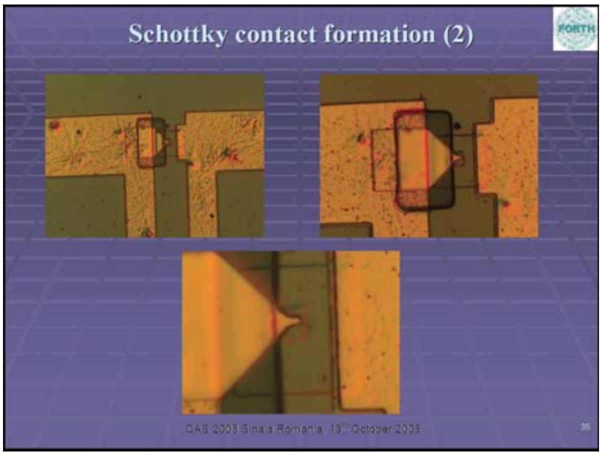
Schottky contact formation (2)
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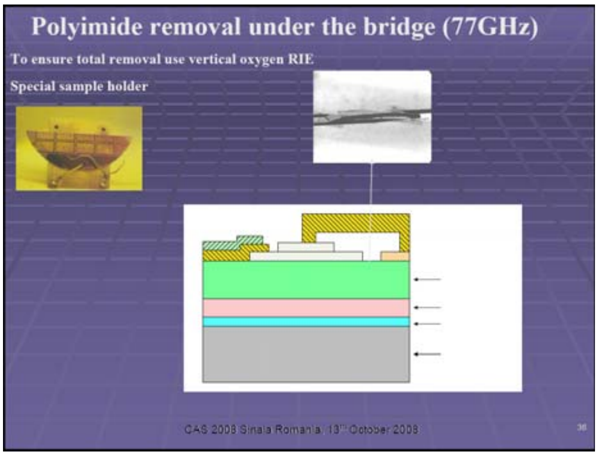
Polyimide removal under the bridge (77GHz)
To ensure total removal use vertical oxygen RIE
Special sample holder
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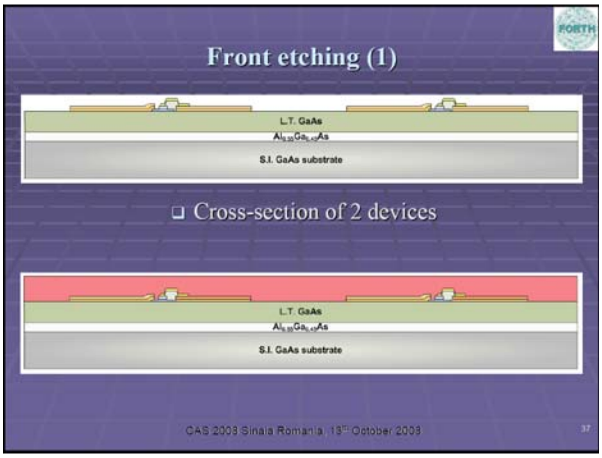
Front etching (1)
L.T. GaAs
S.I. GaAs substrate
❑ Cross-section of 2 devices
L.T. GaAs
S.I. GaAs substrate
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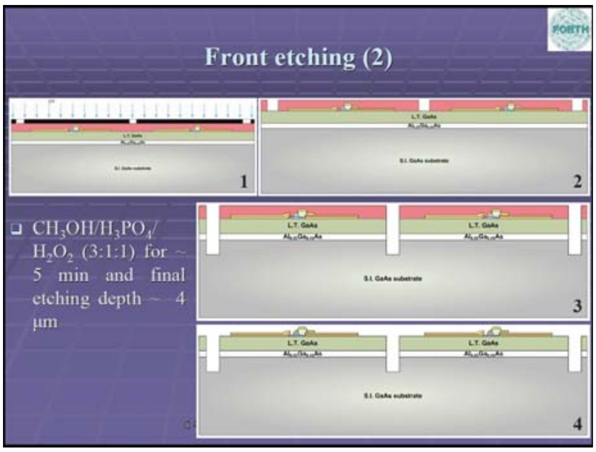
Front etching (2)
1
2
3
4
❑ $CH_3OH/H_3PO_4/H_2O_2$ (3:1:1) for ~ 5 min and final etching depth ~ 4 μm
L.T. GaAs
S.I. GaAs substrate


Separated devices for later dicing
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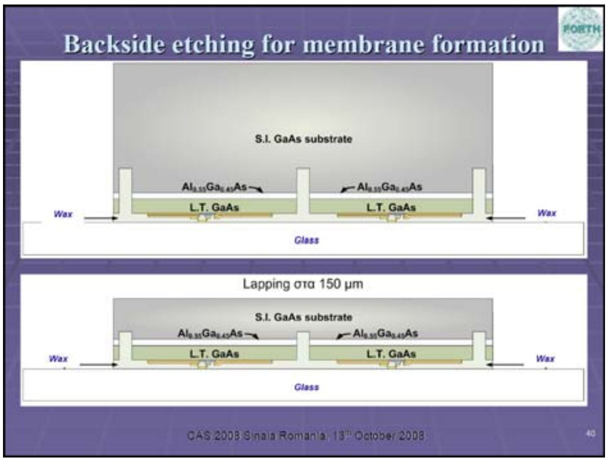
Backside etching for membrane formation
S.I. GaAs substrate
$Al_{0.55}Ga_{0.45}As$
$Al_{0.55}Ga_{0.45}As$
L.T. GaAs
L.T. GaAs
Wax
Wax
Glass
Lapping στα 150 μm
S.I. GaAs substrate
$Al_{0.55}Ga_{0.45}As$
$Al_{0.55}Ga_{0.45}As$
L.T. GaAs
L.T. GaAs
Wax
Wax
Glass
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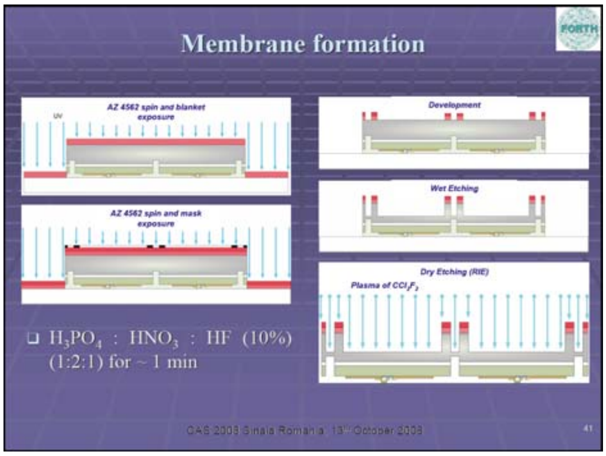
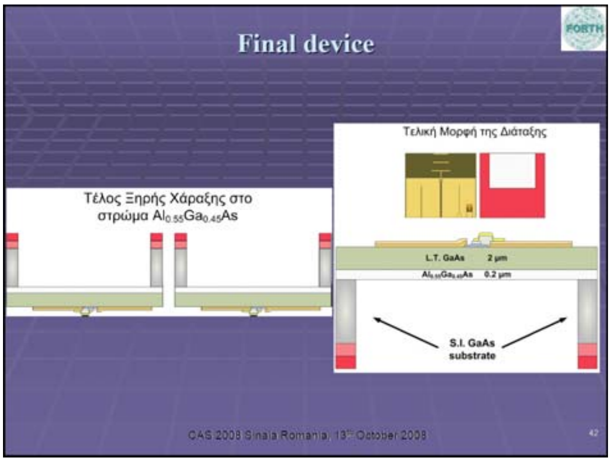

Membrane formation
AZ 4562 spin and blanket exposure
AZ 4562 spin and mask exposure
Development
Wet Etching
Dry Etching (RIE)
Plasma of CCl_2F_2
H_3PO_4 : HNO_3 : HF (10%) (1:2:1) for ~ 1 min
CAS 2008 Sinaia Romania, 13th October 2008
41


Final device
Τελική Μορφή της Διάταξης
Τέλος Ξηρής Χάραξης στο στρώμα $Al_{0.55}Ga_{0.45}As$
L.T. GaAs 2 μm
$Al_{0.55}Ga_{0.45}As$ 0.2 μm
S.I. GaAs substrate
CAS 2008 Sinaia Romania, 13th October 2008
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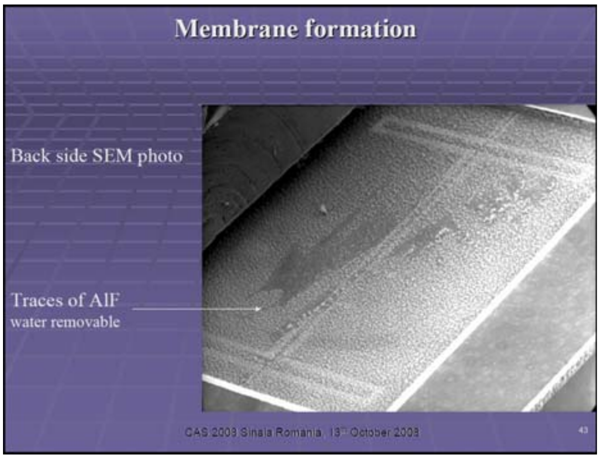
Membrane formation
Back side SEM photo
Traces of AlF
water removable
CAS 2008 Sinaia Romania, 13th October 2008
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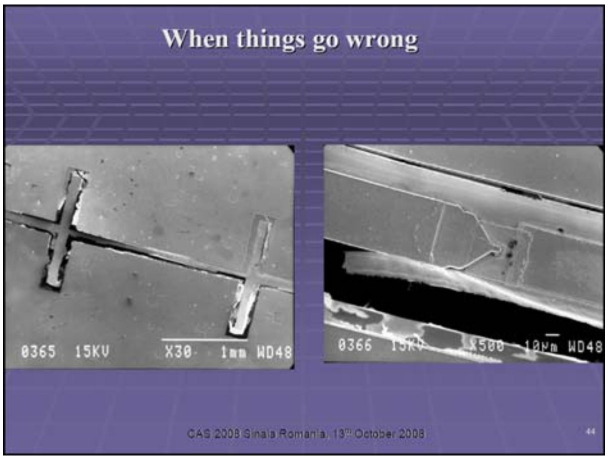
When things go wrong
0365 15KV X30 1mm WD48
0366 15KV X500 10μm WD48
CAS 2008 Sinaia Romania, 13th October 2008
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Membrane formation
BEFORE
AFTER DI-WATER
HF dip clears AlGaAs
CAS 2008 Sinaia Romania, 13th October 2008
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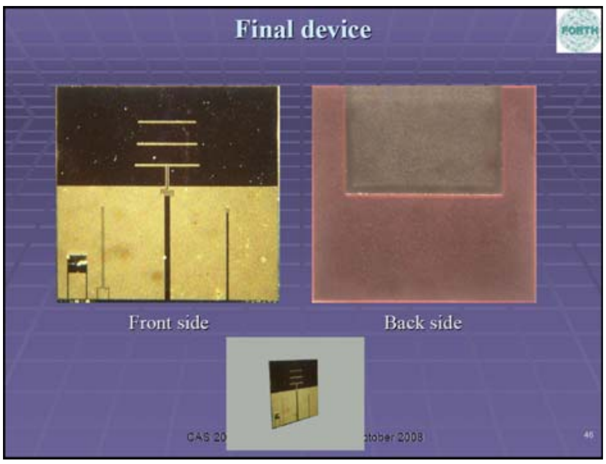
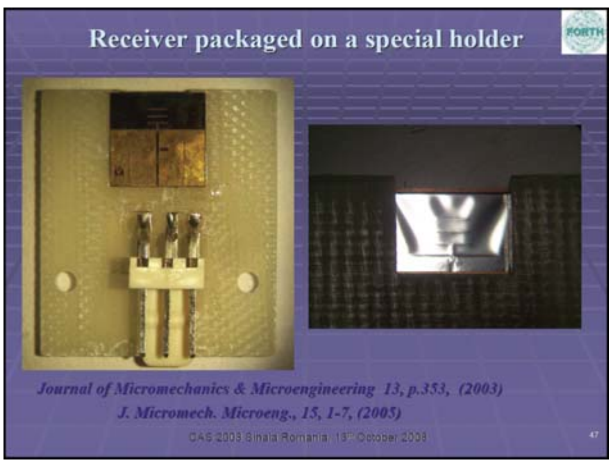

Final device
Front side
Back side
CAS 20
tober 2008
46


Receiver packaged on a special holder
Journal of Micromechanics & Microengineering 13, p.353, (2003)
J. Micromech. Microeng., 15, 1-7, (2005)
CAS 2008 Sinaia Romania, 13th October 2008
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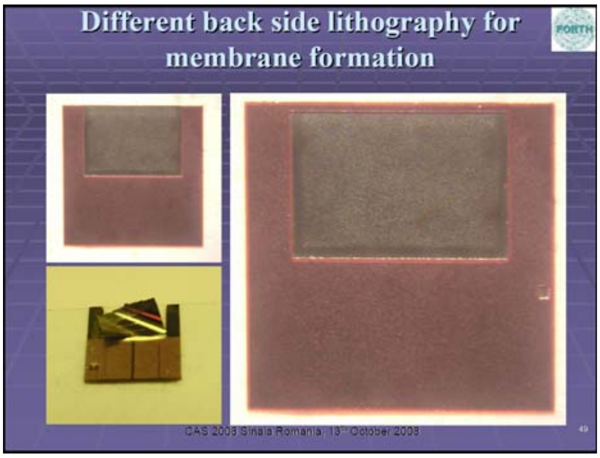
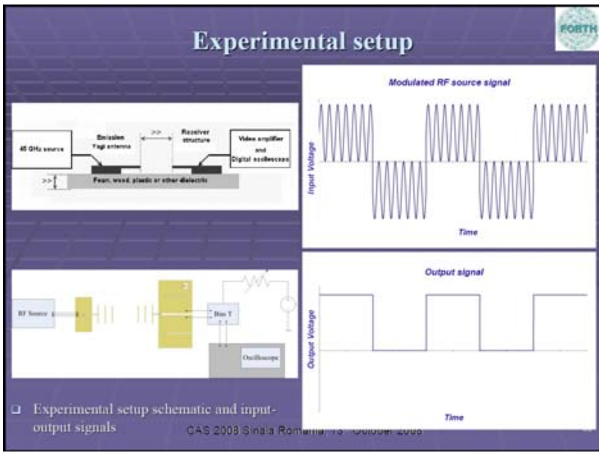
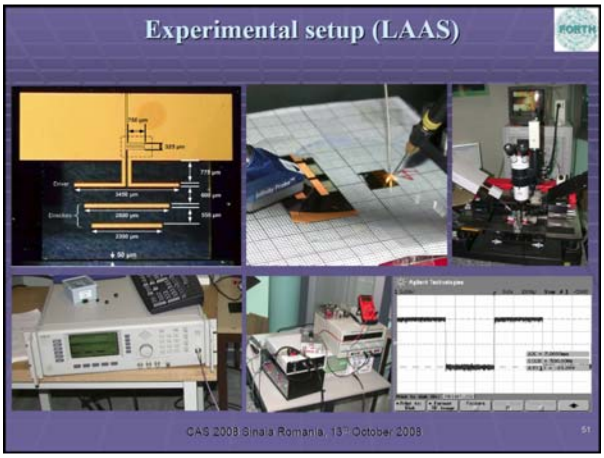
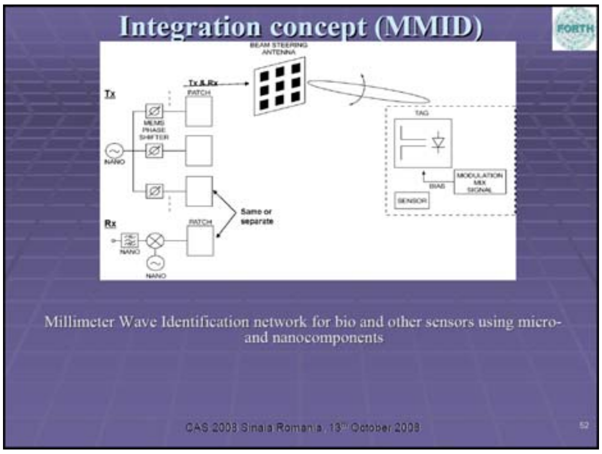
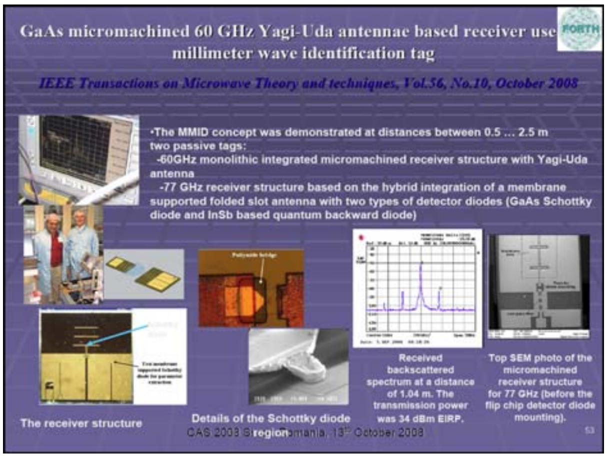
Photolithography mask change
Chromium
Glass
Glass
Chromium
CAS 2008 Sinaia Romania, 13th October 2008

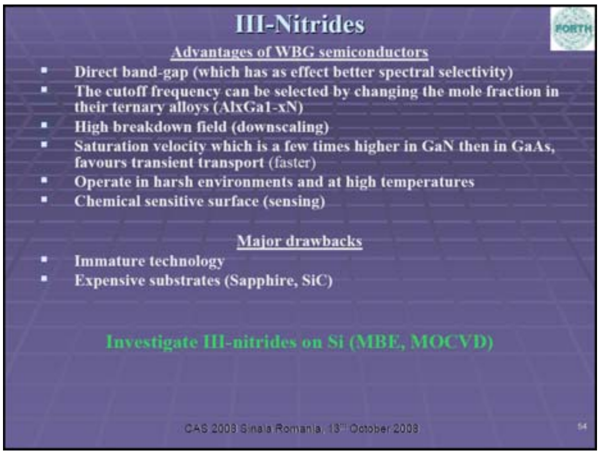

Different back side lithography for membrane formation
CAS 2008 Sinaia Romania, 13th October 2008

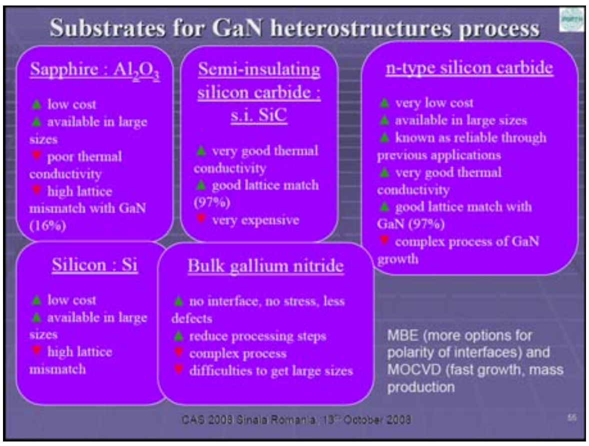

Experimental setup
Modulated RF source signal
Input Voltage
Time
Output signal
Output Voltage
Time
Experimental setup schematic and input-output signals
CAS 2008 Sinaia Romania, 13th October 2008


Experimental setup (LAAS)
CAS 2008 Sinaia Romania, 13th October 2008


Integration concept (MMID)
BEAM STEERING ANTENNA
Tx
Tx & Rx
PATCH
MEMS PHASE SHIFTER
NANO
TAG
MODULATION MIX SIGNAL
BIAS
SENSOR
Same or separate
Rx
PATCH
Millimeter Wave Identification network for bio and other sensors using micro- and nanocomponents
CAS 2008 Sinaia Romania, 13th October 2008


GaAs micromachined 60 GHz Yagi-Uda antennae based receiver use millimeter wave identification tag
IEEE Transactions on Microwave Theory and techniques, Vol.56, No.10, October 2008
•The MMID concept was demonstrated at distances between 0.5 ... 2.5 m two passive tags:
-60GHz monolithic integrated micromachined receiver structure with Yagi-Uda antenna
-77 GHz receiver structure based on the hybrid integration of a membrane supported folded slot antenna with two types of detector diodes (GaAs Schottky diode and InSb based quantum backward diode)
The receiver structure
Details of the Schottky diode region
Received backscattered spectrum at a distance of 1.04 m. The transmission power was 34 dBm EIRP.
Top SEM photo of the micromachined receiver structure for 77 GHz (before the flip chip detector diode mounting).
CAS 2008 Sinaia Romania, 13th October 2008


III-Nitrides
Advantages of WBG semiconductors
Direct band-gap (which has as effect better spectral selectivity)
The cutoff frequency can be selected by changing the mole fraction in their ternary alloys (AlxGa1-xN)
High breakdown field (downscaling)
Saturation velocity which is a few times higher in GaN then in GaAs, favours transient transport (faster)
Operate in harsh environments and at high temperatures
Chemical sensitive surface (sensing)
Major drawbacks
Immature technology
Expensive substrates (Sapphire, SiC)
Investigate III-nitrides on Si (MBE, MOCVD)
CAS 2008 Sinaia Romania, 13th October 2008


Substrates for GaN heterostructures process
Sapphire : Al_2O_3
low cost
available in large sizes
poor thermal conductivity
high lattice mismatch with GaN (16%)
Semi-insulating silicon carbide : s.i. SiC
very good thermal conductivity
good lattice match (97%)
very expensive
n-type silicon carbide
very low cost
available in large sizes
known as reliable through previous applications
very good thermal conductivity
good lattice match with GaN (97%)
complex process of GaN growth
Silicon : Si
low cost
available in large sizes
high lattice mismatch
Bulk gallium nitride
no interface, no stress, less defects
reduce processing steps
complex process
difficulties to get large sizes
MBE (more options for polarity of interfaces) and MOCVD (fast growth, mass production
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RIE GaN

⇒**Only DRY etching is practically possible**

⇒ Chlorine based chemistry (BCl_3, Cl_2, CCl_2F_2, $SiCl_4$)

⇒ Typical reaction

⇒ GaN + Cl $GaCl_3$ + N_2

⇒ Gaseous byproducts removed

⇒ Monitoring processes

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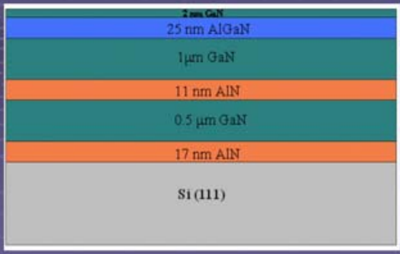
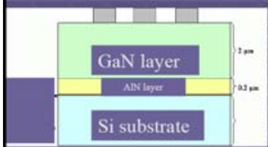
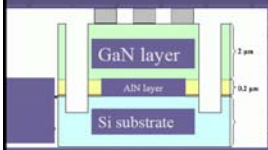
MBE layers



CAS 2008 Sinaia Romania, 13th October 2008 57

Antenna metallization & Front side etch and chip definition





Conventional contact lithography, e-gun evaporation and lift-off techniques are used to define the filter structure.

To ensure lift-off, chlorobenzene treatment is used for the resist.

A 500 Å Ti / 7000 Å Au metallization is used.

Then again contact lithography is used to define the perimetry on the top surface where the GaN layers will be etched.

This step serves in the definition of the free membrane edge as well as for chip dicing during the subsequent RIE etch for the formation of the membrane

Then, RIE is used with $Cl_2$and BCl_3 chemistry

Then the wafers are mounted face-down on special glass plates and the Si substrate is thinned down to 150 µm by lapping technique.

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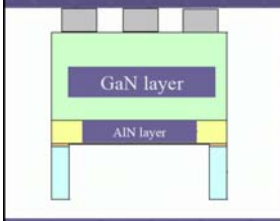
Membrane formation & release of free membrane edge



The etching pattern for the membranes is defined by backside alignment contact photolithography.

Here, Aluminum is used as the etch mask (e-beam deposition and lift-off)

Then, the wafer is removed from the glass carrier, cleaned in TCE and dried.

The membranes are fabricated in a Vacutec 1350 RIE chamber using SF_6 chemistry

With the prior removal of the etch stop layer around the perimetry the free membrane edge is formed and the chips are diced.

Because there are numerous "fragile" chips in the plasma chamber, a special carriage is under design to remove them all at once

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Realised devices/GaN on Silicon

Back-side of GaN based Yagi-Uda

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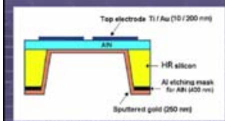
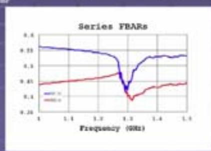
First GaN membrane FBAR structures



Cross section of the FBAR structure with the evaporated Ti/Au for the top metallization and sputtered Au for the bottom contact. Sputtered Al is used as mask for the bulk-micromachining of the membrane

GaN membrane supported series connection of two FBAR structures (test structures)



Applied Physics Letters 89 (14), 142122, (2006)

The thickness of the membrane was 2.2µm

Superlattices and Microstructures 40 (4-6), pp.426-431, (2006)

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GaN FBARs

500 nm (GaN) +280nm (buffer) thin membrane supported FBAR structure based on GaN micromachining

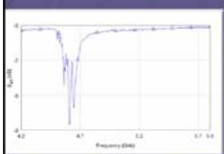
•50nm thin Mo metallization

•GaN/Si wafers from NTT AT Japan

Before membrane manufacturing

Top view; bottom illumination

Top view top illumination



Top view; top+ bottom illumination

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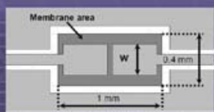
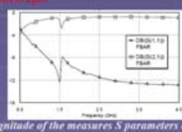
AlN FBAR structures



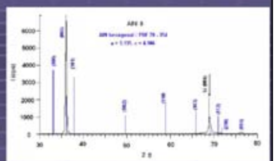
The layout of the AlN FBAR test structure

Top optical photo of the manufactured FBAR structure (w = 300µm, membrane: 1000x400µm)

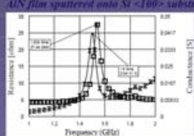
Membrane thickness 2µm



Magnitude of the measures S parameters of the AlN based FBAR 300 µm test structure



XRD diffraction pattern for a high oriented AlN film sputtered onto Si <100> substrate



The resistance and the conductance of the two FBARs structures connected in series

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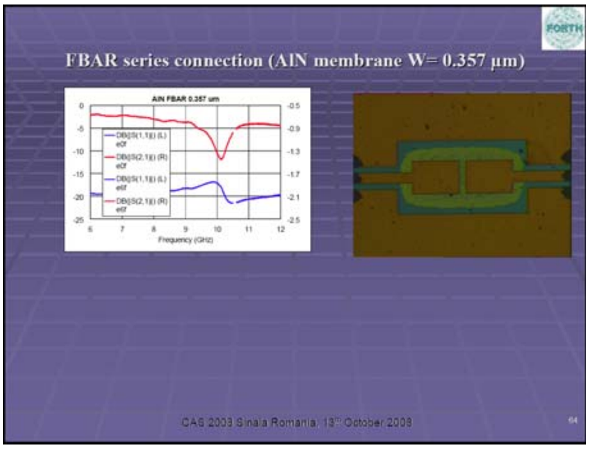
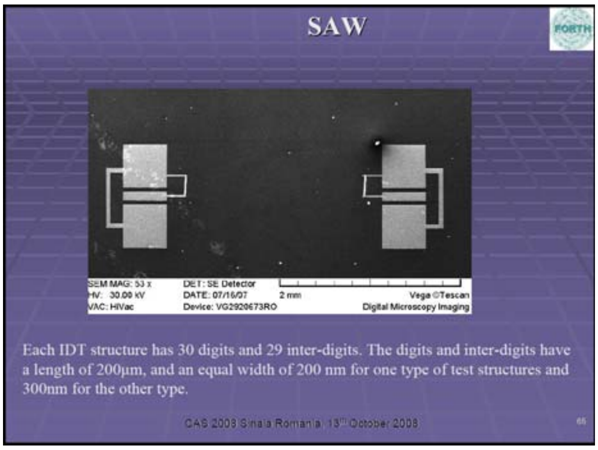
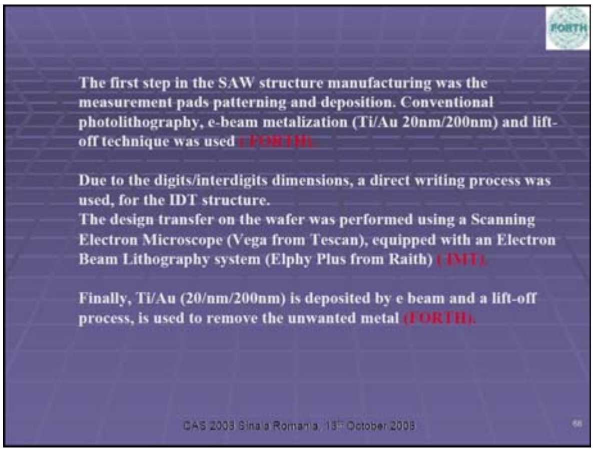

FBAR series connection (AlN membrane W= 0.357 μm)
AlN FBAR 0.357 um
Frequency (GHz)
CAS 2008 Sinaia Romania 13th October 2008
64


SAW
SEM MAG: 53 x
HV: 30.00 kV
VAC: HiVac
DET: SE Detector
DATE: 07/16/07
Device: VG2920673RO
2 mm
Vega ©Tescan
Digital Microscopy Imaging
Each IDT structure has 30 digits and 29 inter-digits. The digits and inter-digits have a length of 200μm, and an equal width of 200 nm for one type of test structures and 300nm for the other type.
CAS 2008 Sinaia Romania 13th October 2008
65


The first step in the SAW structure manufacturing was the measurement pads patterning and deposition. Conventional photolithography, e-beam metalization (Ti/Au 20nm/200nm) and lift-off technique was used (FORTH).
Due to the digits/interdigits dimensions, a direct writing process was used, for the IDT structure.
The design transfer on the wafer was performed using a Scanning Electron Microscope (Vega from Tescan), equipped with an Electron Beam Lithography system (Elphy Plus from Raith) (IMT).
Finally, Ti/Au (20/nm/200nm) is deposited by e beam and a lift-off process, is used to remove the unwanted metal (FORTH).
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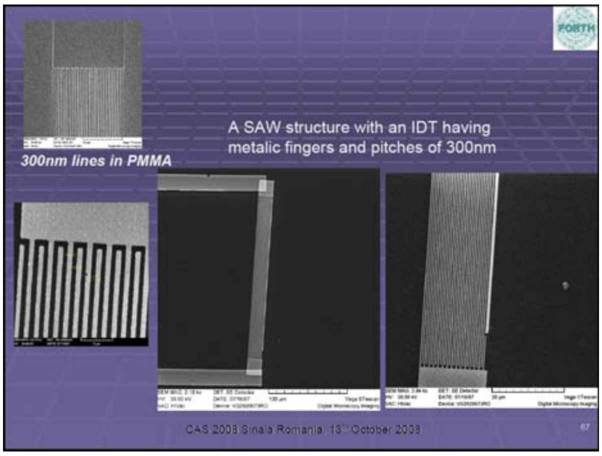
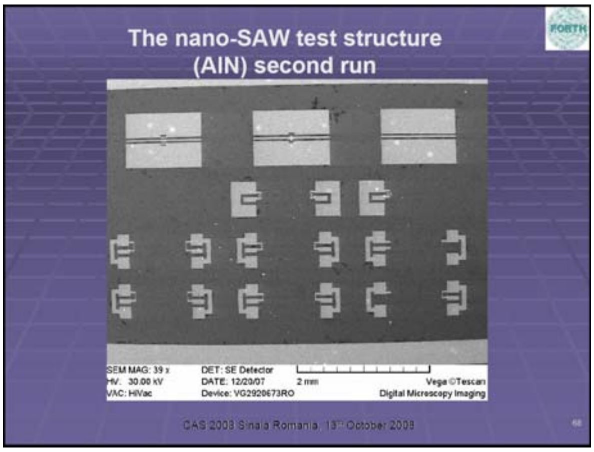
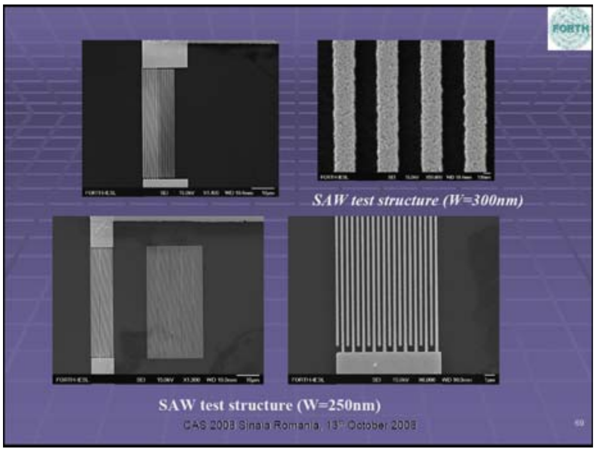
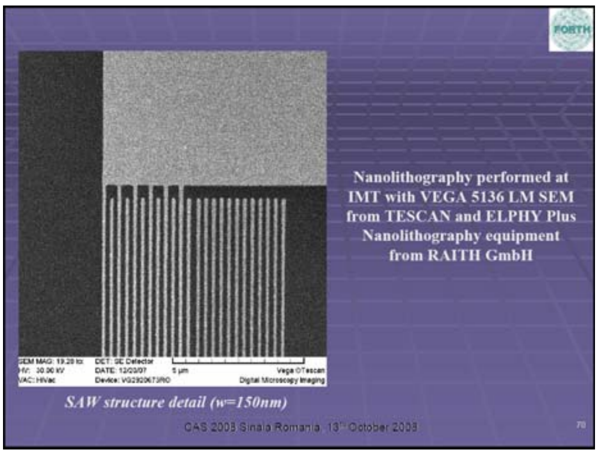
66


300nm lines in PMMA
A SAW structure with an IDT having metalic fingers and pitches of 300nm
CAS 2008 Sinaia Romania 13th October 2008
67


The nano-SAW test structure (AlN) second run
SEM MAG: 39 x
HV: 30.00 kV
VAC: HiVac
DET: SE Detector
DATE: 12/20/07
Device: VG2920673RO
2 mm
Vega ©Tescan
Digital Microscopy Imaging
CAS 2008 Sinaia Romania 13th October 2008
68


SAW test structure (W=300nm)
SAW test structure (W=250nm)
CAS 2008 Sinaia Romania 13th October 2008
69


Nanolithography performed at IMT with VEGA 5136 LM SEM from TESCAN and ELPHY Plus Nanolithography equipment from RAITH GmbH
SAW structure detail (w=150nm)
CAS 2008 Sinaia Romania 13th October 2008
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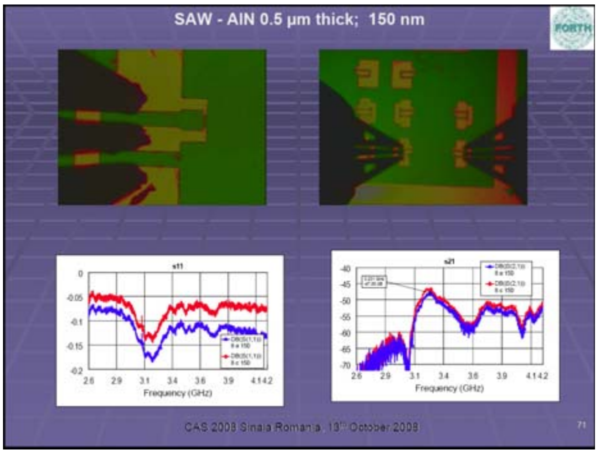
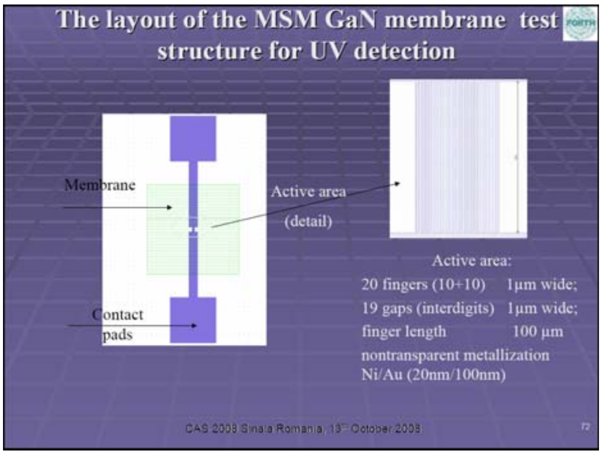

SAW - AlN 0.5 μm thick; 150 nm
s11
s21
Frequency (GHz)
CAS 2008 Sinaia Romania 13th October 2008
71


The layout of the MSM GaN membrane test structure for UV detection
Membrane
Active area
(detail)
Contact pads
Active area:
20 fingers (10+10) 1μm wide;
19 gaps (interdigits) 1μm wide;
finger length 100 μm
nontransparent metallization
Ni/Au (20nm/100nm)
CAS 2008 Sinaia Romania, 13th October 2008
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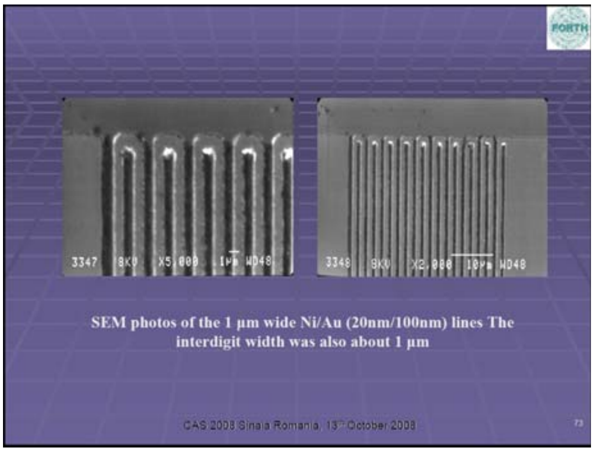
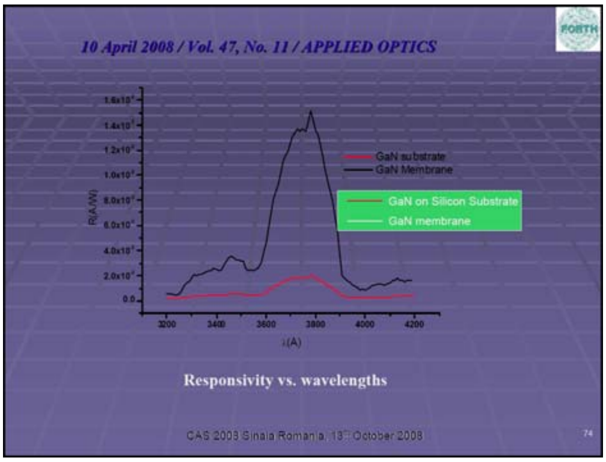

SEM photos of the 1 μm wide Ni/Au (20nm/100nm) lines The interdigit width was also about 1 μm
CAS 2008 Sinaia Romania, 13th October 2008
73


10 April 2008 / Vol. 47, No. 11 / APPLIED OPTICS
GaN substrate
GaN Membrane
GaN on Silicon Substrate
GaN membrane
R(A/W)
λ(A)
Responsivity vs. wavelengths
CAS 2008 Sinaia Romania, 13th October 2008
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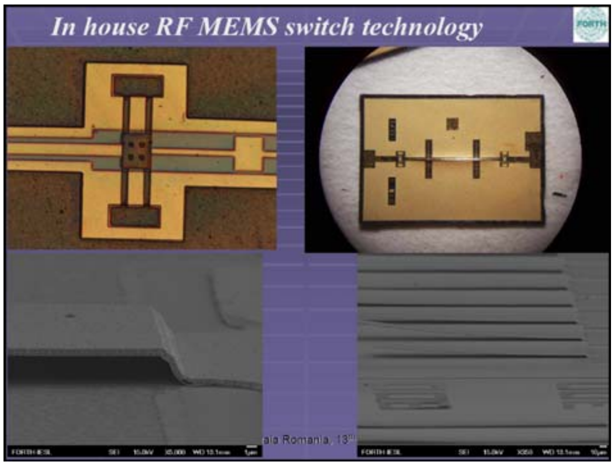
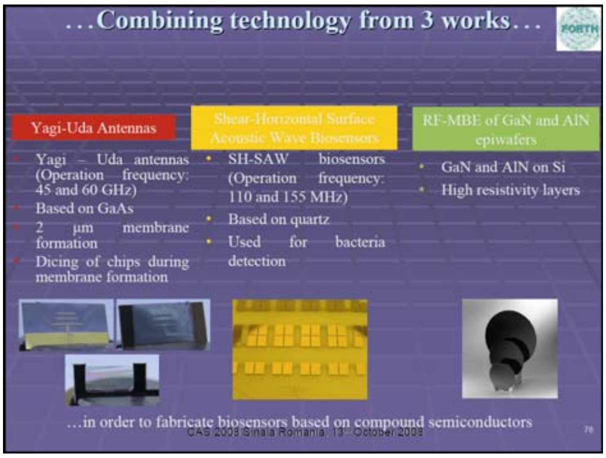
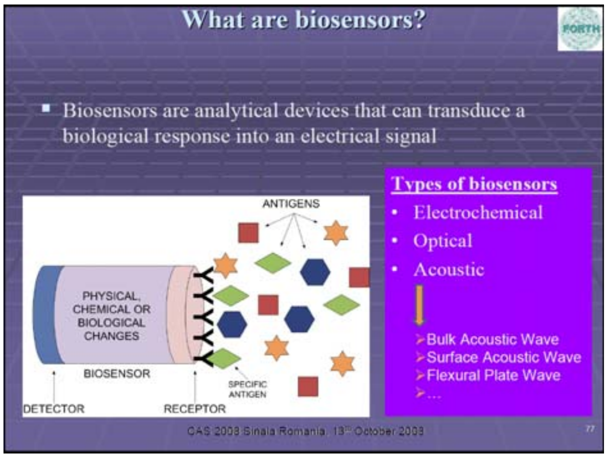
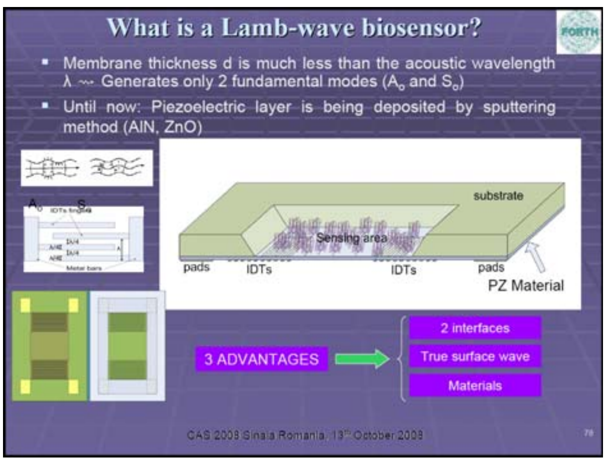

In house RF MEMS switch technology


...Combining technology from 3 works...
Yagi-Uda Antennas
Shear-Horizontal Surface Acoustic Wave Biosensors
RF-MBE of GaN and AlN epiwafers
Yagi – Uda antennas (Operation frequency: 45 and 60 GHz)
Based on GaAs
2 μm membrane formation
Dicing of chips during membrane formation
SH-SAW biosensors (Operation frequency: 110 and 155 MHz)
Based on quartz
Used for bacteria detection
GaN and AlN on Si
High resistivity layers
...in order to fabricate biosensors based on compound semiconductors
CAS 2008 Sinaia Romania, 13th October 2008
76


What are biosensors?
Biosensors are analytical devices that can transduce a biological response into an electrical signal
ANTIGENS
PHYSICAL, CHEMICAL OR BIOLOGICAL CHANGES
BIOSENSOR
SPECIFIC ANTIGEN
DETECTOR
RECEPTOR
Types of biosensors
Electrochemical
Optical
Acoustic
Bulk Acoustic Wave
Surface Acoustic Wave
Flexural Plate Wave
...
CAS 2008 Sinaia Romania, 13th October 2008
77


What is a Lamb-wave biosensor?
Membrane thickness d is much less than the acoustic wavelength λ ⇝ Generates only 2 fundamental modes (A₀ and S₀)
Until now: Piezoelectric layer is being deposited by sputtering method (AlN, ZnO)
substrate
Sensing area
pads
IDTs
IDTs
pads
PZ Material
3 ADVANTAGES
2 interfaces
True surface wave
Materials
CAS 2008 Sinaia Romania, 13th October 2008
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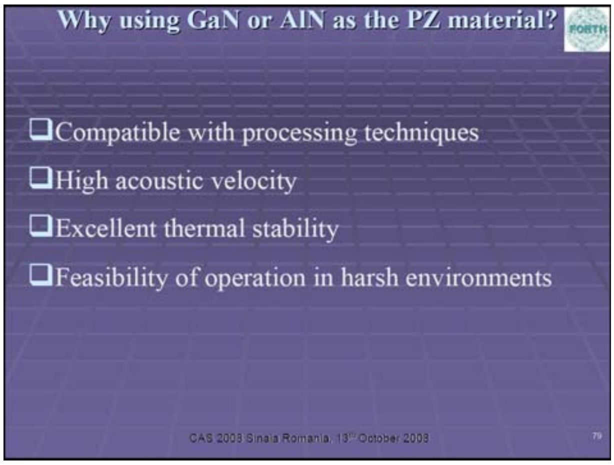
Why using GaN or AlN as the PZ material?
Compatible with processing techniques
High acoustic velocity
Excellent thermal stability
Feasibility of operation in harsh environments
CAS 2008 Sinaia Romania, 13th October 2008
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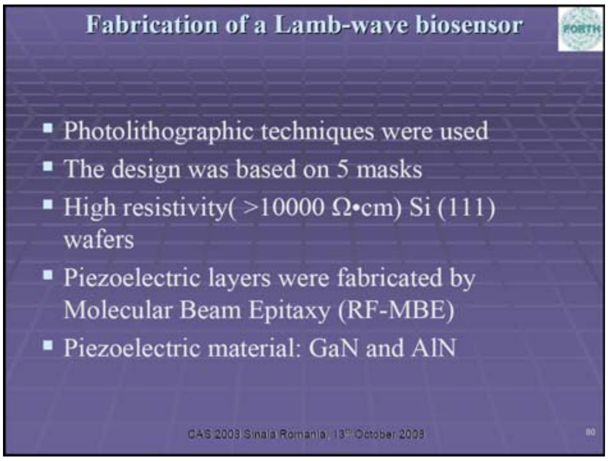
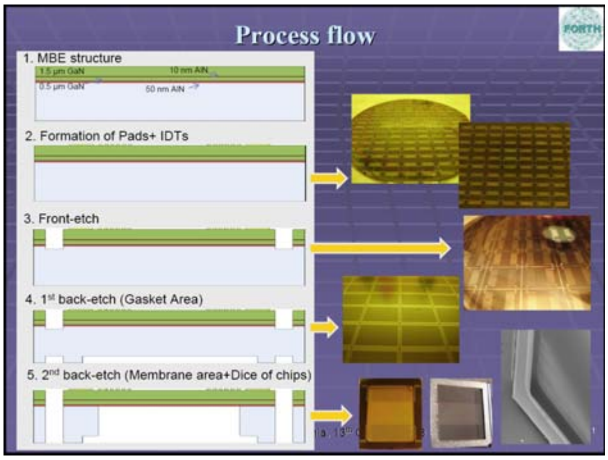
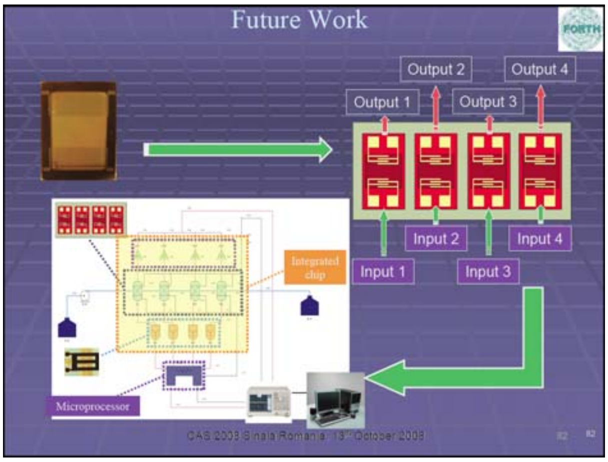
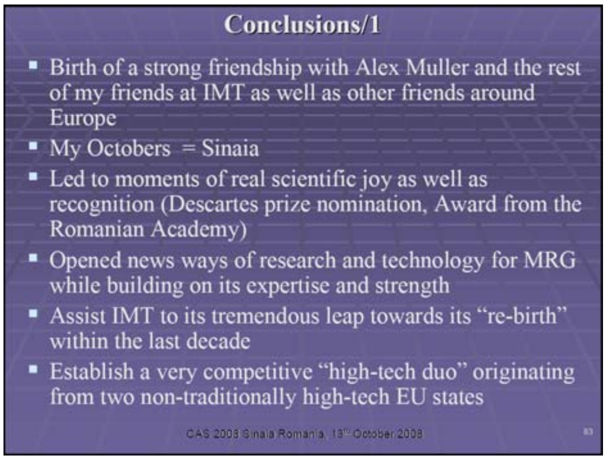
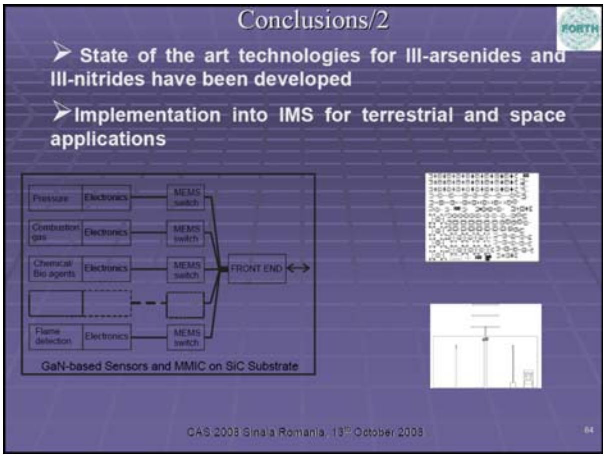

Fabrication of a Lamb-wave biosensor
Photolithographic techniques were used
The design was based on 5 masks
High resistivity(>10000 Ω•cm) Si (111) wafers
Piezoelectric layers were fabricated by Molecular Beam Epitaxy (RF-MBE)
Piezoelectric material: GaN and AlN
CAS 2008 Sinaia Romania, 13th October 2008


Process flow
1. MBE structure
2. Formation of Pads+ IDTs
3. Front-etch
4. 1st back-etch (Gasket Area)
5. 2nd back-etch (Membrane area+Dice of chips)

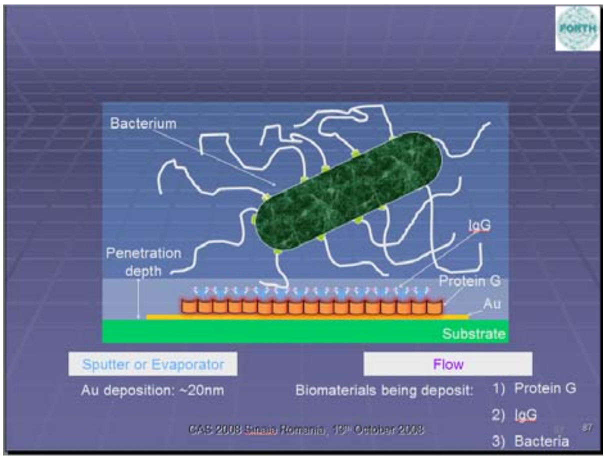

Future Work
Output 1
Output 2
Output 3
Output 4
Input 1
Input 2
Input 3
Input 4
Integrated chip
Microprocessor
CAS 2008 Sinaia Romania, 13th October 2008

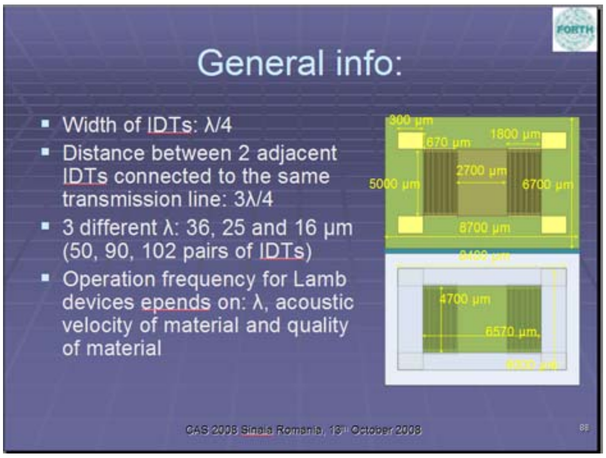

Conclusions/1
Birth of a strong friendship with Alex Muller and the rest of my friends at IMT as well as other friends around Europe
My Octobers = Sinaia
Led to moments of real scientific joy as well as recognition (Descartes prize nomination, Award from the Romanian Academy)
Opened news ways of research and technology for MRG while building on its expertise and strength
Assist IMT to its tremendous leap towards its "re-birth" within the last decade
Establish a very competitive "high-tech duo" originating from two non-traditionally high-tech EU states
CAS 2008 Sinaia Romania, 13th October 2008

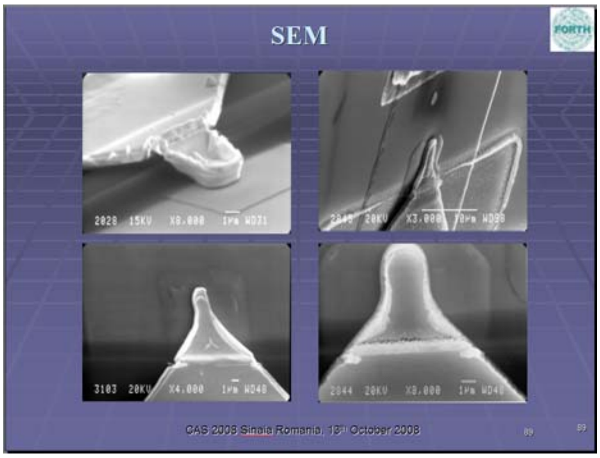

Conclusions/2
State of the art technologies for III-arsenides and III-nitrides have been developed
Implementation into IMS for terrestrial and space applications
Pressure
Electronics
MEMS switch
FRONT END
GaN-based Sensors and MMIC on SiC Substrate
CAS 2008 Sinaia Romania, 13th October 2008

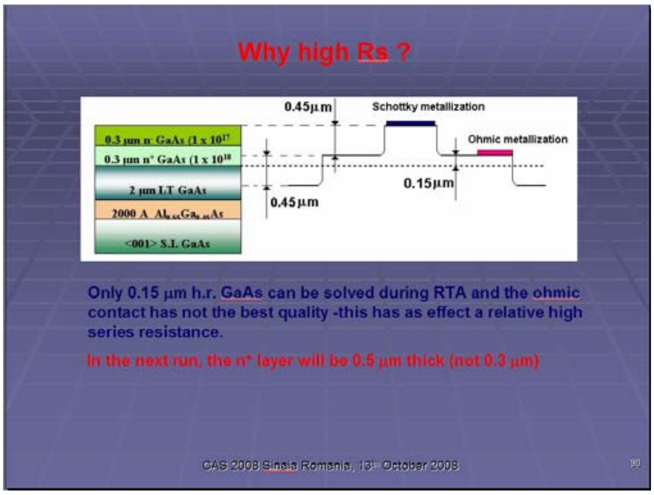

Acknowledgements
"NoE" AMiCOM
(Advanced MEMS for RF and Millimeter Wave Communications)
North Star Project (NSP)
MMID (Millimeter wave identification network for bio and other sensors using micro- and nanocomponents)
CAS 2008 Sinaia Romania, 13th October 2008


Thank you !
Multumesc!
CAS 2008 Sinaia Romania, 13th October 2008


Bacterium
Penetration depth
IgG
Protein G
Au
Substrate
Sputter or Evaporator
Flow
Au deposition: ~20nm
Biomaterials being deposit:
1) Protein G
2) IgG
3) Bacteria
CAS 2008 Sinaia Romania, 13th October 2008


General info:
Width of IDTs: λ/4
Distance between 2 adjacent IDTs connected to the same transmission line: 3λ/4
3 different λ: 36, 25 and 16 μm (50, 90, 102 pairs of IDTs)
Operation frequency for Lamb devices epends on: λ, acoustic velocity of material and quality of material
300 μm
670 μm
1800 μm
2700 μm
5000 μm
6700 μm
8700 μm
4700 μm
6570 μm
CAS 2008 Sinaia Romania, 13th October 2008


SEM
CAS 2008 Sinaia Romania, 13th October 2008


Why high Rs ?
0.45μm
Schottky metallization
Ohmic metallization
0.15μm
0.45μm
2 μm LT GaAs
<001> S.I. GaAs
Only 0.15 μm h.r. GaAs can be solved during RTA and the ohmic contact has not the best quality -this has as effect a relative high series resistance.
In the next run, the n+ layer will be 0.5 μm thick (not 0.3 μm)
CAS 2008 Sinaia Romania, 13th October 2008