Projet UEB « Optimise »

Contributions : Ch. Person, C. Quendo

e@mails :

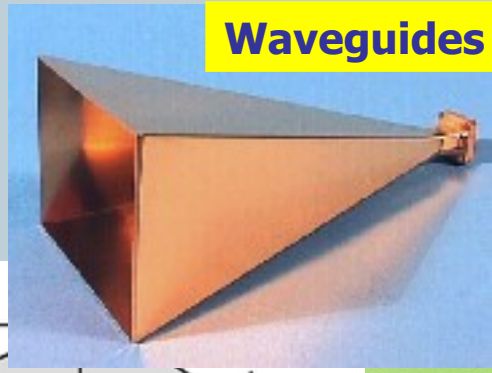
christian.person@telecom-bretagne.eu
cedric.quendo@univ-brest.fr

14/04/2010

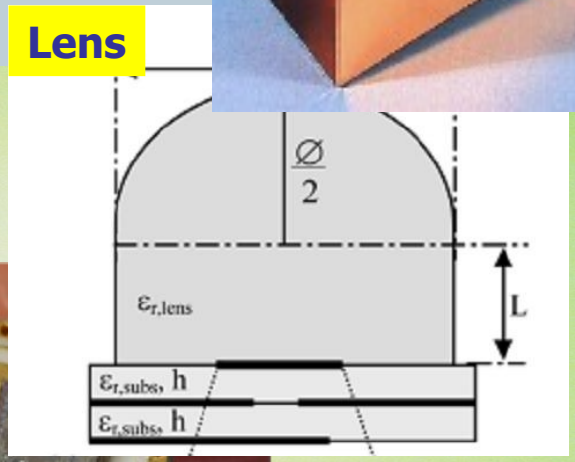
Mm-Wave Antennas

- Design features

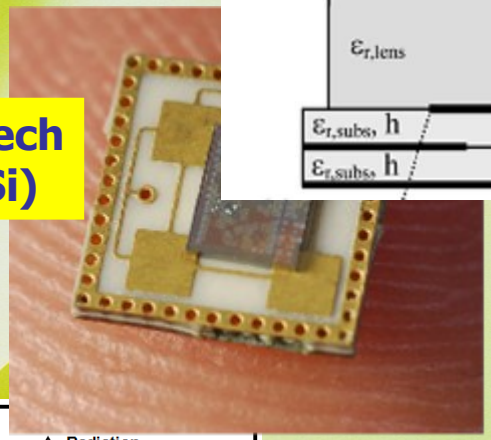
Waveguides



Lens



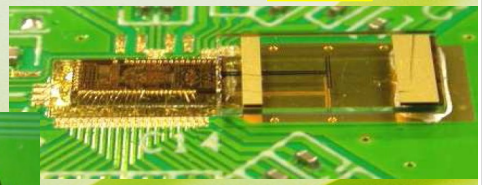
Hybrid tech (LTCC+Si)

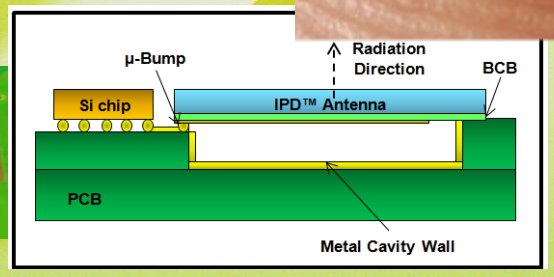


Gain

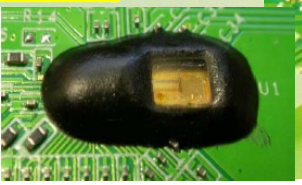
Integration

SiP





SoC



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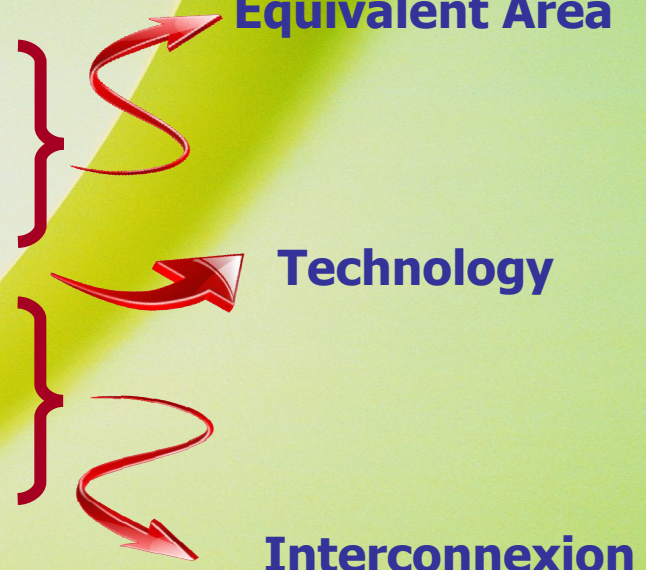
SOUS PROJET 3 : Hybridation des techniques de synthèse et d'optimisation sur la base de technologies 3-D nouvelles

- **Coordinateur : Lab-STICC**
- **Objectifs et description du travail**
  - Définition et identification de structures innovantes d'antennes
  - Validation expérimentale des outils logiciels développés en SP2
  - Nouvelle méthode d'hybridation entre techniques de synthèse de filtres & d'optimisation d'antennes
    - Conception d'antennes filtrantes
    - Fonctionnalités filtrage & rayonnement co-maîtrisées/optimisées
- **Moyens : Plates formes**
  - Fabrication 3D - Lab-STICC
  - Caractérisation mm – IETR

Mm-Waves Antennas

- **Design features**
  - Wideband
  - Relatively « High gain »
  - High Efficiency …. loss ?
  - Low Cost …….. Integration
  - Miniaturization

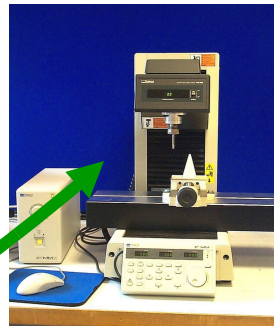


ANTENNES MM-WAVE : SOLUTIONS PLANAIRES

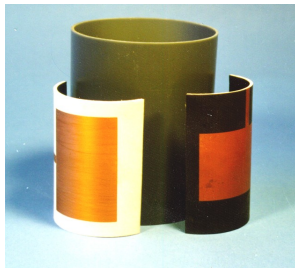
Technologie Mousse

- **Propriétés électriques / mécaniques**
  - ✓ Permittivité proche de l'air (ε_r=1,05-1,07)
  - ✓ Tan δ faible (# 10^{-3} jusqu'en mm)
  - ✓ Faible poids (densité 0,05 g/cm³)
  - ✓ Faible coût
- **Procédés de conformation**
  - Usinage 3D
  - Technique de Pressage à chaud, moulage par injection
- **Procédés de métallisation**
  - Bains électrochimiques
  - Dépôts sous vide
  - Peintures
  - Pressage à chaud de plaques métalliques

Usinage en 3D



Pressage à chaud



Peinture Ag. Spraylat

% Ag. solide = 47% du poids

Résistivité : < 0.015Ω/ *(Epaisseur 12.5µm)*

Technologies & Opportunities

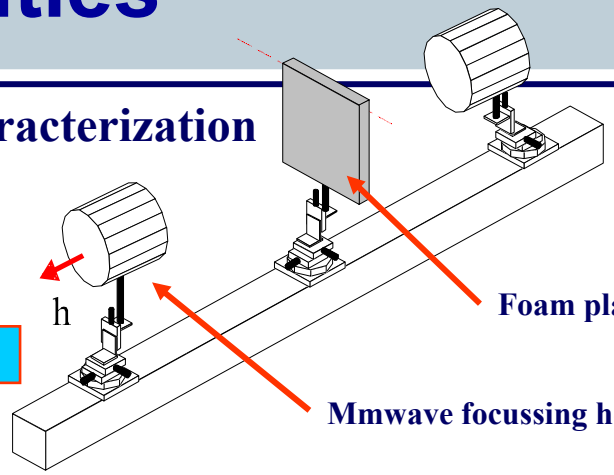
- Substrate

Foam material

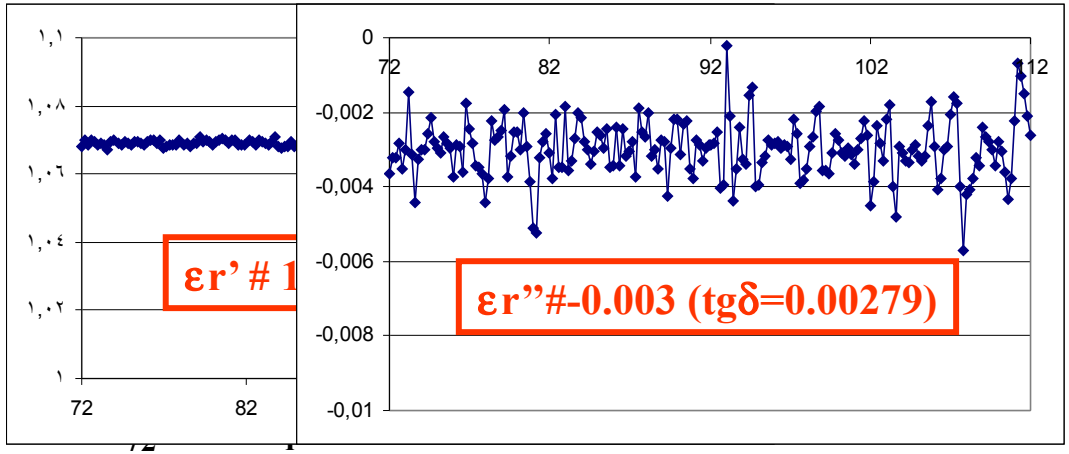
Rohacell©

- ✓ εr # 1.07
- ✓ Tan δ # 0.001
- ✓ Thickness : 20µm to 100mm
- ✓ Density, robustness

Experimental characterization



Quasi-optical test bench



Technologies & Opportunities

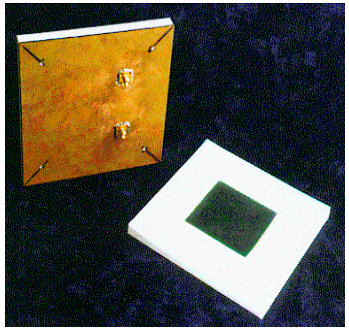
- **Substrate**

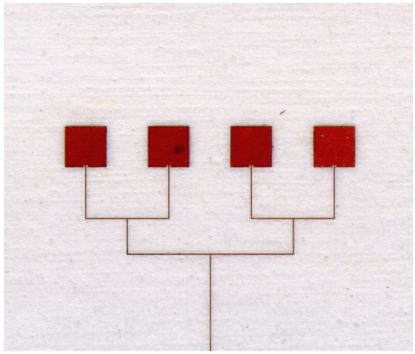
Foam material

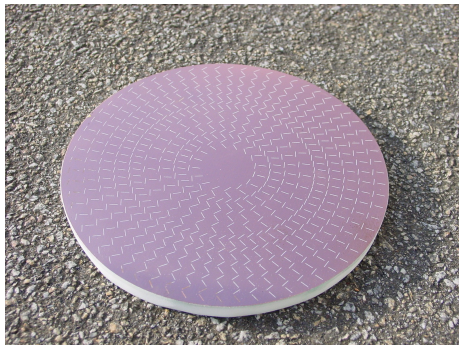
Rohacell©

- ☑ εr # 1.07
- ☑ Tan δ # 0.001
- ☑ Thickness : 20µm to 100mm
- ☑ Density, robustness

Foam Substrate for Planar Antennas







Technologies & Opportunities

- Process

- *Moulded or milled structures*
- *Overlapping and 3D assembling possibilities*

ay painting

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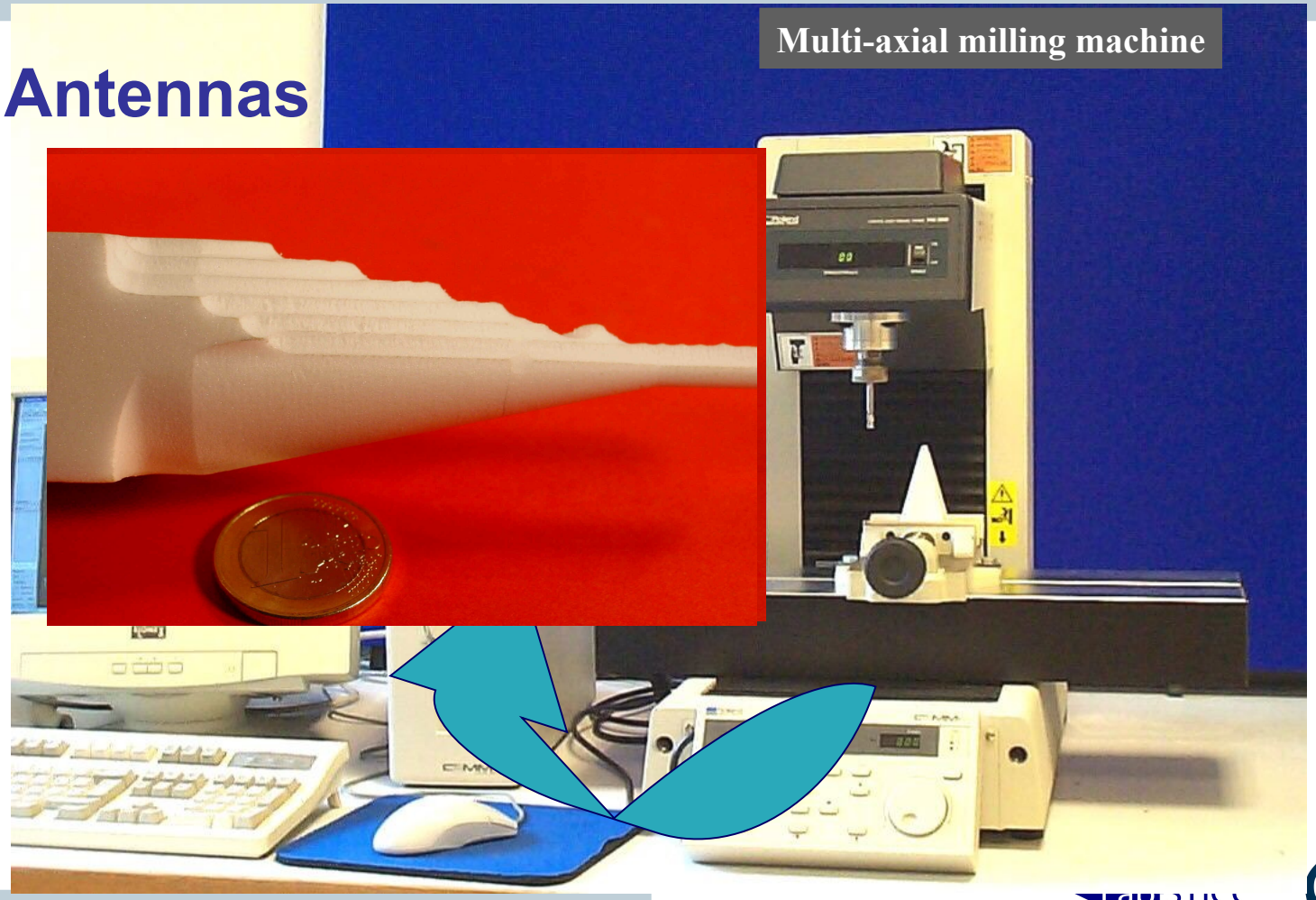
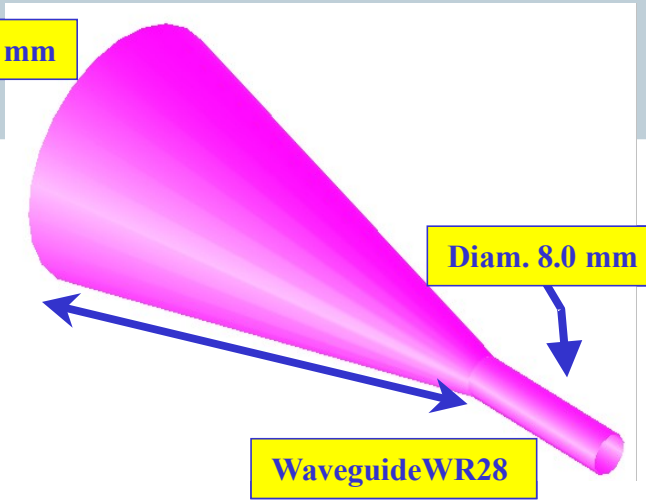
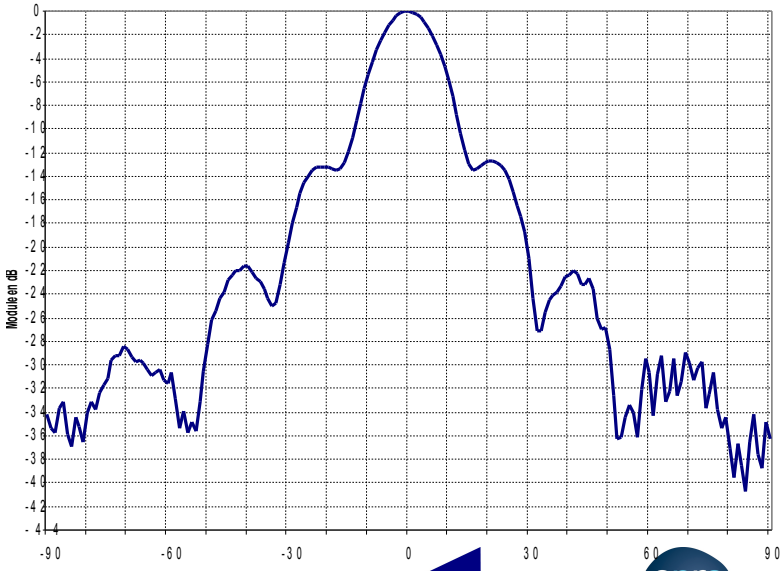
Technologies & Opportunities

- 3D Antennas



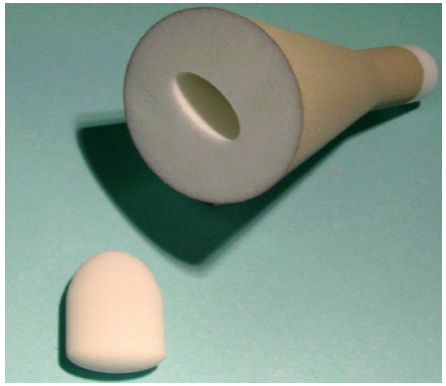
Circular Horn

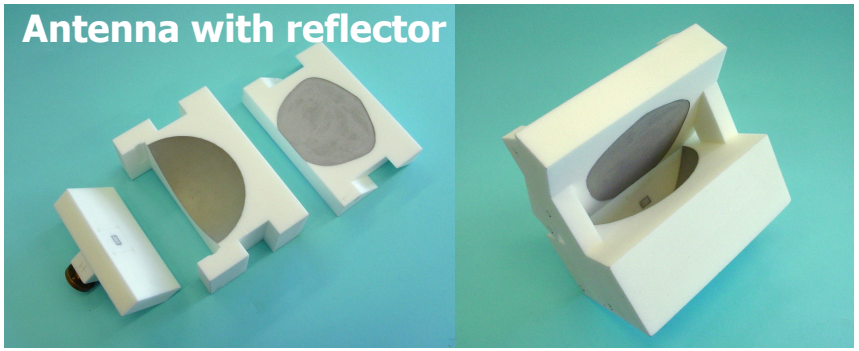


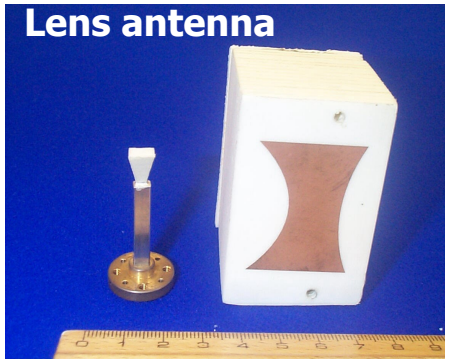


Technologies & Opportunities

- 3D mm antenna designs

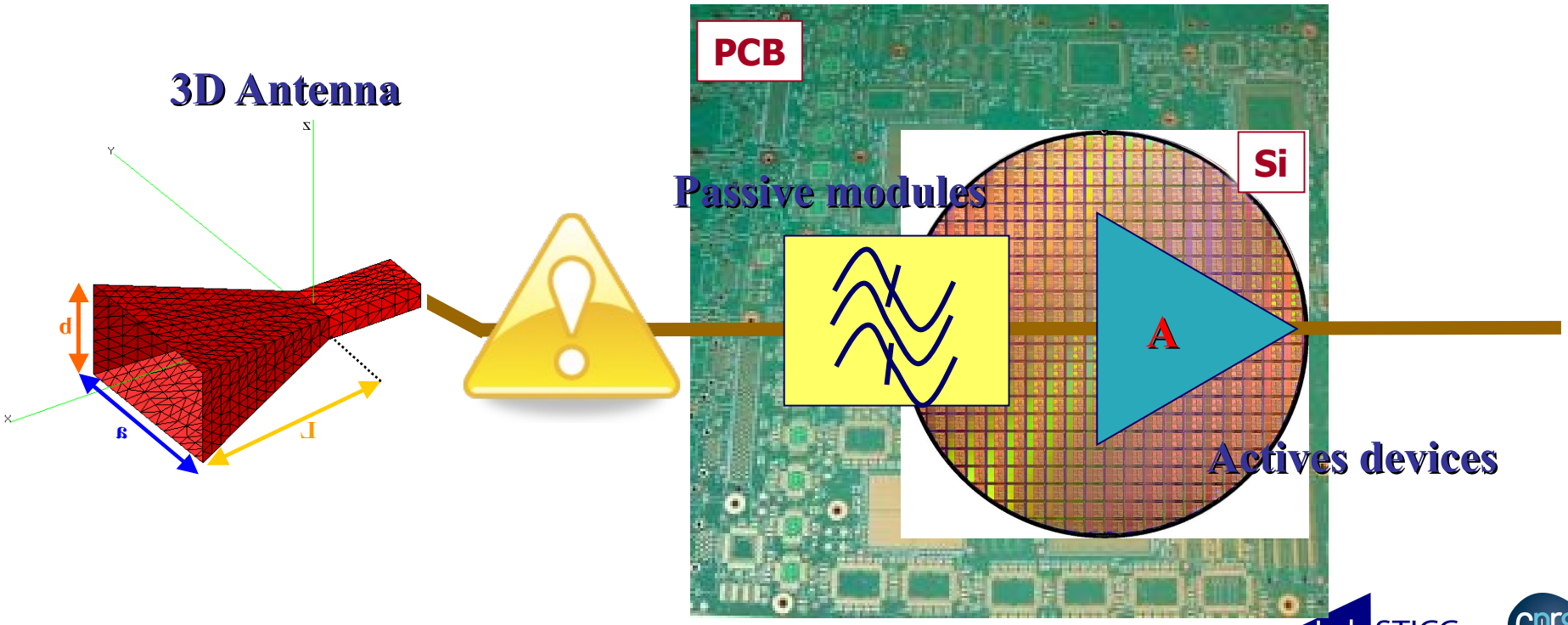






Technologies & Opportunities

- 3D mm antenna designs



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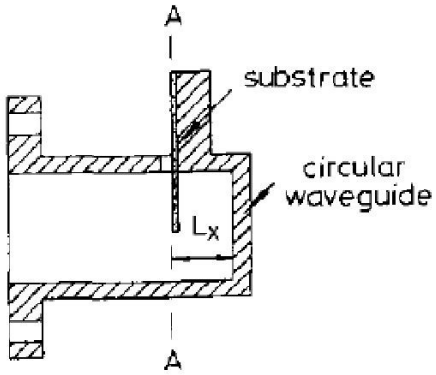
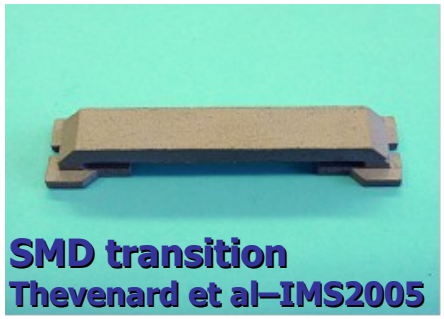
Technologies & Opportunities

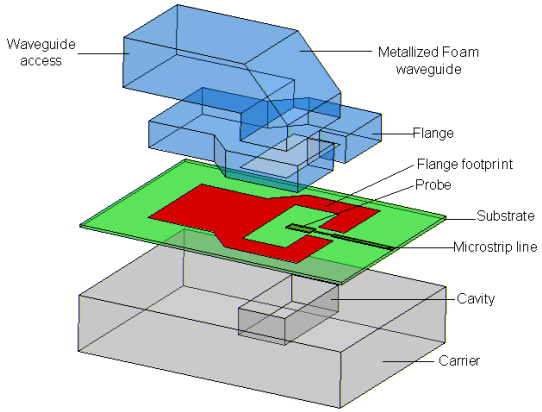
○ Interconnexions

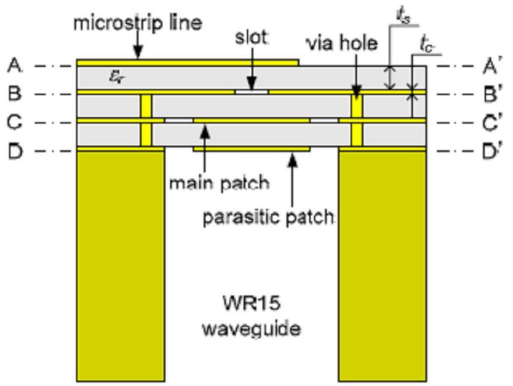


Vertical transition



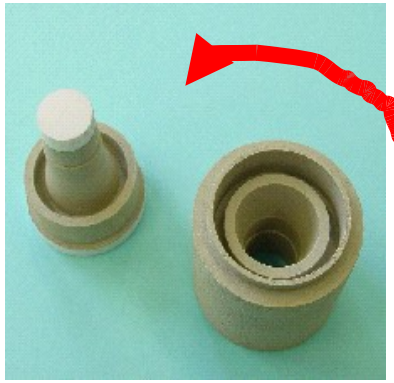
SMD transition
Thevenard et al–IMS2005



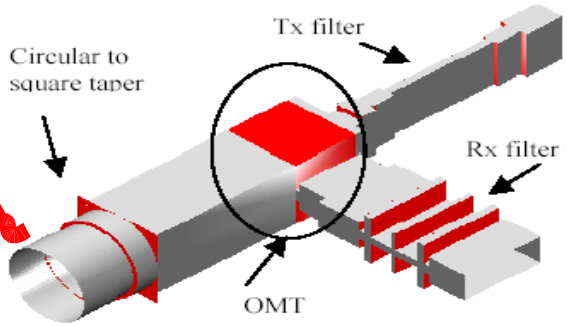


EM coupling

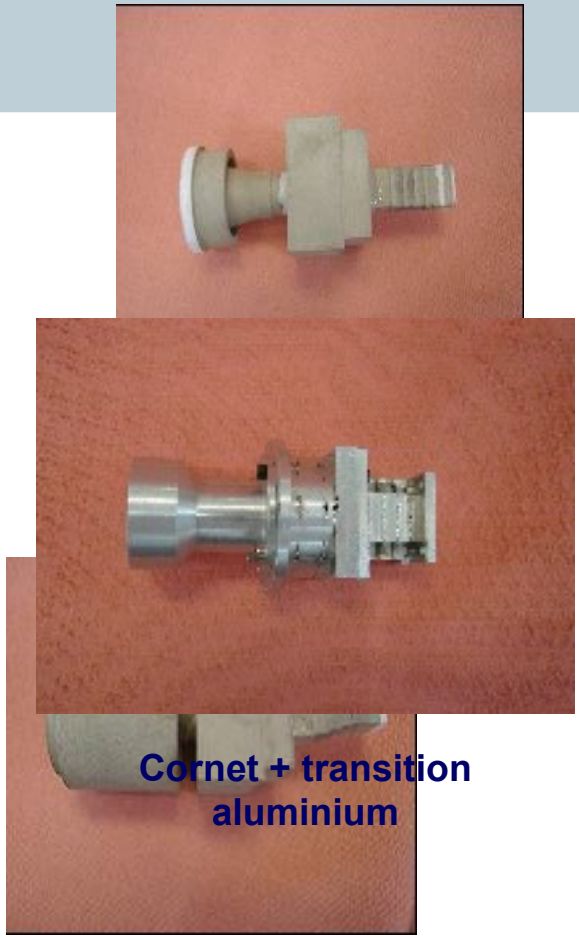
Réalisation de filtres / interfaces



Cornet en mousse pleine et évidée



Séparateur OMT et transition associée

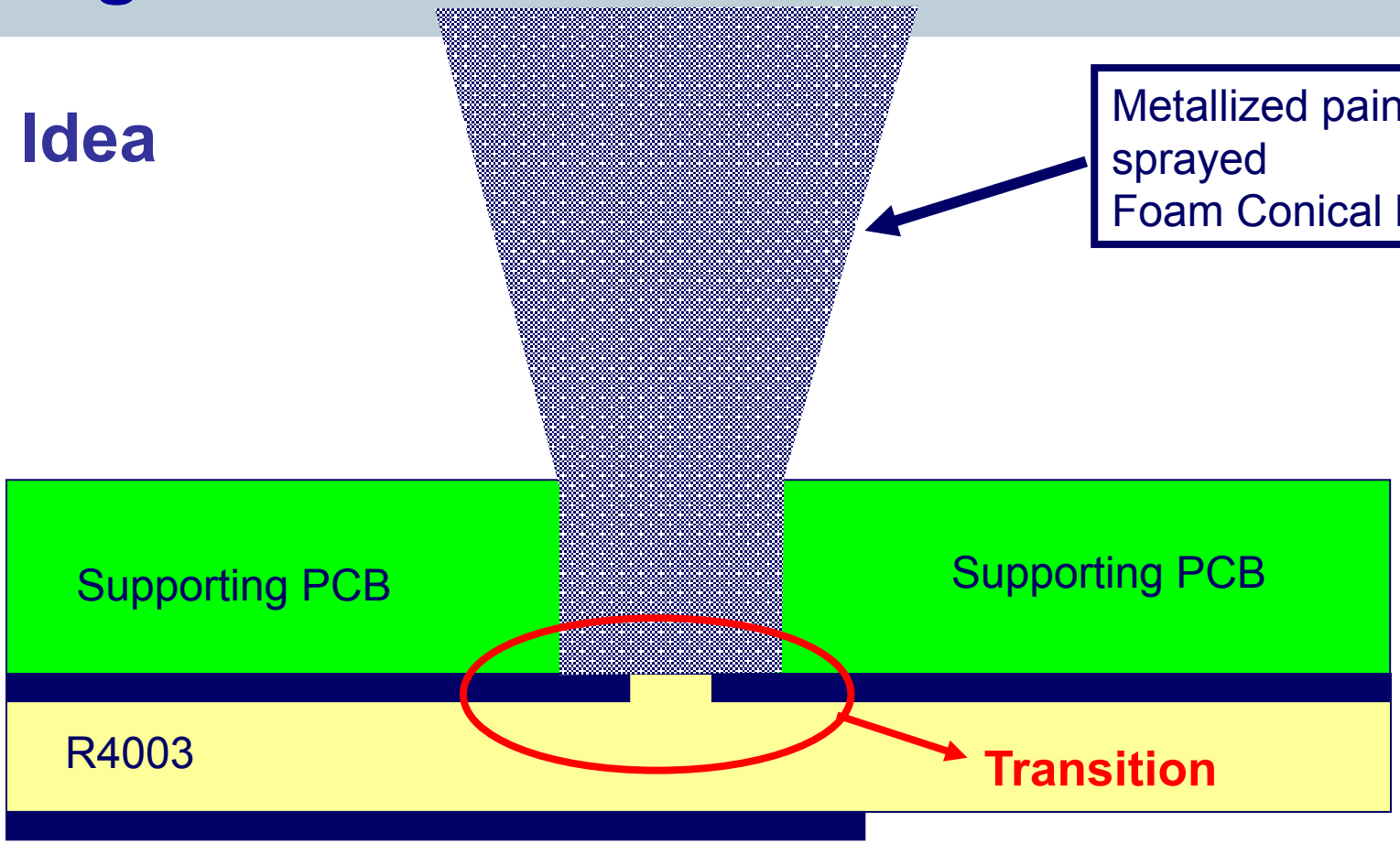


Cornet + transition aluminium

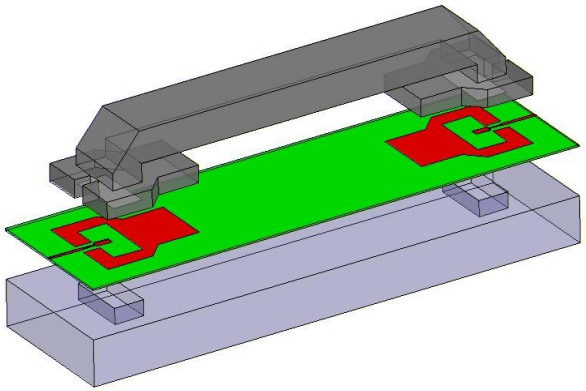
Cornet + transition mousse évidée

Integrated Conical Horn Antenna

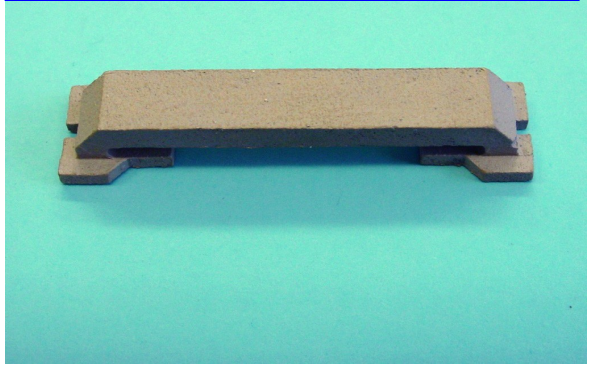
- Idea



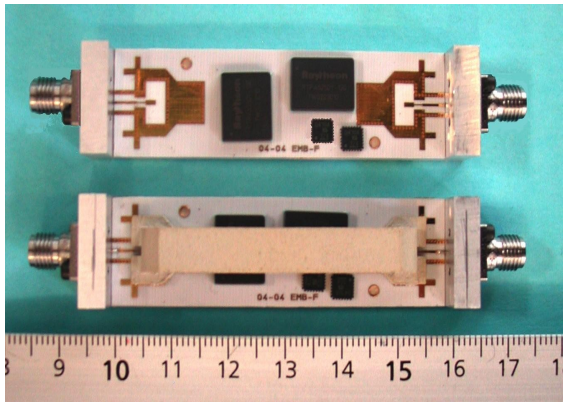
Réalisation d'interfaces

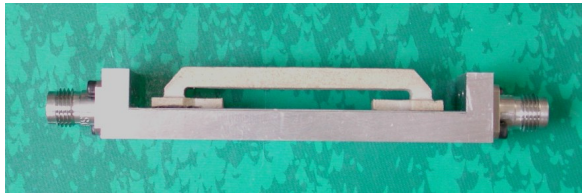


Pièce métallisée



Double transition en matière Plastique





Pièce reportée

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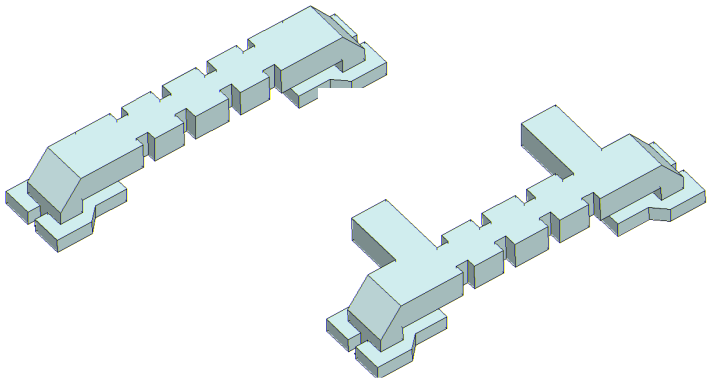
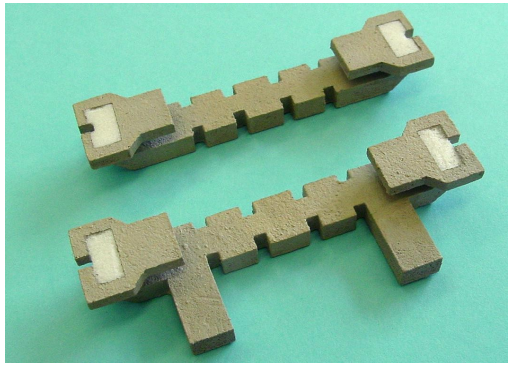
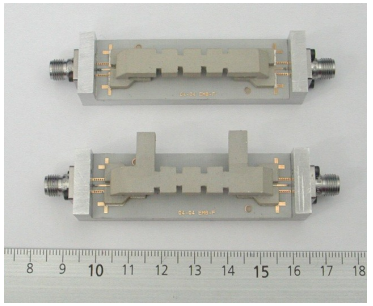
Réalisation de filtres / interfaces

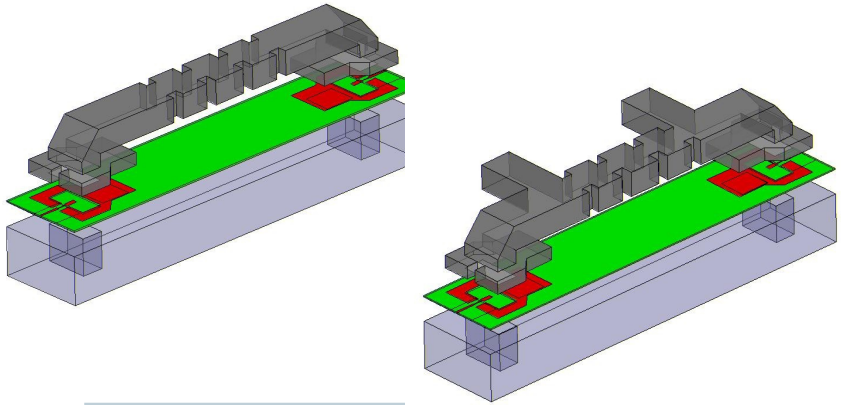


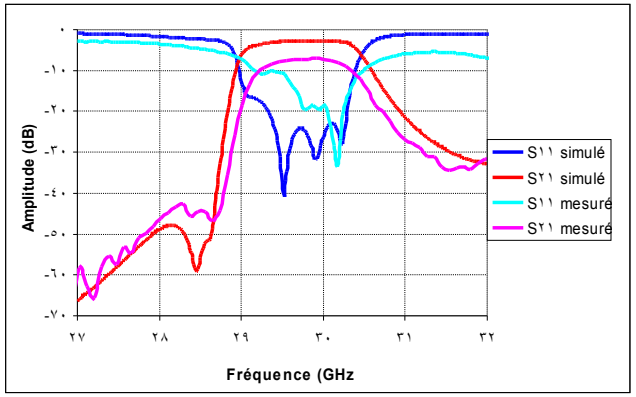
Filtre avec double transition



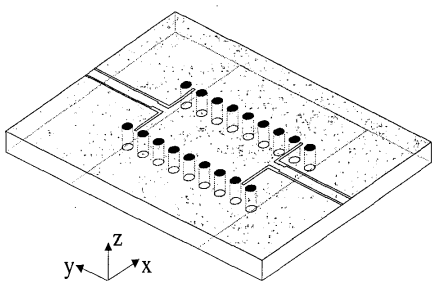


Application bande VSAT [29.5-30]GHz

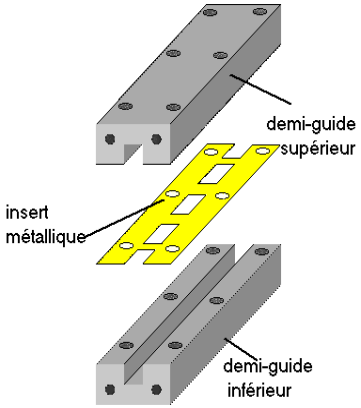


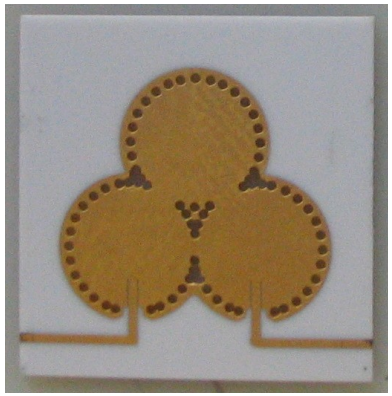


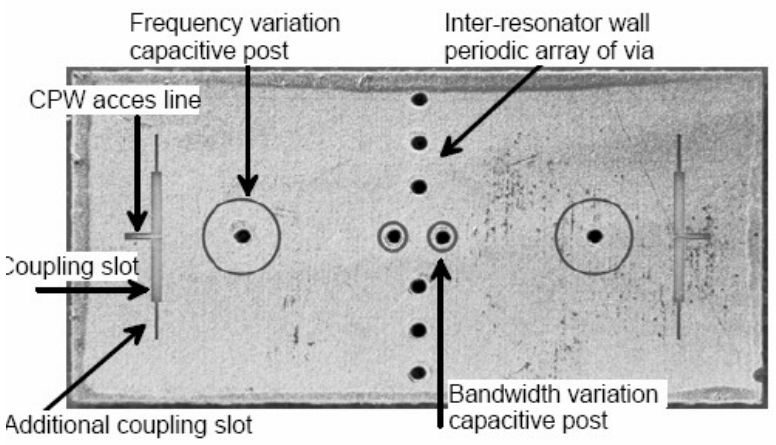
Réalisation de filtres / interfaces



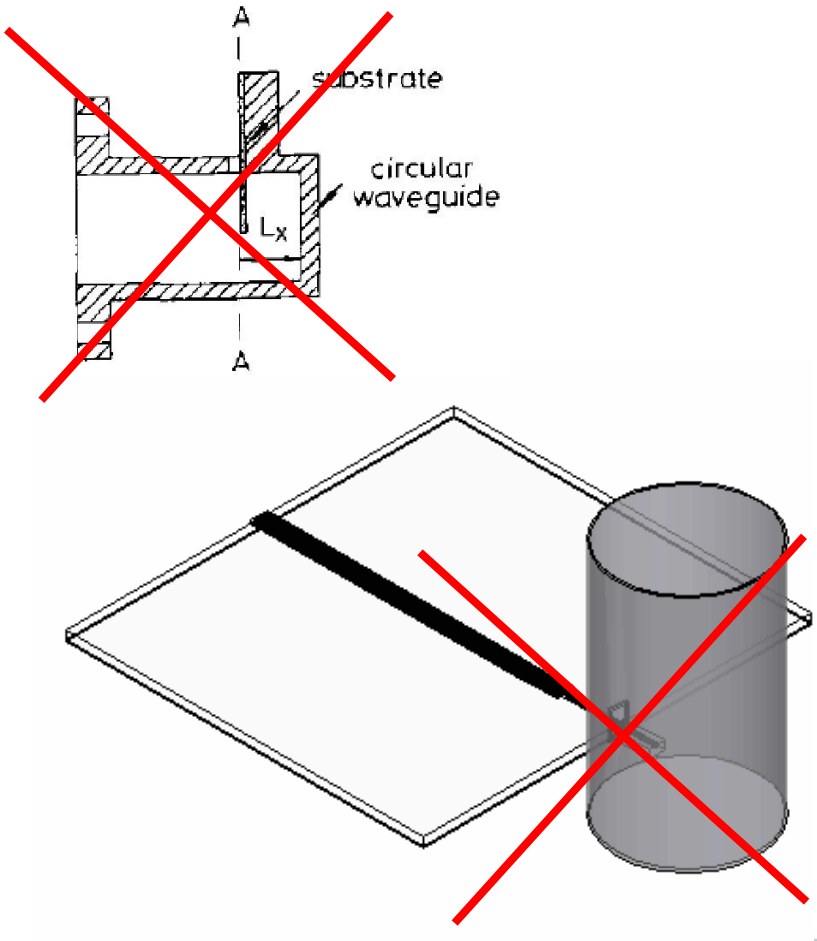
- ✓ Intégration de filtres
- ✓ Transitions / interfaces Multi-technologies
- ✓ Synthèse dédiée
- ✓ Optimisation

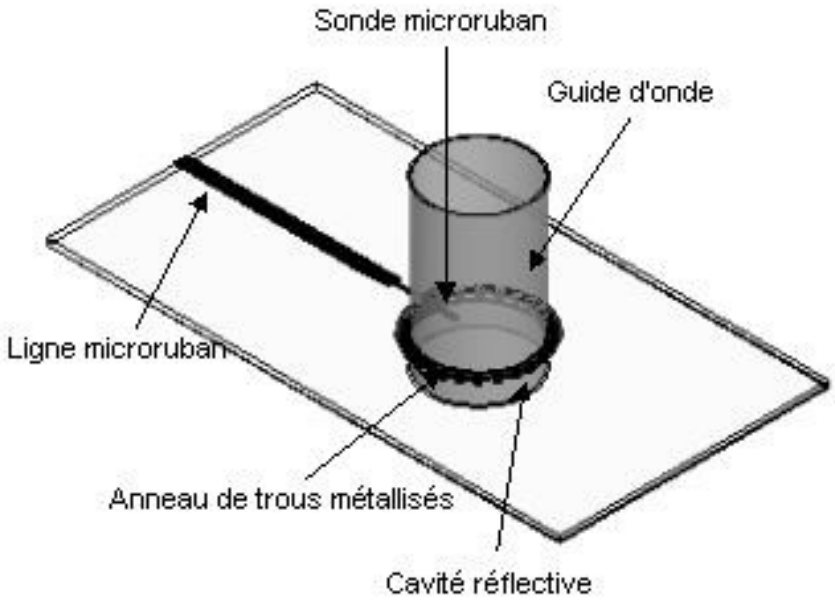




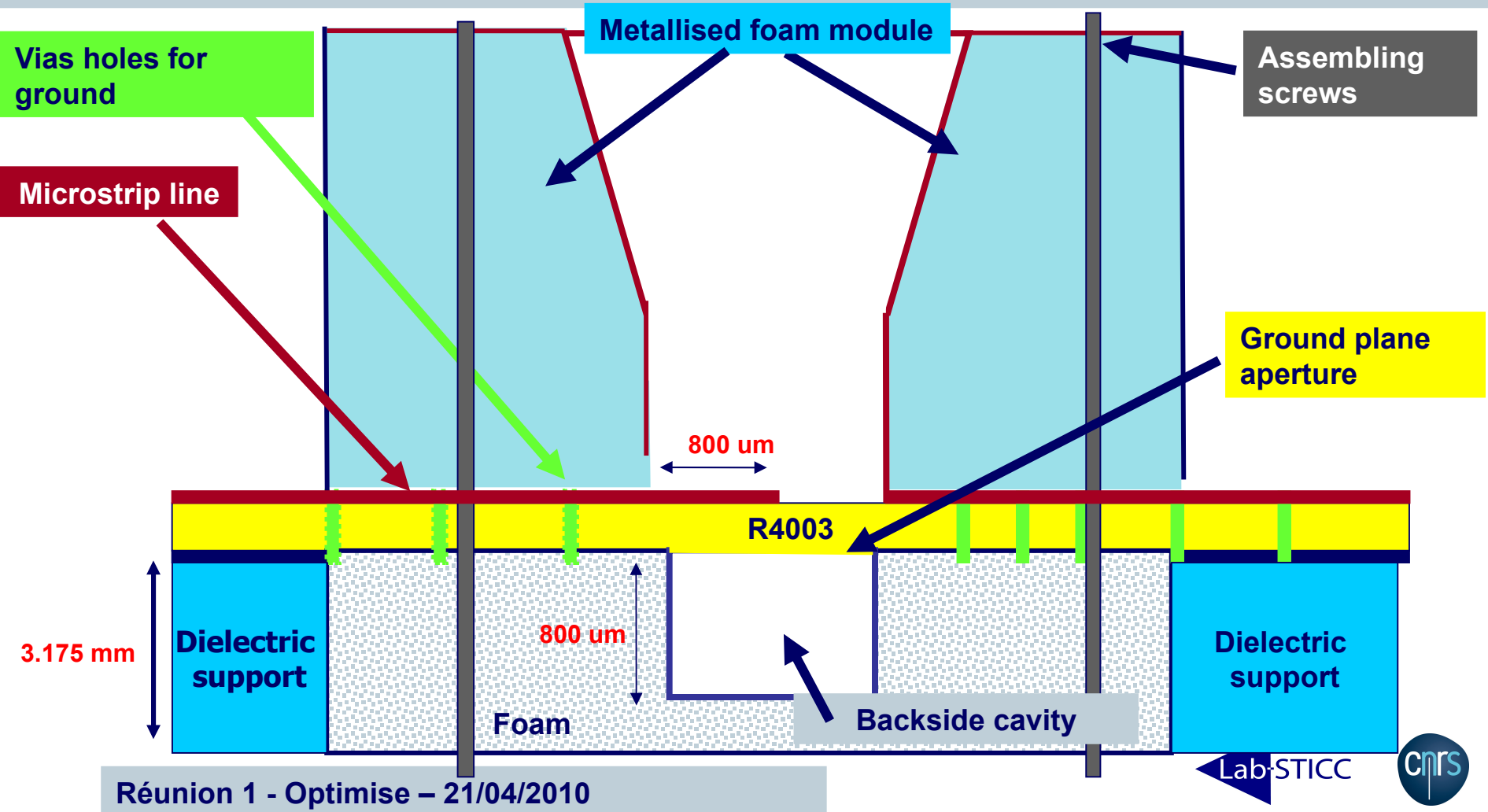


Waveguide to Microstrip line transition





Integrated Conical Horn Antenna



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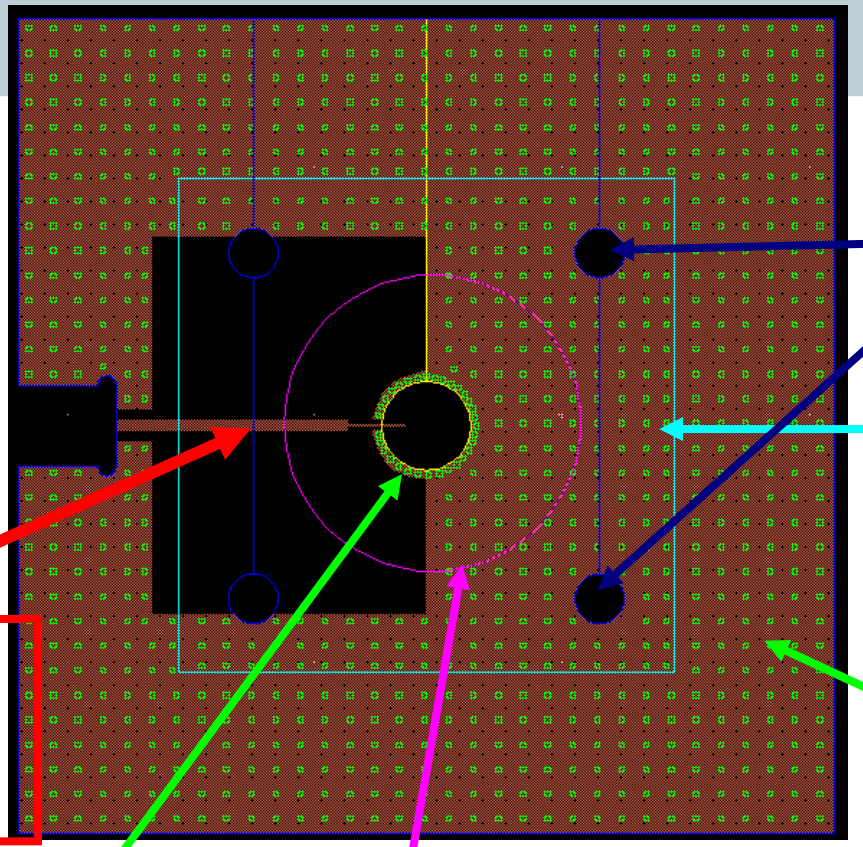
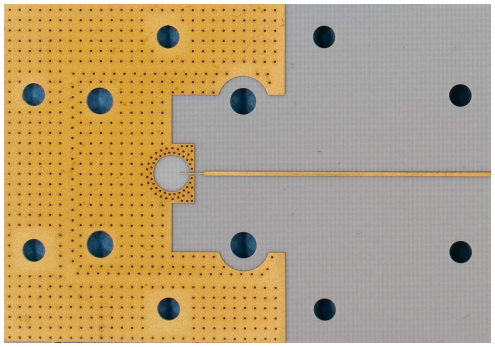
Layout


33 mm
GPPO Connector
Assembling holes
Backside cavity delimitation
Microstrip feeder
TE11 mode excitation
Vias holes for ground plane continuity
Annular ring with vias holes
Circular horn diameter

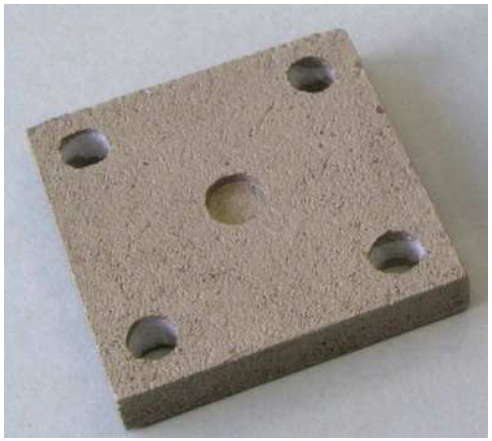
Micromachined Foam Horn Antenna Fed by a Microstripline

- **Building blocs**

Micromachined horn antenna



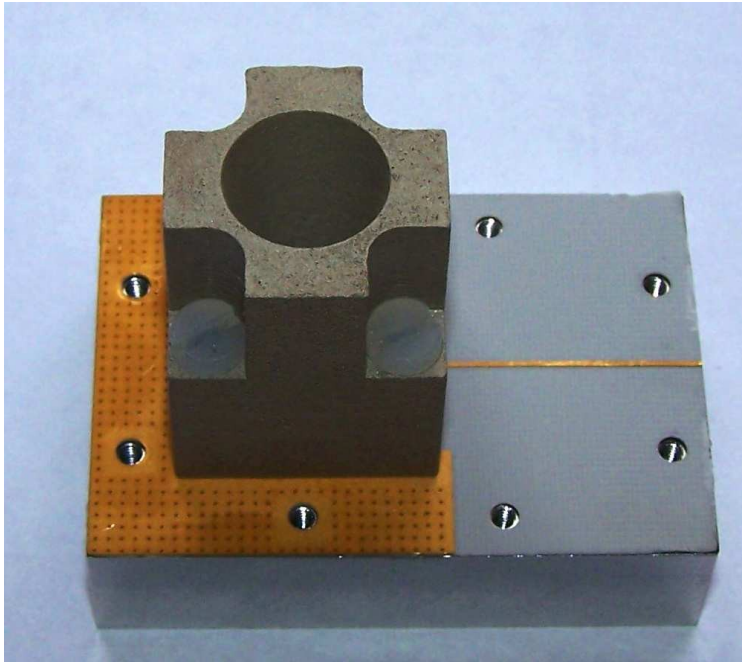
Printed circuit board with annular ring interface



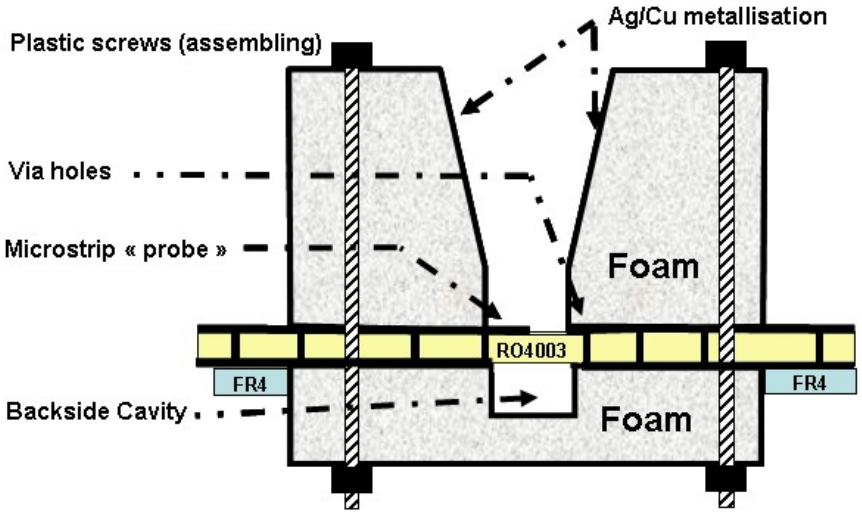
Back-side cavity

Micromachined Foam Horn Antenna Fed by a Microstrip line

- Assembled structure

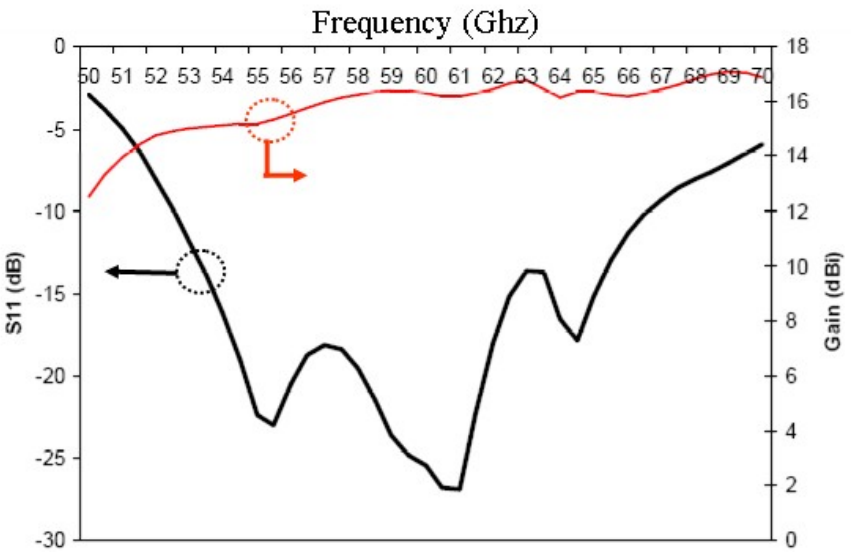


- Cross section



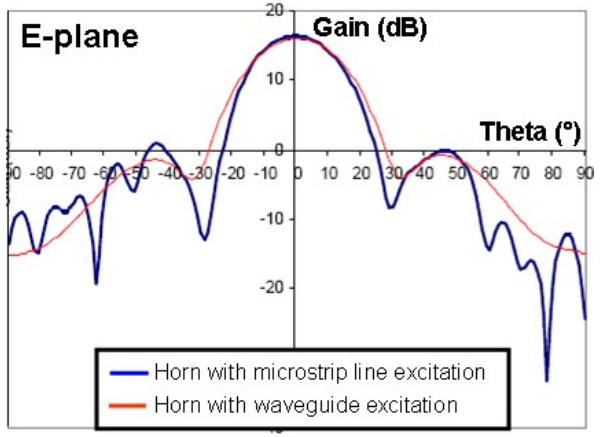
SIMULATION RESULTS (HFSS)

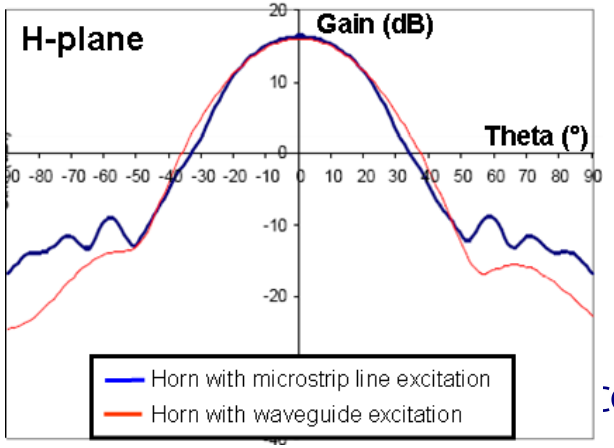
- **Return Loss & Bandwidth**



16.3 dBi gain @ 60 GHz
(17.2 dBi for a conventional metallic circular waveguide)

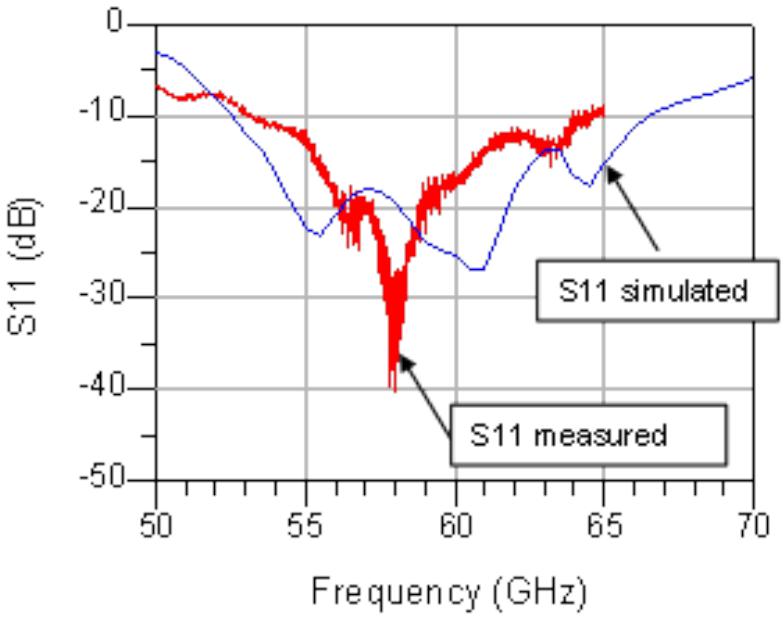
- **Radiation Patterns**



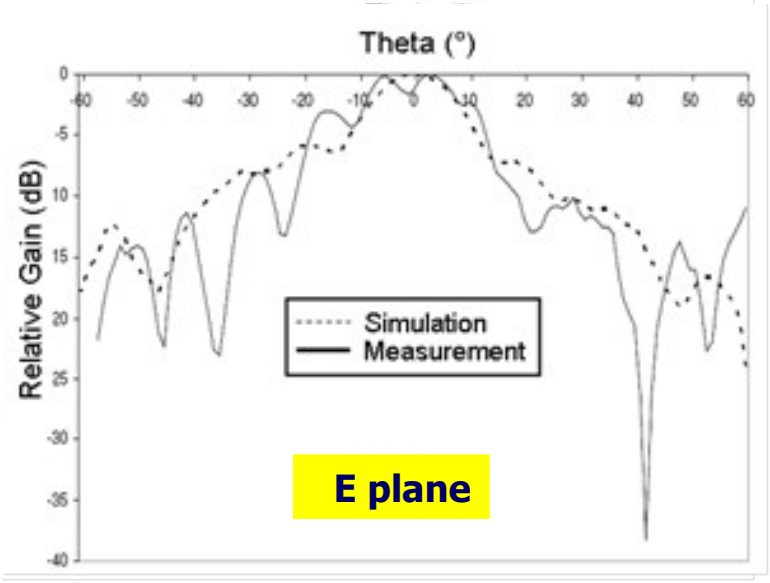


EXPERIMENTAL RESULTS

- Return Loss & Bandwidth



- Radiation Patterns



16.3 dBi gain @ 60 GHz
20.45% relative bandwidth

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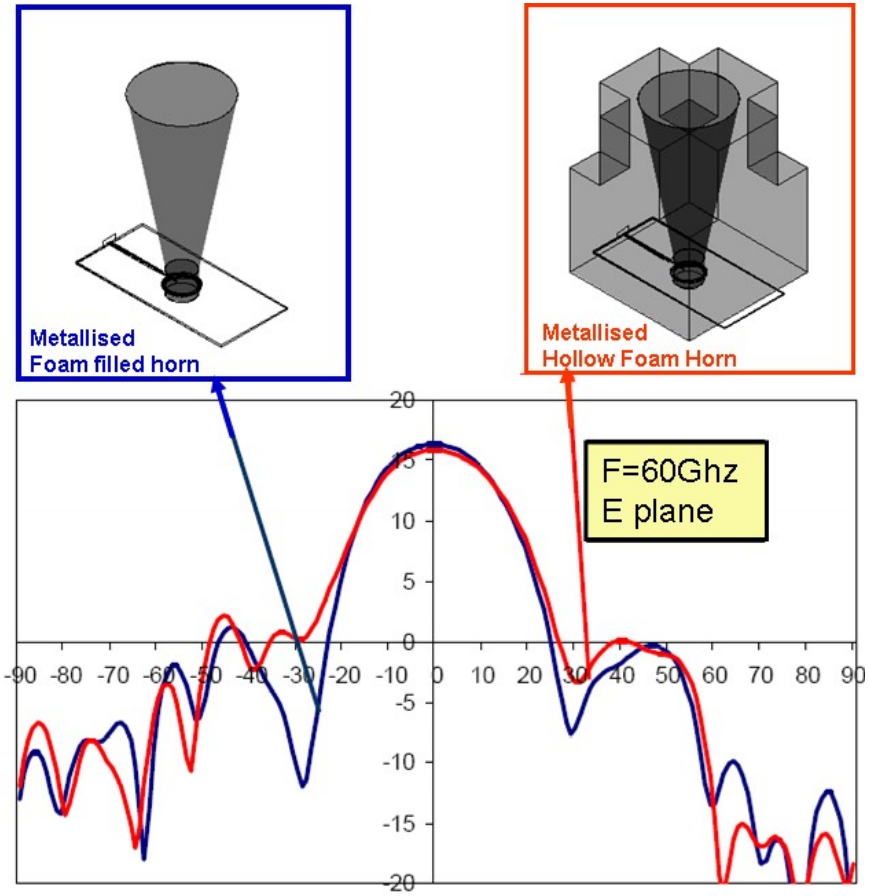
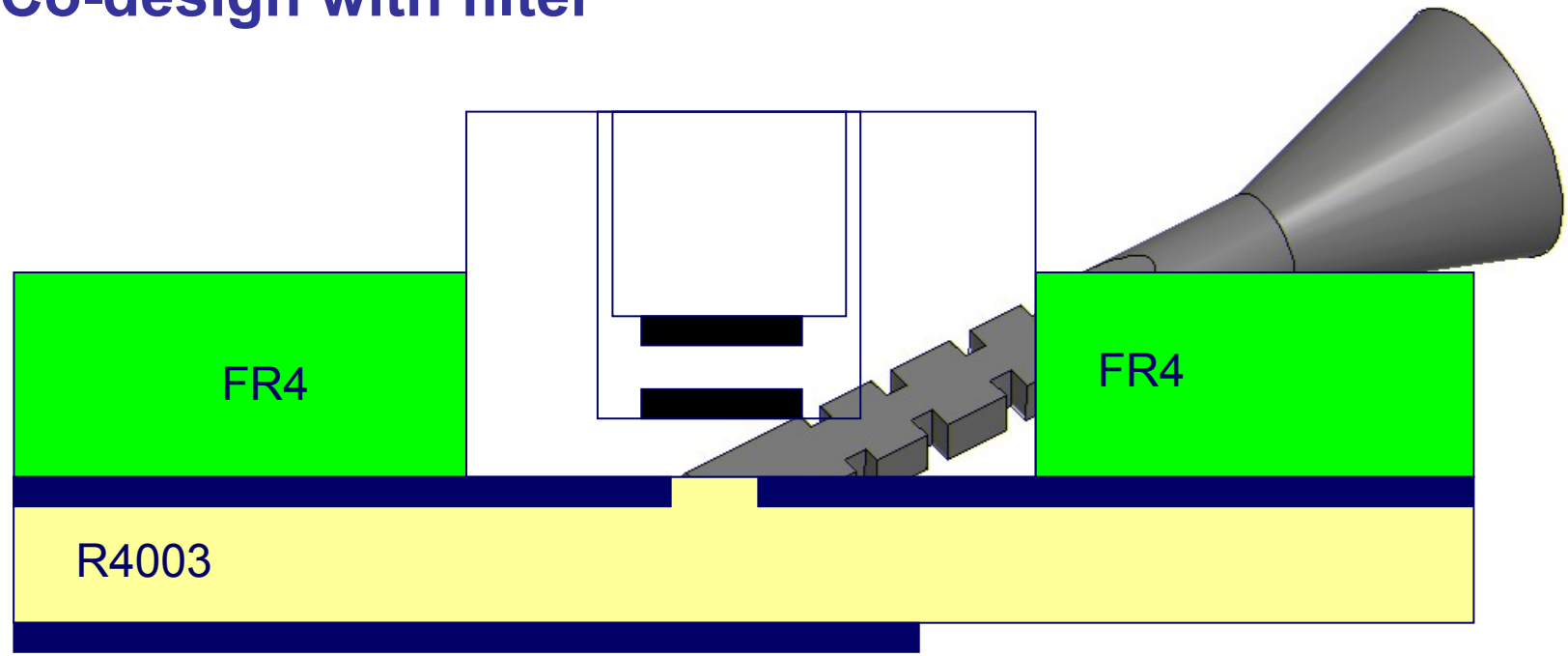
Incidence of the foam external metallization and shape on radiation performances

- Comparative analysis
  - Foam Inside
  - Foam Outside

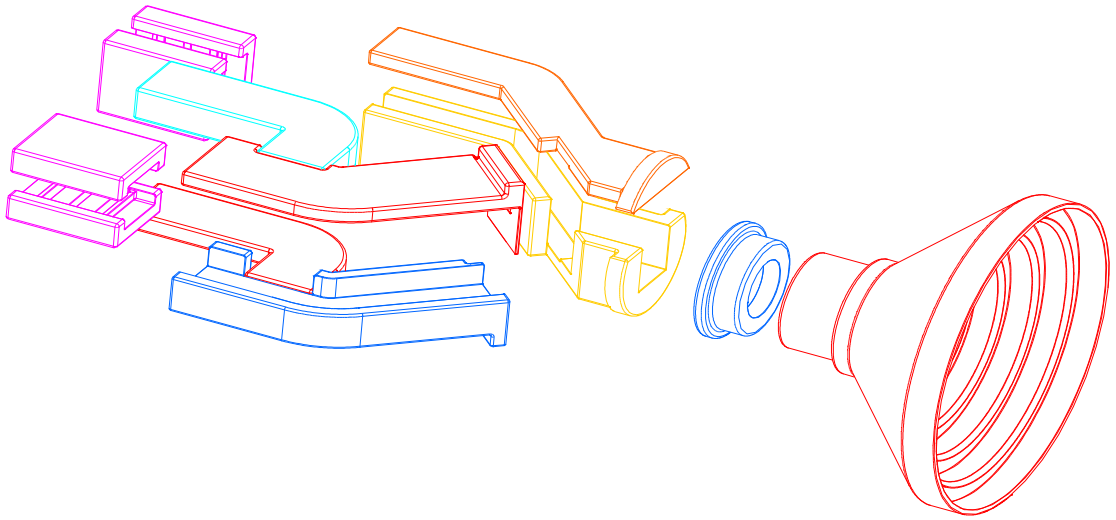


Investigations

- Enhanced Bandwidth
- Co-design with filter



Investigations

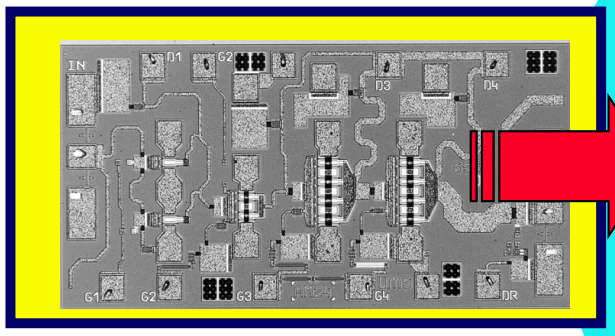


Vers une miniaturisation des systèmes: intégration de sous-ensembles actifs et passifs

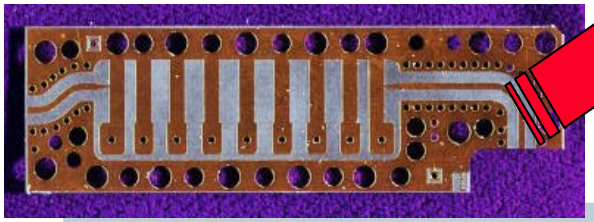
TECHNOLOGIES 3D

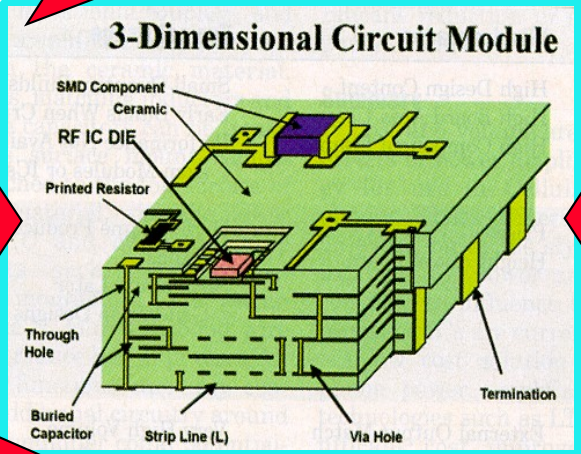
Composants Boîtier

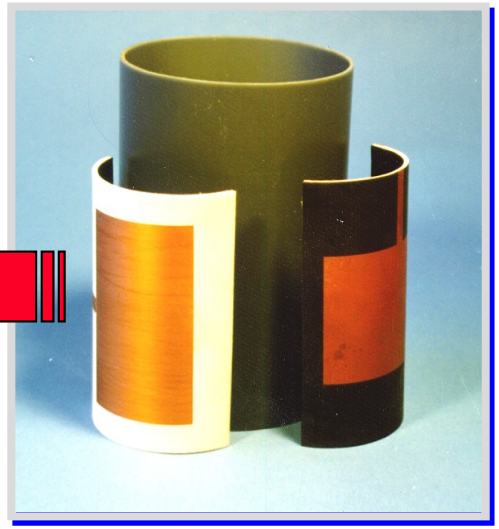
Amplificateur MMIC



Filtre microruban

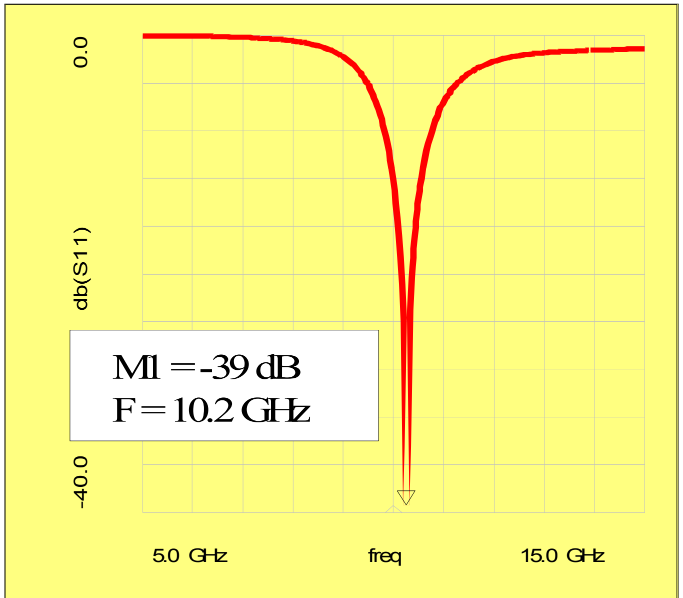




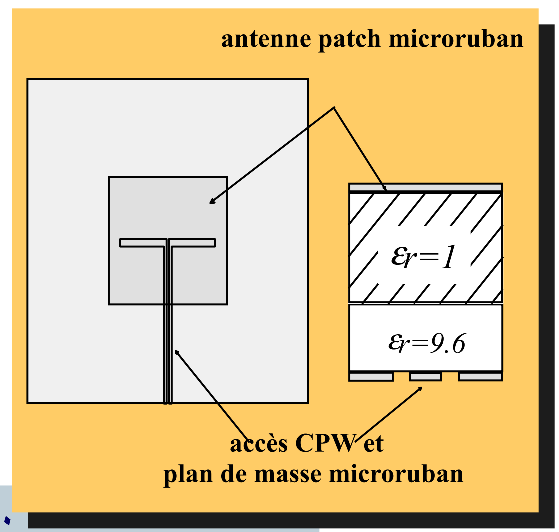


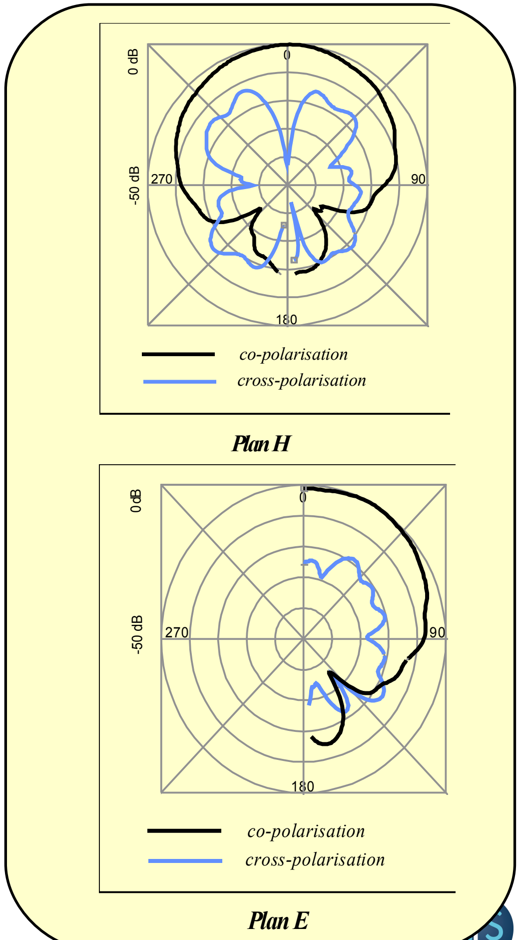
Antenne conformée - support Mousse

SOLUTION D'INTEGRATION SUR SUBSTRAT COMPOSITE CERAMIQUE - MOUSSE

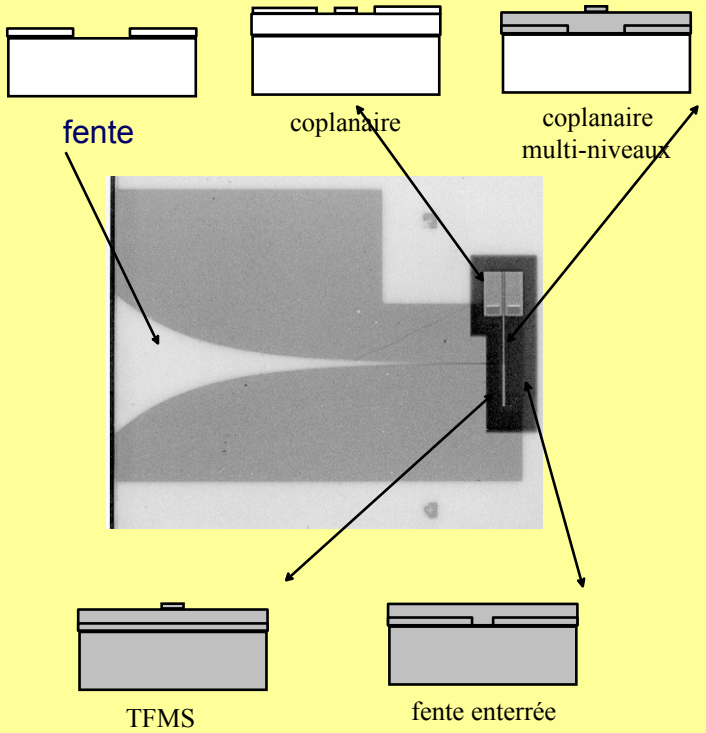


bande passante 7%
(ROS=2)
Gain = 5 dBi





LA TECHNOLOGIE COUCHES EPAISSES



exemple d'intégration en technologie couches épaisses

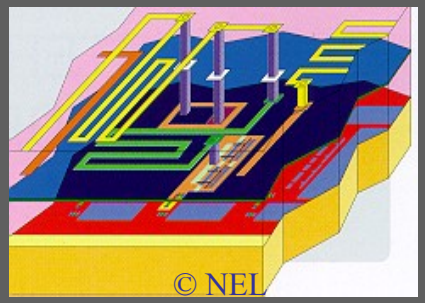
dépôts de couches sérigraphiées:
-diélectriques (10 µm / couche)
-conductrices (3 à 8 µm / couche)
-résistives
Précision d'alignement # 20 µm
Résolution # 80 µm

sérigravure:
-niveaux conducteurs
Précision d'alignement # 2 µm
Résolution # 20 µm

procédé technologique:
faible coût (moyennes séries)
reproductible
de grande précision

MINIATURISATION DES SYSTEMES

Technologies multicouches :



✓Interconnexion 3D des fonctions

performances des circuits

Technologies multicouches :

✓Modules multifonctions

Adopter une démarche de synthèse purement 3D

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APPROCHE D'INTEGRATION GLOBALE

Principe:

✓ *Analyse des besoins:*

- suppression des éléments redondants (DC-Blocks, etc…)
- choix d'impédances de charge autres que 50 Ω

- compacité
- diminution des pertes en ligne

✓ *Association de fonctions:*

- synthèse simultanée de plusieurs fonctions

- compacité
- diminution des pertes en ligne
- maîtrise de la bande passante

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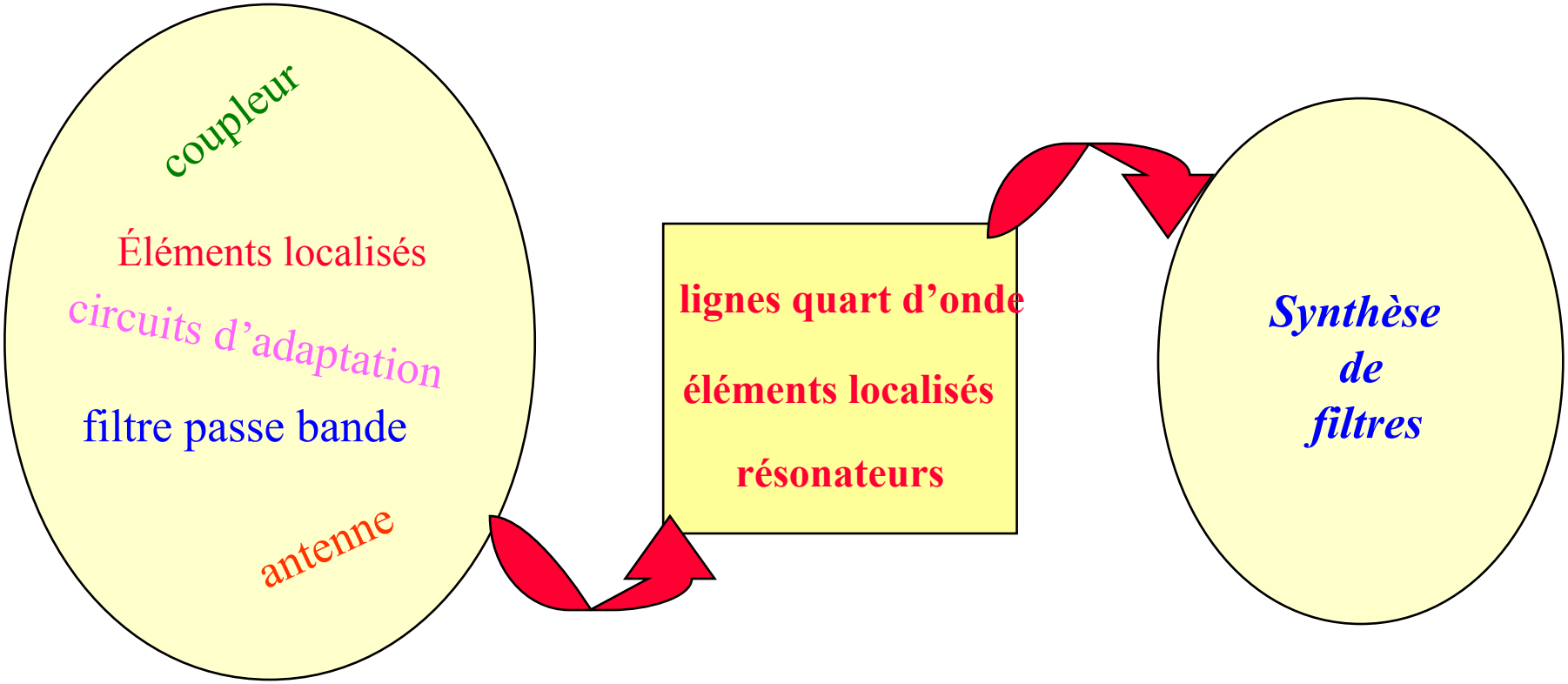
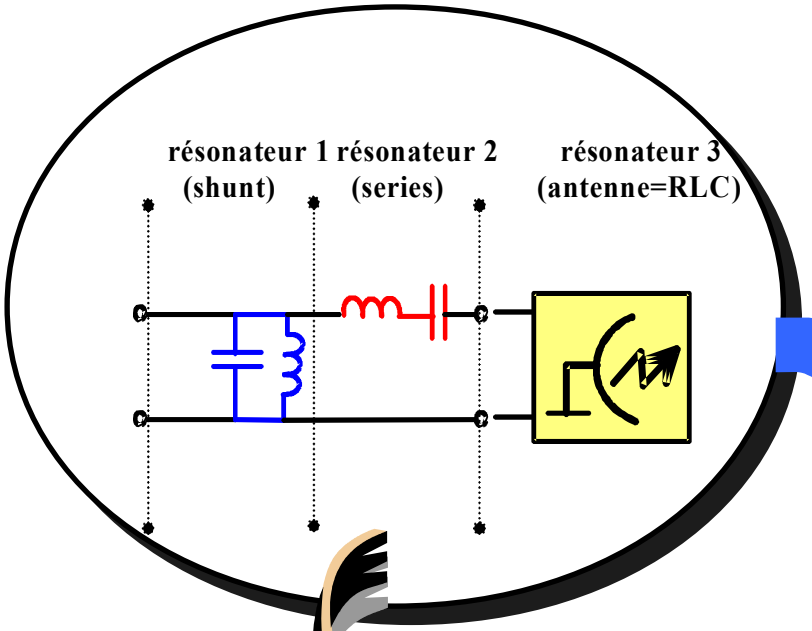
PRINCIPES D'UNE SYNTHESE MULTIFONCTIONS



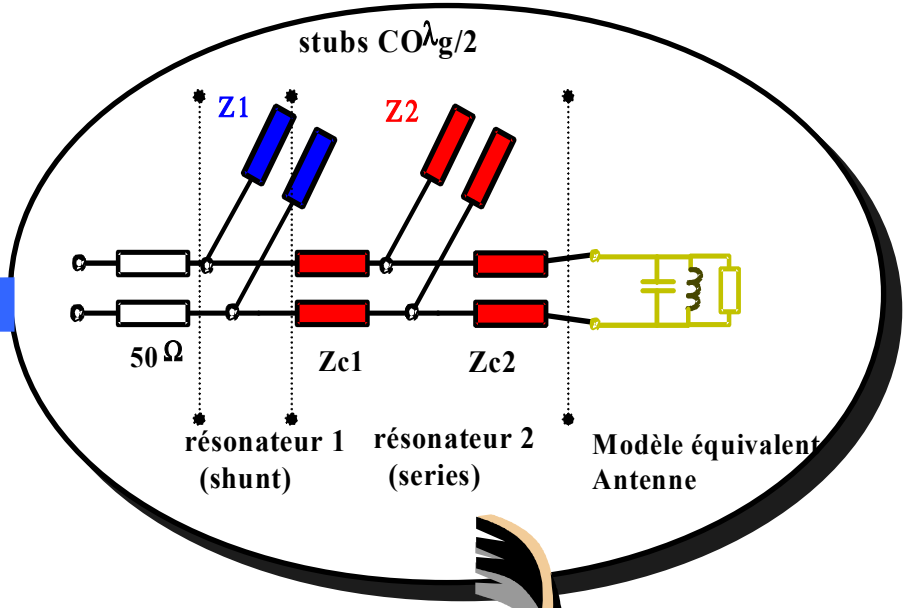
Synthèse globale d'un module passif antenne / filtre

EXEMPLE D'APPLICATION : ASSOCIATION FILTRE-ANTENNE

ANTENNE = RESONATEUR



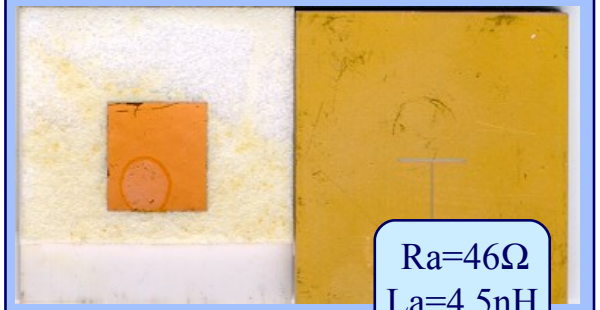
FILTRE = ASSOCIATION DE RESONATEURS



CONTRAINTES TECHNOLOGIQUES MULTIPLE

APPLICATION A UN MODULE FILTRE / ANTENNE (PATCH A COUPLAGE ELECTOMAGNETIQUE)

Antenne:
Patch excité par CPW.



substrat alumine

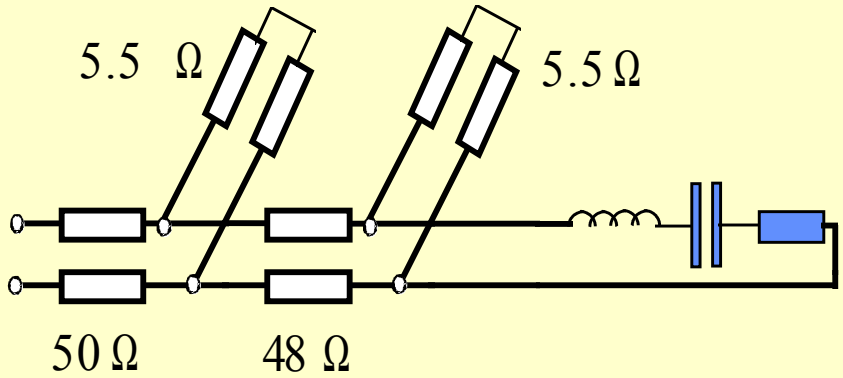
Filtre
- filtre de Tchebyscheff
- n=3
- 0.1 dB d'ondulation
- stubs et inverseurs quart d'onde

Détermination des Zc des différentes lignes

Bande passante du filtre

$$BP = \frac{R_a . g_3}{2.\pi . L_a} \text{ (Hz)} \qquad Z_i = \frac{2\pi . Z_{pi} . BP}{4 . fo . g_i} (\ \Omega) \qquad Z_{ci} = \sqrt{Z_{pi-1} . Z_{pi}} (\ \Omega)$$

EXEMPLE DE SYNTHESE



$$BP = \frac{R_a \cdot g_3}{2.\pi.L_a}$$

$$Z_i = \frac{۲\pi.Z_{pi}.BP}{٤.fo.g_i} \quad (\Omega)$$

Bande passante	ripple	Z1	Z2
9.9%	0.01 dB	5.5	3.3
18%	**0.2 dB**	**5.5**	**5.5**
23%	0.5 dB	5.5	7.5

contrôle de la bande
contraintes technologiques
☞ 3 D

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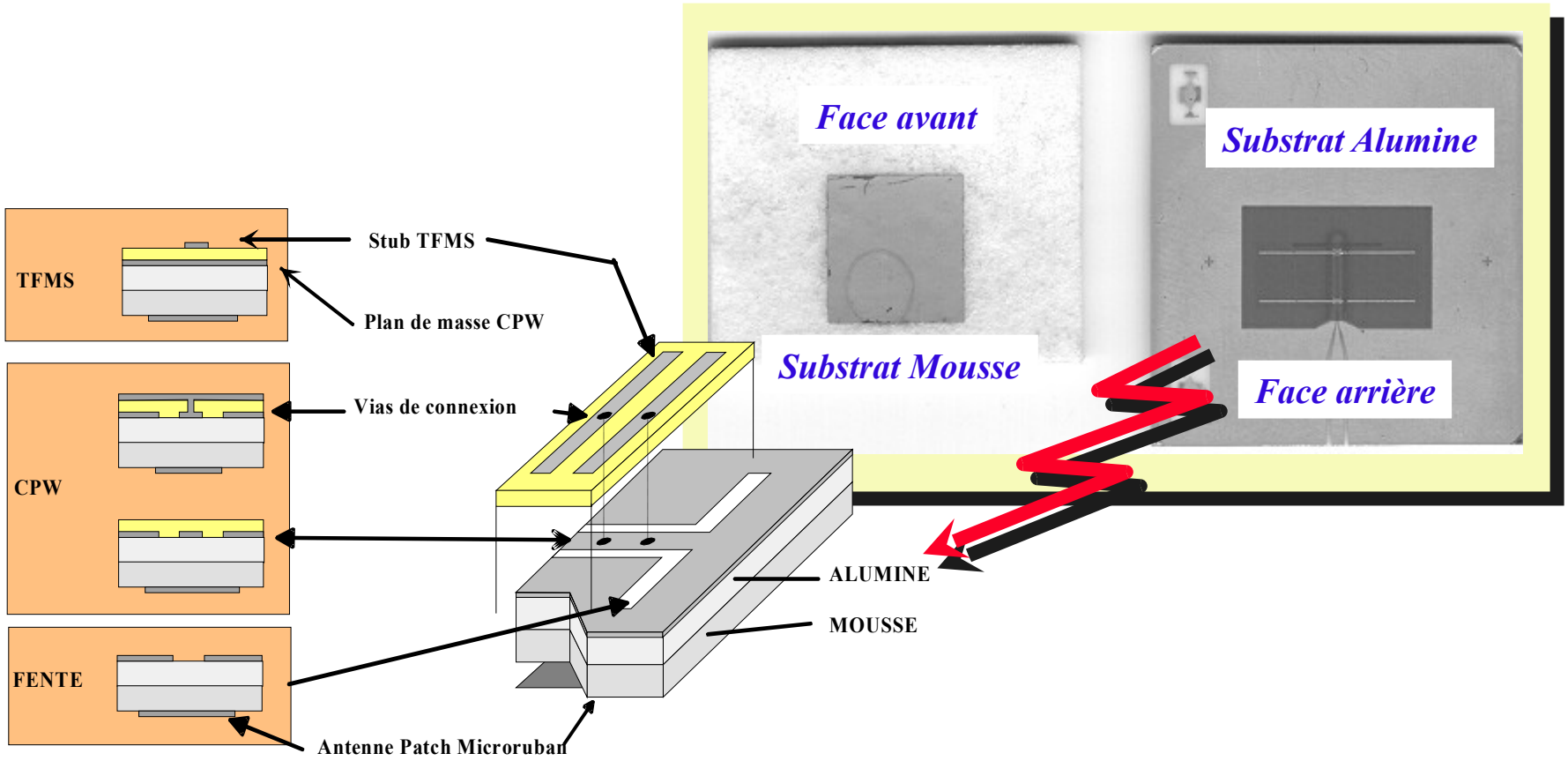
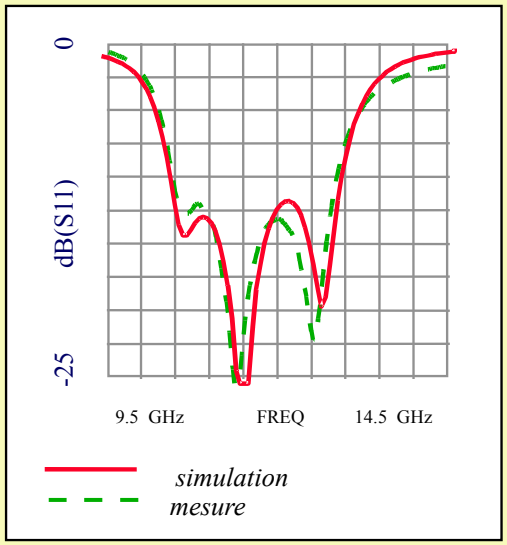
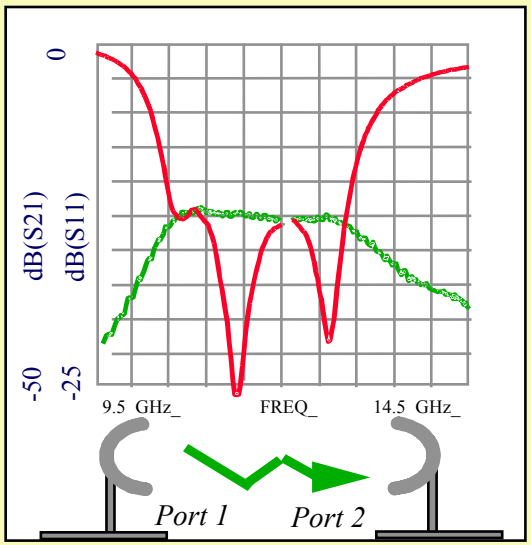
ANTENNE-FILTRE 3D



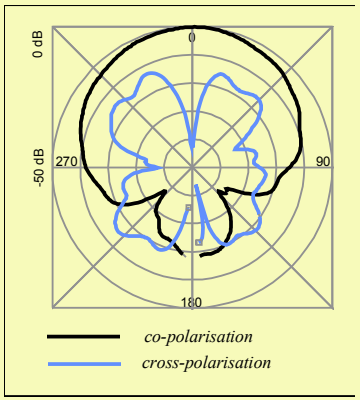
ANTENNE-FILTRE 3D : CARACTERISATION



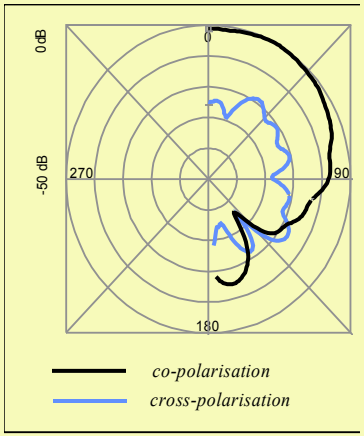
Adaptation du module antenne-filtre



Mesure en transmission



Plan H



Plan E

- ***Bande passante 20 % (ROS = 2)***
- ***Gain = 3.5 dBi***
- ***écouplage réseau alimentation / éléments rayonnants***

ANTENNE-FILTRE 3D : EXTENSION DU PRINCIPE A UNE MISE EN RESEAU D'ANTENNES

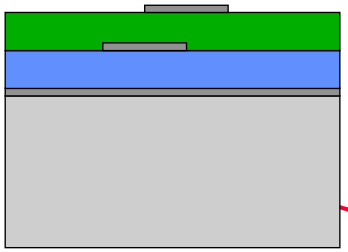
Contrôle des:

bandes passantes
diagrammes de rayonnement

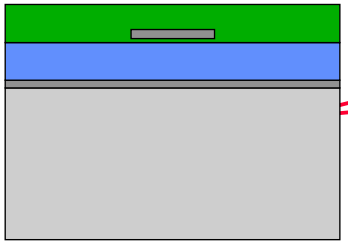
méthodologie

- Caractérisation des éléments rayonnants
- Choix d'une topologie d'alimentation:
  - série (dépointage)
  - **parallèle**
- Choix de la nature des résonateurs:
  - **lignes couplées**
  - **stubs**
- Détermination des grandeurs électriques:
  (impédances caractéristiques)

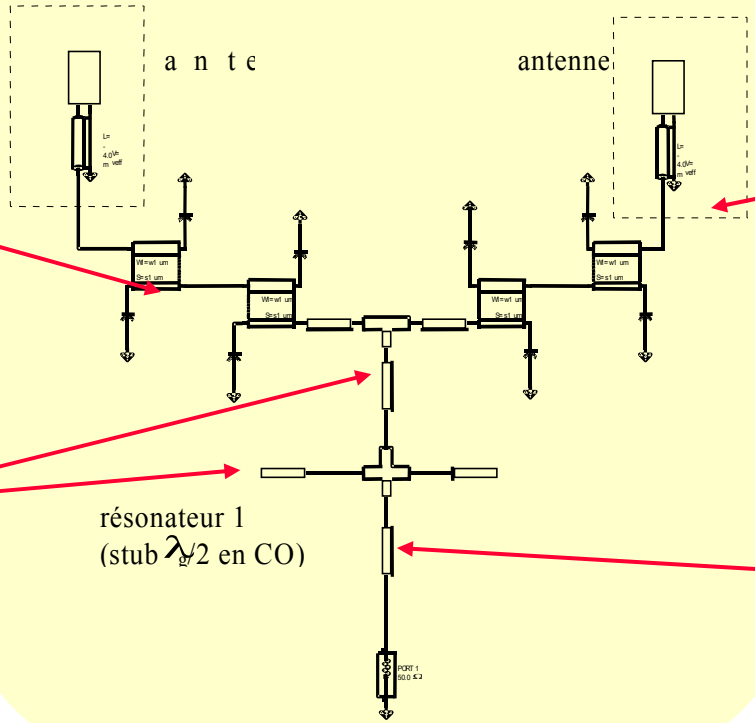
RESEAU D'ANTENNES-FILTRE 3D : ARCHITECTURE

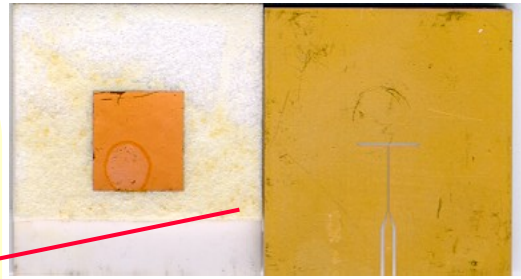


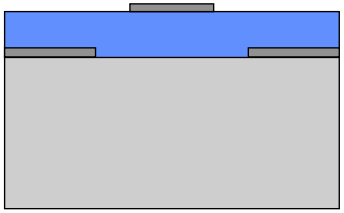
Lignes couplées TFMS



TFMS enterrée







CPW 3D

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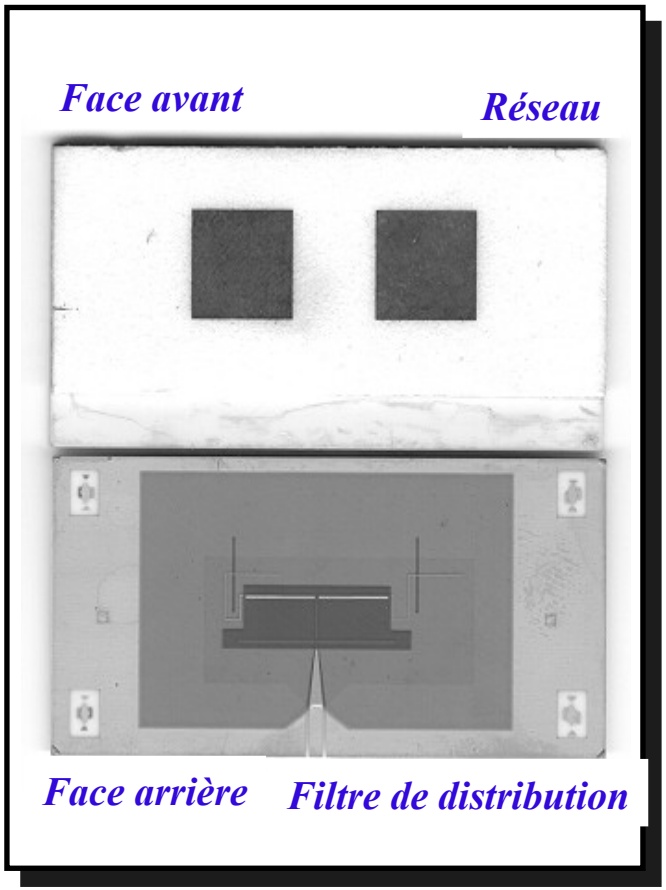
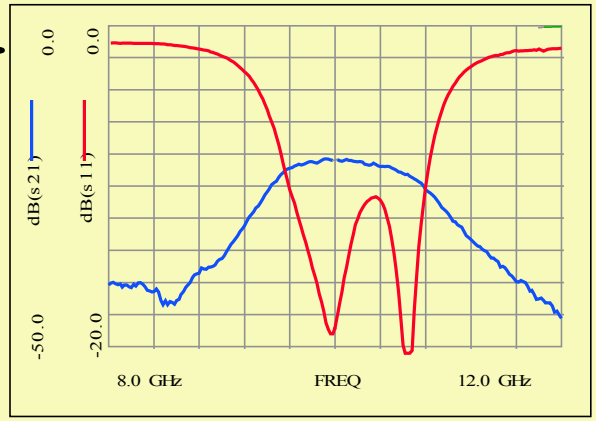
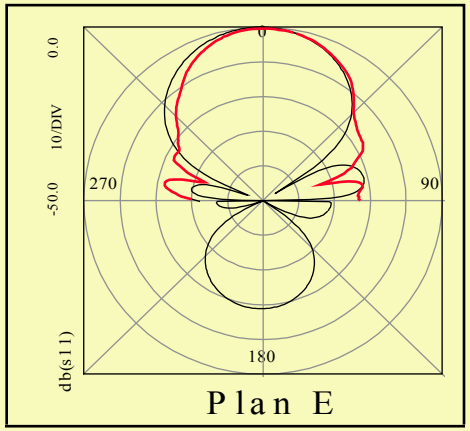
APPROCHE HYBRIDE 3D ETENDUE A DES MODULES ANTENNE-FILTRE RESEAU

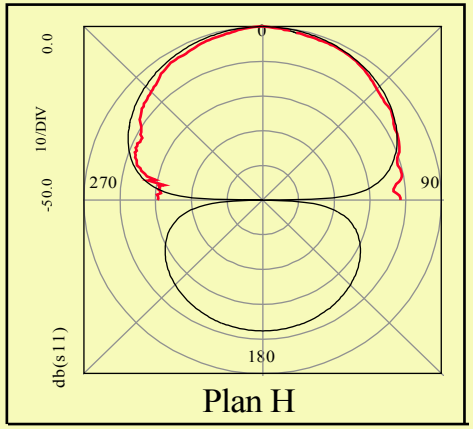


Paramètres [S]

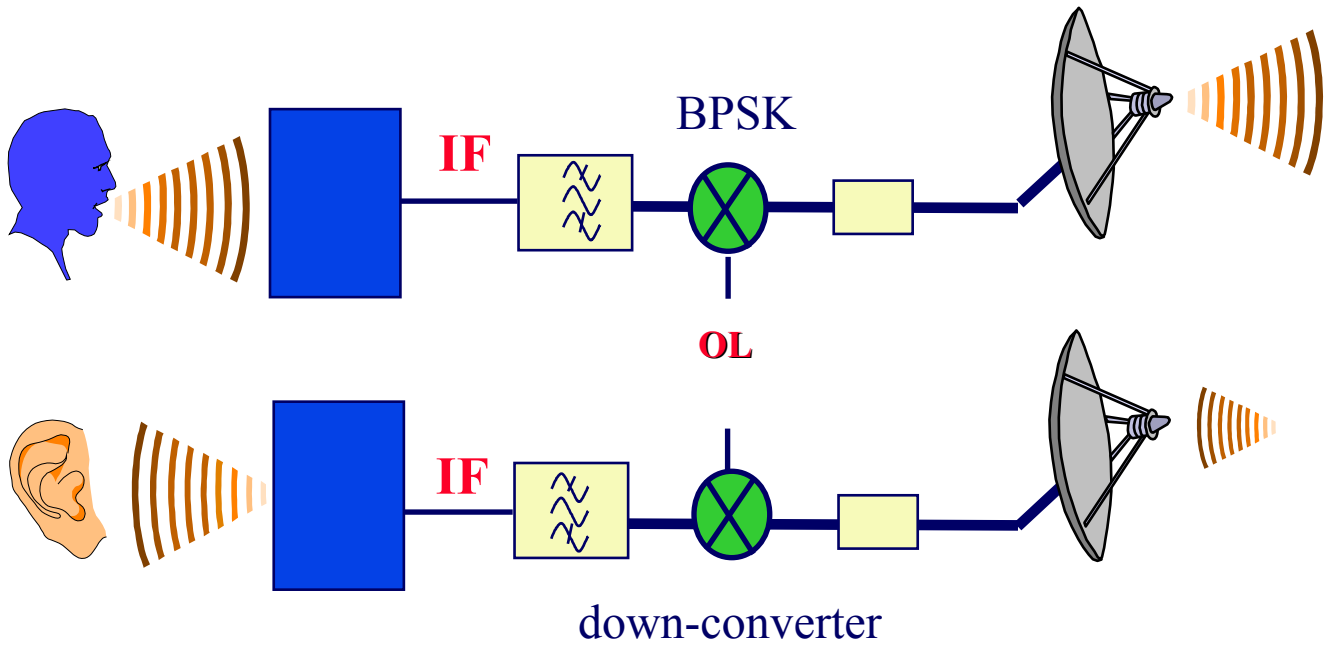


Diagrammes plan E / H





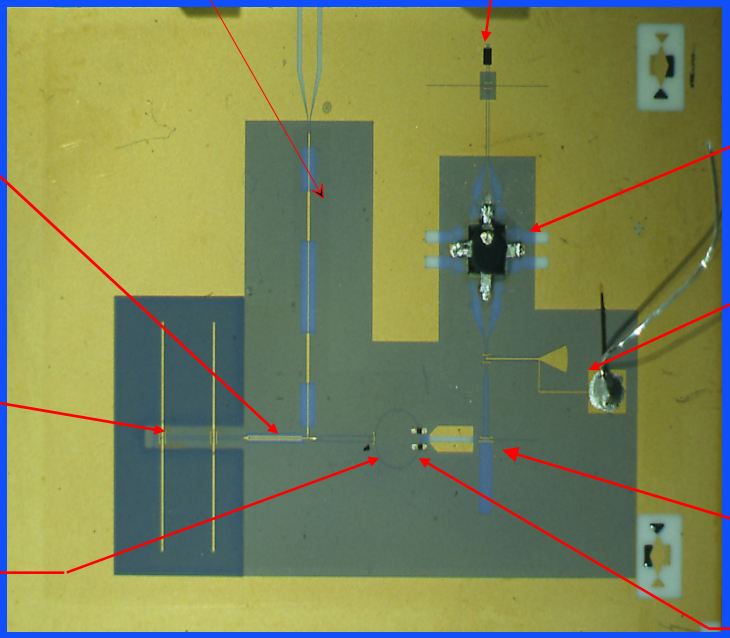
Intégration 3D d'un système radioélectrique complet



DEVELOPPEMENT DE MODULES RF HYBRIDES 3D COMPLET

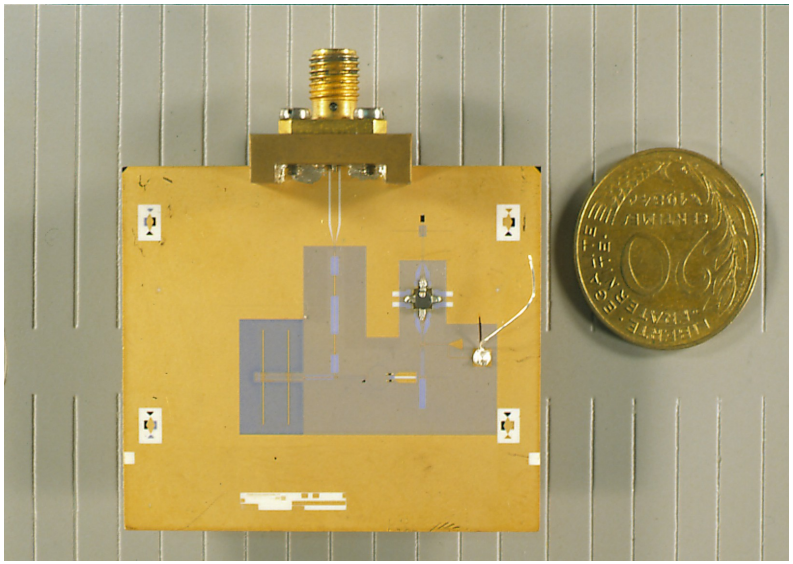
Module radioélectrique complet

50.8 mm x 30 mm



LIAISON RADIOFREQUENCE COMPLETE : PERFORMANCES

Module RF – Fonctionnement dual



Emission : Modulateur BPSK

Réception : Mélangeur équilibré

Liaison à 2 Mbits/s – porteuse 10GHz

Que faire dans OPTIMISE - idées …

- **Synthèse / optimisation**
  - Filtre & antenne imbriqués 3D
    - Antenne = résonateur : Synthèse et optimisation EM
    - Résonateur = cavité = source : Optimisation EM
  - Filtre rayonnant / Cavité SIW à pertes
    - Plan de masse limité / filtre distribué & couplage lentille : Optimisation
    - Filtre SIW/3D et substrats « stackés » faisant office de « lentille distribuée »
- **Bande passante et couplages Source / antenne**
  - Objectif « large bande » - Couplages
  - Objectif source filtrante angulairement/ correction de phase a priori
  - Excitation multi-sources
- **Coque = Filtre spatial/fréquentiel**
  - Optimisation de forme et masquage
  - Application Beamforming/Dosimétrie
- **Lentille plate et filtrage distribué /Cornets coniques et lentille**
  - Apport et contraintes d'optimisation
  - Insert diélectrique/métallique
- **Problèmes inverses – Lentille fixe et optimisation de la source ponctuelle/spatiale**