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New materials for next generation of microwave packaging

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Outline

Trends on new materials for microwave packaging

New interface material for thermal management

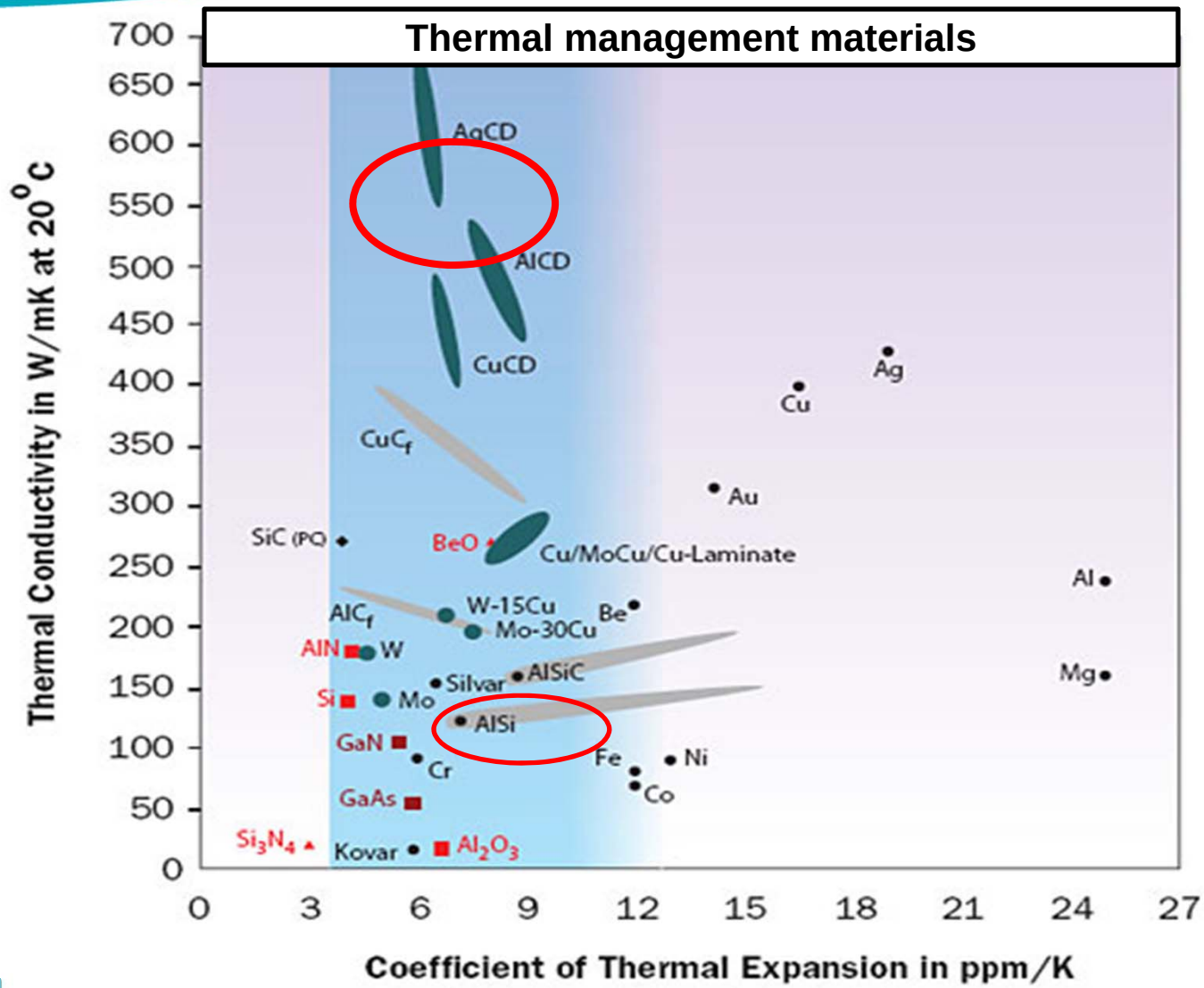
Multifunctional ceramic substrate for embedded passive components

New laminate substrate for complex PCBs

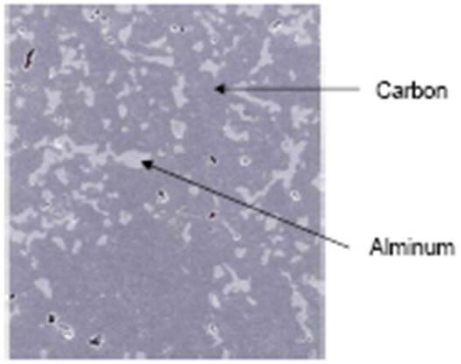
Advanced interconnects using microelectronic techniques

Conclusions

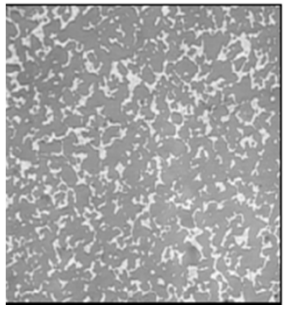
Microwave hermetic package material trends



Composite material : MMC for large hybrids



Cross Section of AIC (x 200)



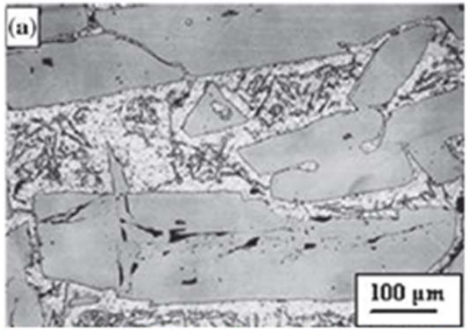
Microsection AlSi (CE7)

	Kovar / Dilver	Aluminium	AlSi (CE 9)	AIC
densité	8.4	2.8	2.5	2.1
conductivité thermique (W/m.°C)	17.5	238	140-180	150
C E T moyen (ppm/°C)	5.9	23	9	6.5

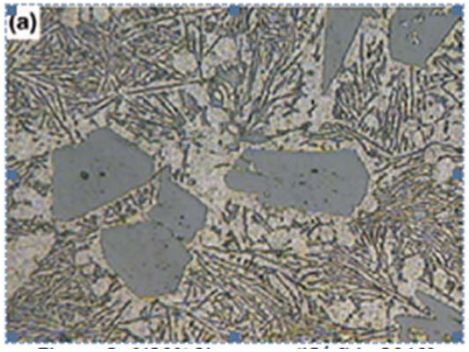
These material are fragile which limits their use to small hermetic packages and non hermetic carrier

Composite material : Moving toward nanocomposite for tailored properties

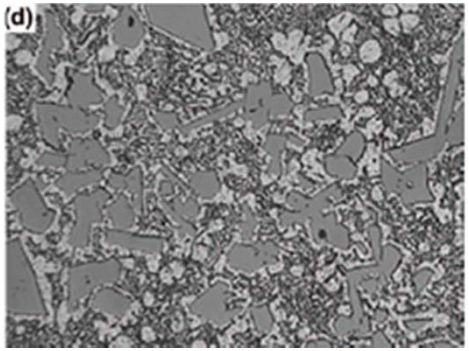
SiAl alloy with large Si crystal
Flexural strength <60 MPa



SiAl alloy with medium Si Crystal
Flexural strength <100 MPa

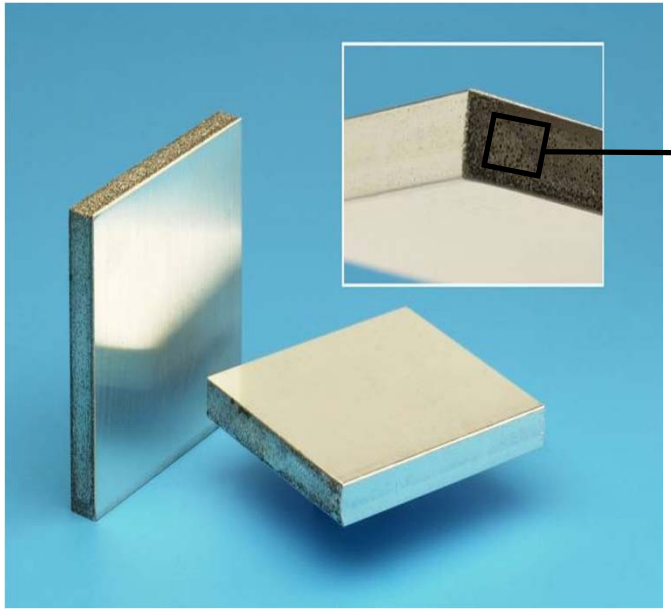


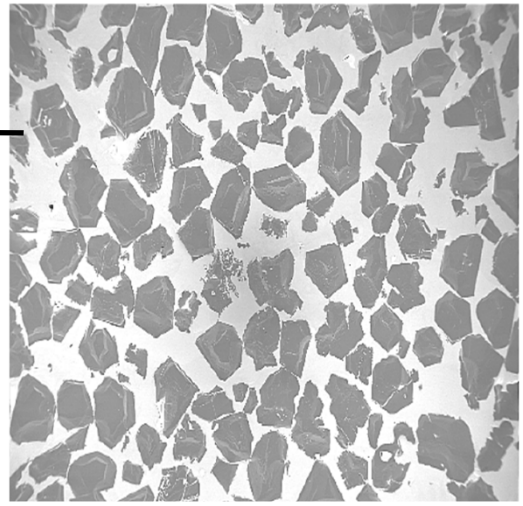
SiAl alloy with small Si Crystal
Flexural strength <150 MPa



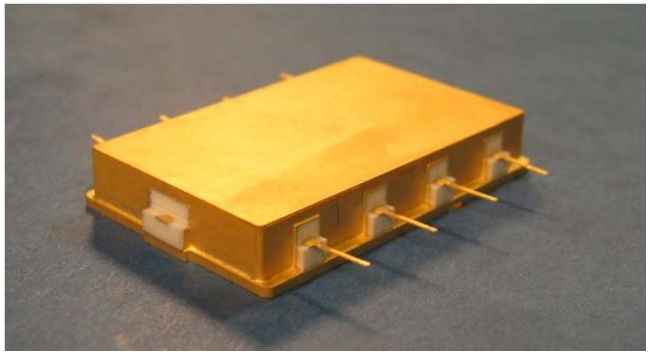
Rounded shape of Si Crystal has also a

Composite material : high thermal performance MMC





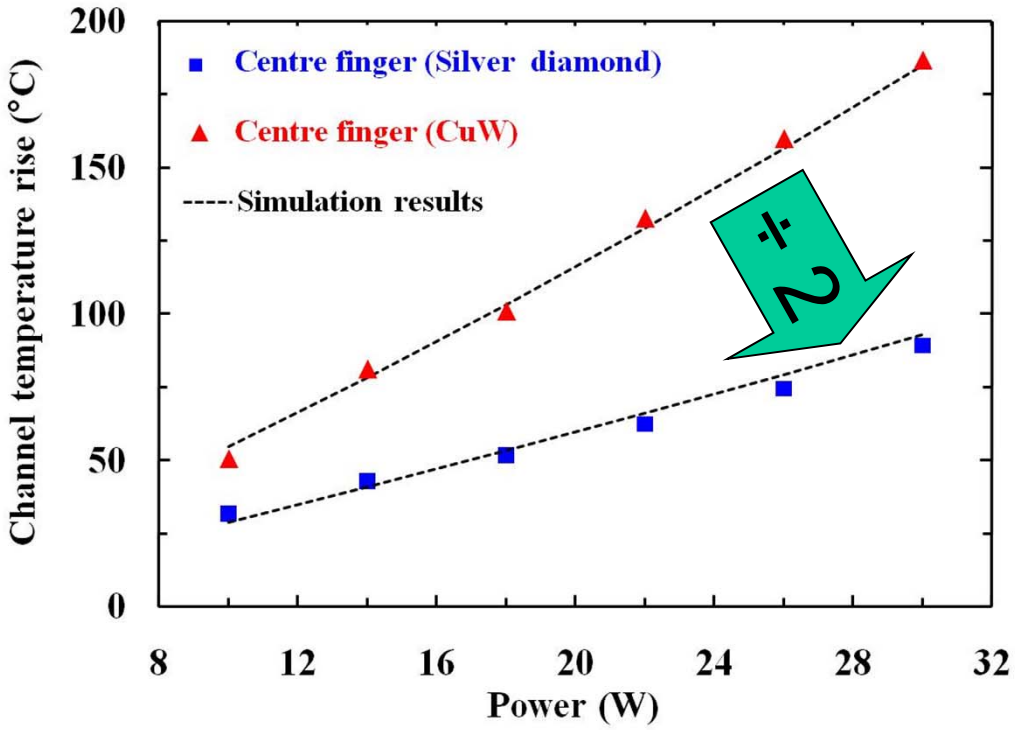
Diamond silver composite (Tc>800 W/m°C)



Micropackage for L band power amplifier

Material impact on RF power module

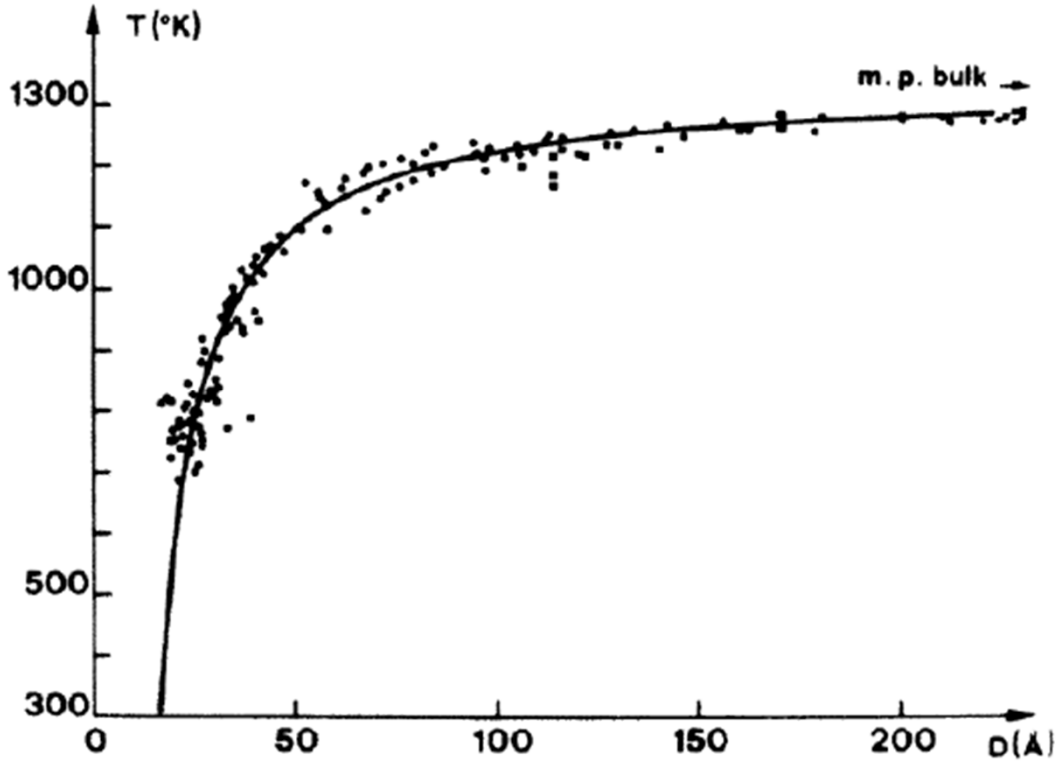
Junction temperature measurement done on GaN power bar mounted onto AgCD and WCu micropackage using µRaman method



With same dissipated power, junction temperature is divided by 2 with AgCd

Innovative nanomaterials for high performance interface

Size effect on melting temperature of gold particule



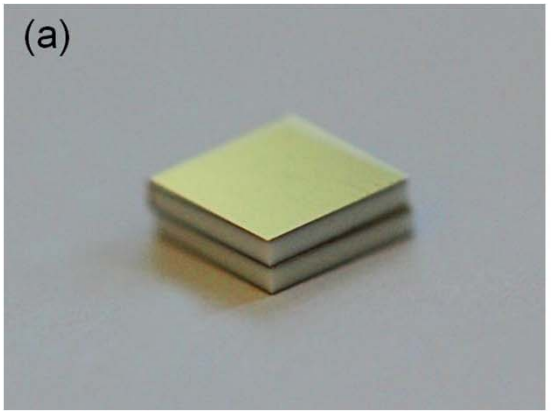
P. Buffat and J.-P. Borel, “Size effect on the melting temperature of gold particles,” Physical Review A, vol. 13, no. 6, p. 2287, Jun. 1976

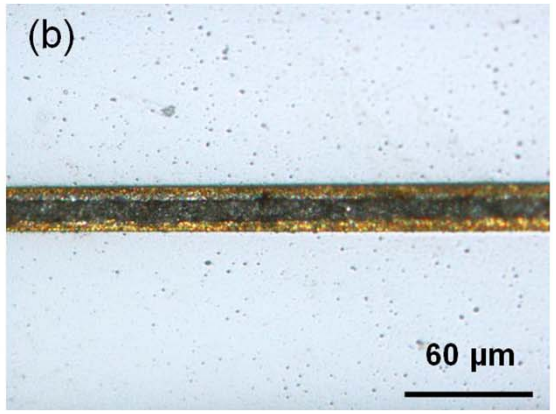
Innovative nanomaterials for high performance interface

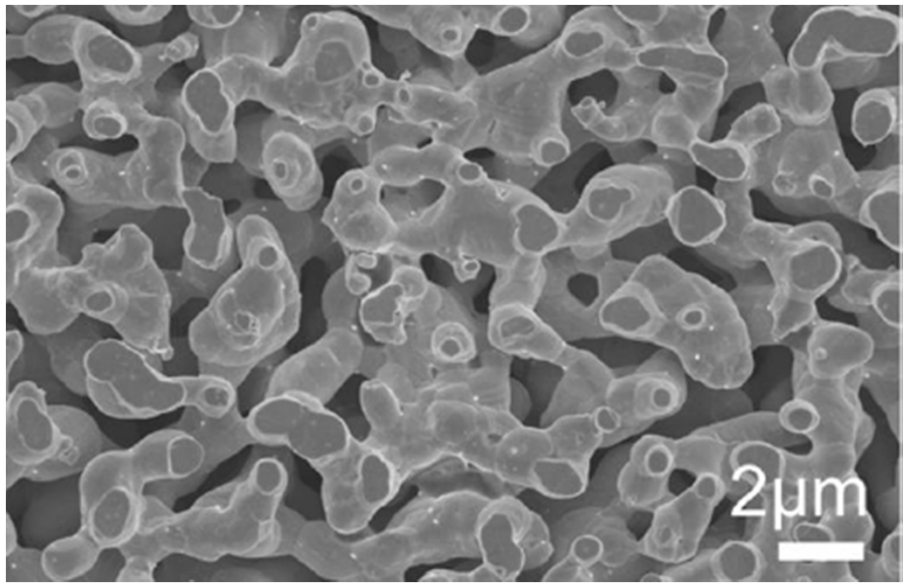
- Up to 100 W/m°C pure silver interface
- Sintering done at low pressure at temperature lower than 300 °C
- No flux necessary > formation of AuAg alloy

- Interesting candidate to replace AuSn eutectic alloy

- Patent pending on specific product non affected by REACH







Ceramic substrates for microwave application : main trends

Size reduction at low frequencies, low loss and temperature stability at high frequencies.

Material	εr	Tan δ 10^{-4}	CTE ppm/°C	TC $W.m^{-}$
Quartz-SiO_2	3.75	1.5	0.5	1.5
Cordierite	4.9	10	3.5	3
Steatite	6-6.5	6	7-9	2-4
Forsierite	6-8	2-3	8.5-10	3
BeO	6.6	2	7.5	260
AlN	8.5	3-10	4.5-5	107
Al_2O_3 99.6%	9.2	2	7.2	33
Al_2O_3 96%	10.2	2	7.5	21
Mg, Za	20	1.5	8	7
Zr, Sn titanate	35	1.5	7.4	2
Ba, Nd	85	3	8	2

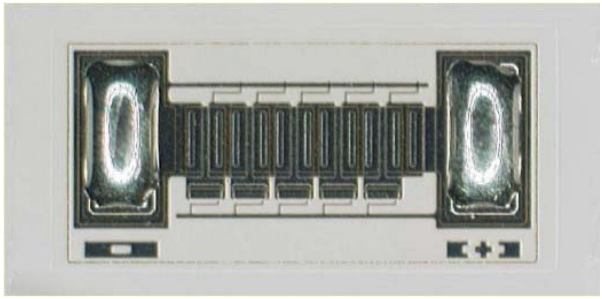
Ceramic substrate : Moving toward functionalization

Ceramics Al2O3 SC with ferroelectric nanolayer

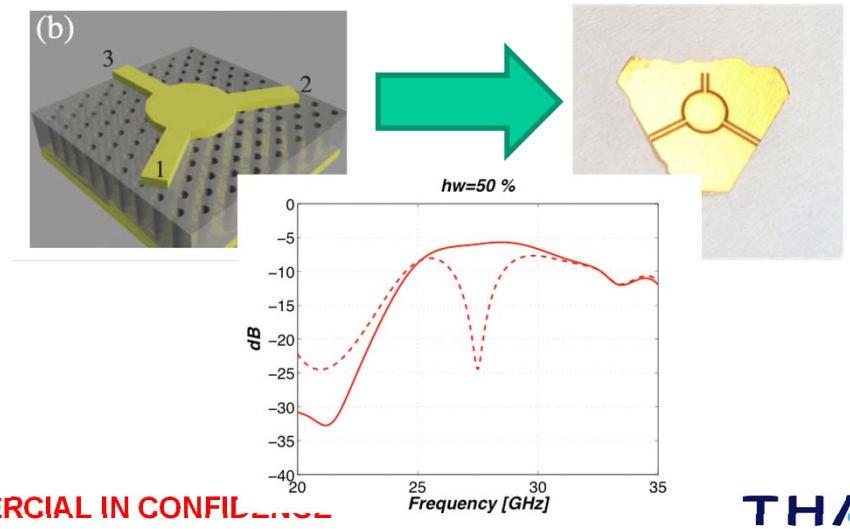
Application toward tuneable capacitors

Ceramics dopped with magnetic nanowire

Application toward integrated isolator



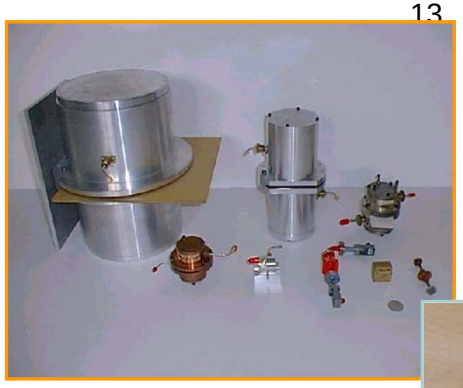
Tension Vc	Capacité F	Capacité G	Capacité H	Capacité I
0V	8,11	9,97	7,76	9,22
0,5V	6,56	7,84	6,69	7,32
1V	4,94	5,66	4,3	5,35
1,5V	3,79	4,19	3,37	4,01
2V	3,02	3,27	2,73	3,14
2,5V	2,5	2,65	2,27	2,57
3V	2,12	2,23	1,95	2,16
3,5V	1,84	1,92	1,7	
4V	1,62	1,69	1,52	1,867
Ratio=C(0V)/C(4V)	5,01	5,90	5,11	4,94

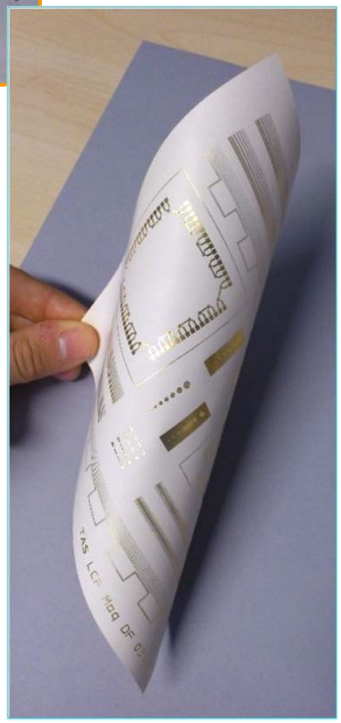


Laminate : reliability (CTE), higher density to thinner layer laminate, flexible

Material (resin)	εr	Tan δ 10^{-3}	CTEz ppm/°C	Tg °C	
Modified epoxy	3.5-3.8	8-20	> 40	> 180	Amorphous
Thermoset	3.55-10	3-5	> 40	> 260	
Thermoplastic	2.9-3.2	1-2	20-30	> 280	
New : LCP	2.9-3.0	2-3	> 150	> 310	Crystaline

New sequential multilayer board for microwave : use of LCP





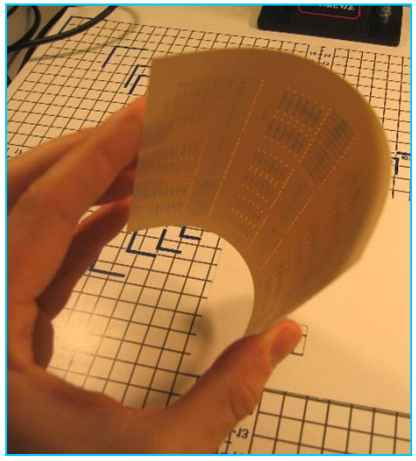
Good and stable dielectric properties

Very good copper adhesion

Possibility to achieve small via diameters, fine tracks / gaps

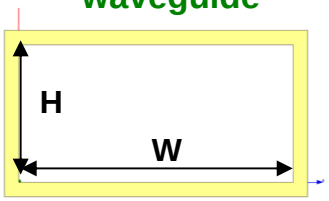
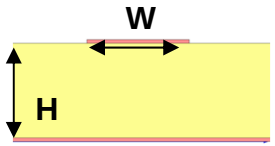
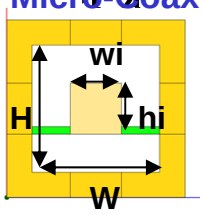
Possibility to achieve etched resistors both in outer layer and buried in the circuit

Full technological evaluation on going on a 6 layer LCP board according to ECSS standards

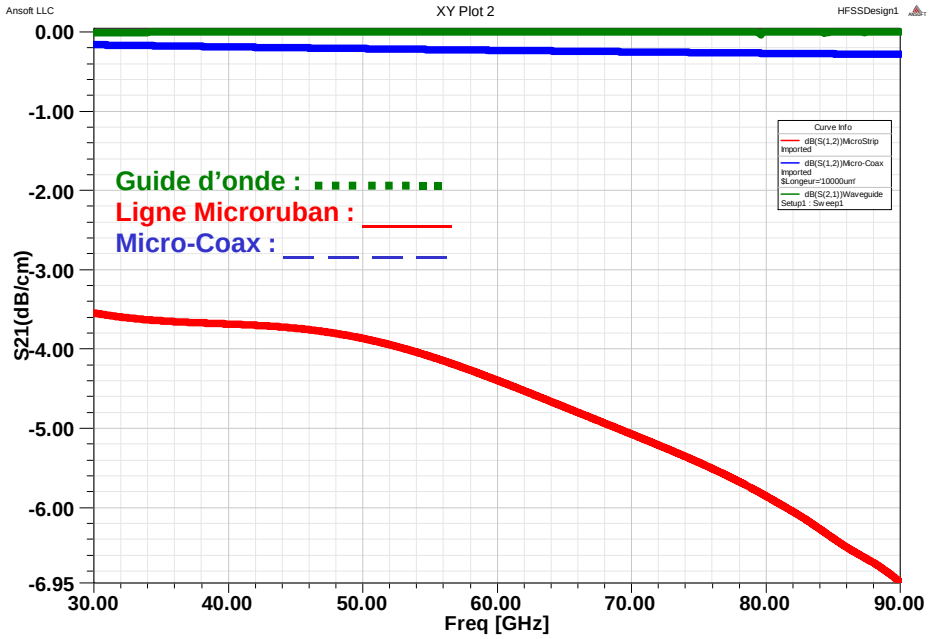


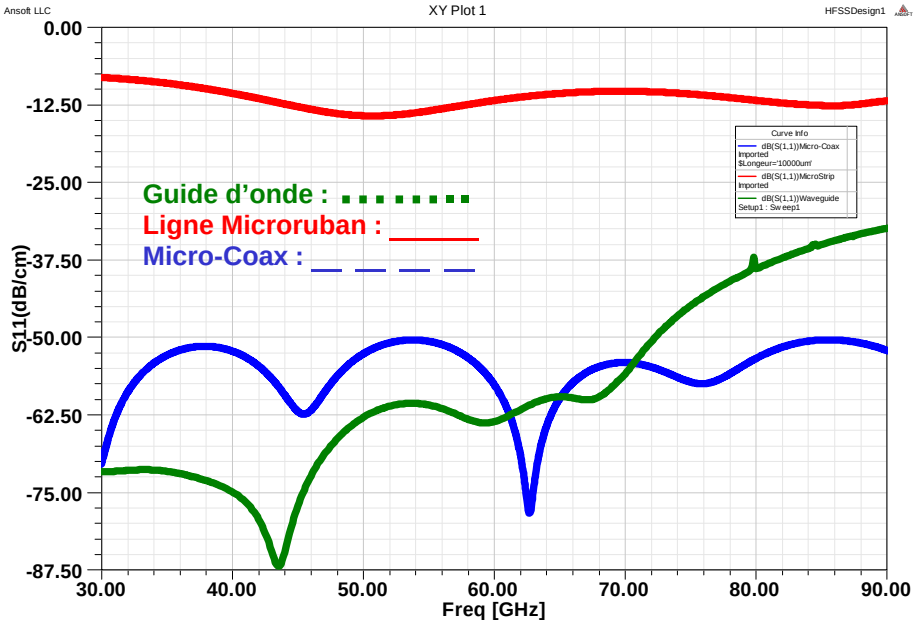
Advanced transmission lines and micromachining

Study case : Frequencies higher than 30 GHz

Type :	waveguide 	Microstrip line 	Micro-Coax 
Dimensions	**H=2844µm** **W=5689µm**	**H=254µm** **W=144µm**	**H=250µm** **hi=100µm** **W=250µm** **wi=100µm**
Substrat :	**Air**	**Alumine**	**Air**

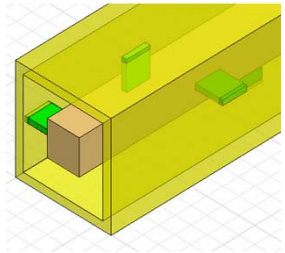
Advanced transmission lines and micromachining

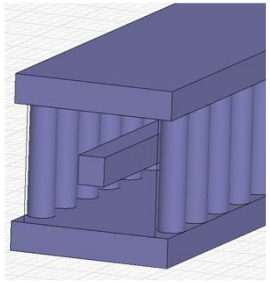


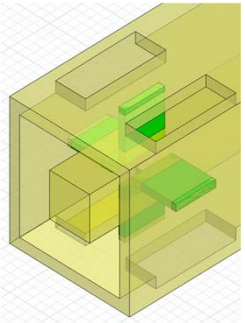


Advanced transmission lines and micromachining :short term objective

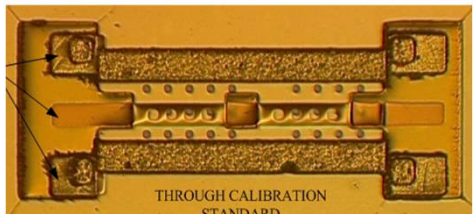
- **Design and validation of basic transition and function**

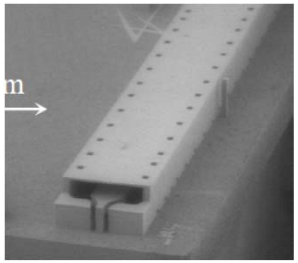






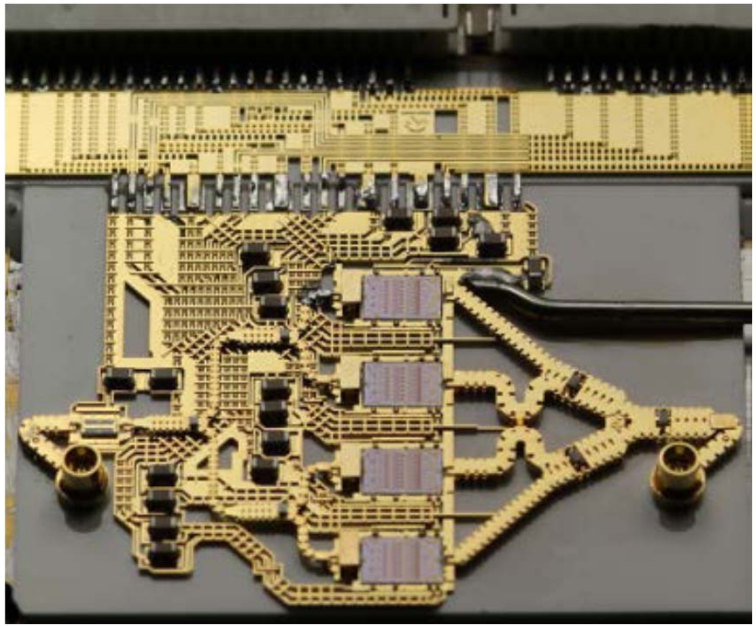
- **Analysis of reliability of built structure**

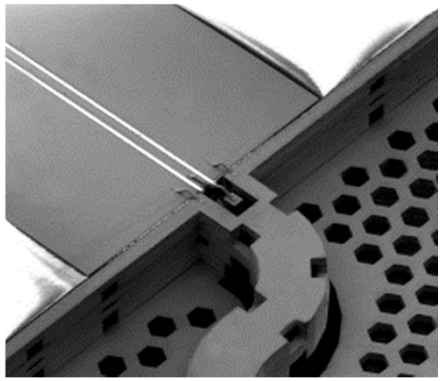




Some perspectives for the technology

Fully integrated subsystem





SSPAs / Power Combining
(courtesy of Nuvotronics)

On-going microwave packaging activities :

New material engineering and evaluation : substrate, package, assembly ,

- Substrate and material with new properties : composite approach
- New interface material for improved performance
- Multifunctional ceramic substrate to enable integration of passive components (variable capacitor, magnetic, non reciprocal materials
- Disruptive interconnect using microelectronics techniques

Target ultimate objective:

- Increase of microwave & thermal performances,
- Reduction of mass budget,
- Increase of reliability,

Induce cost reduction at system level