



EUREKA project E!2448 FACTORY PROKOSMOS was launched in order to develop innovative ways of producing RF modules in a competitive manner. Project participants from Ireland, Austria and Germany decided to form a research consortium with the ultimate goal of safeguarding their existing competitive advantage in the production of microwave components and antennas. FACTORY PROKOSMOS received the EUREKA label in October 2000.

Topic:

Novel Module Architectures up to 50 GHz - SMT and RF-Boards

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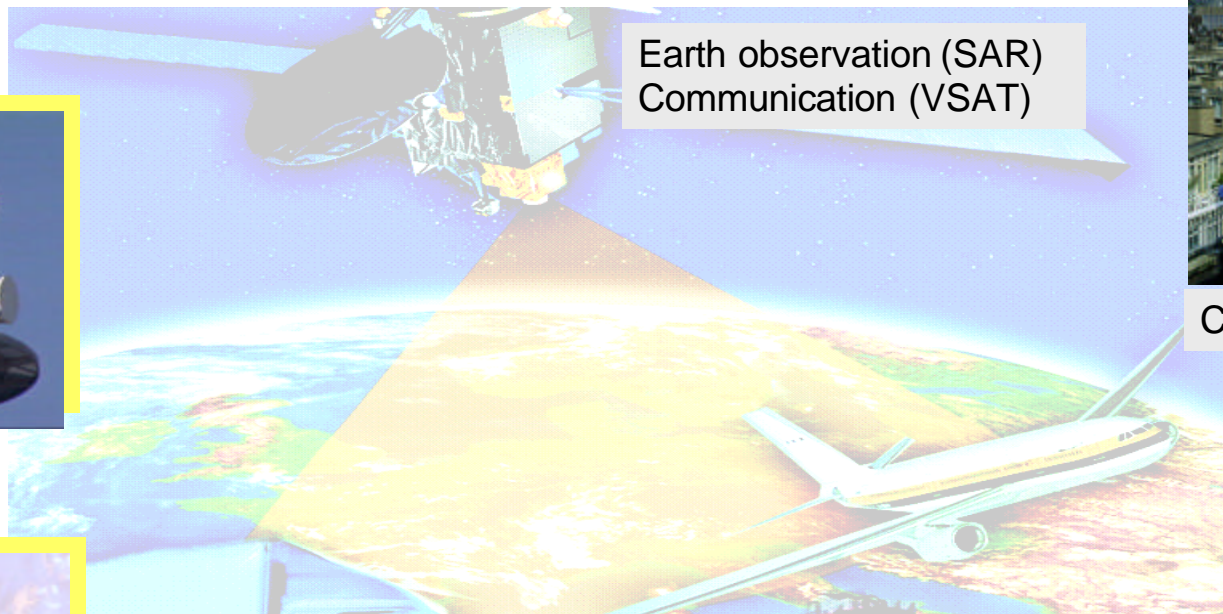
Ulm, 89077, Germany

e-mail: Martin.Oppermann@sysde.eads.net

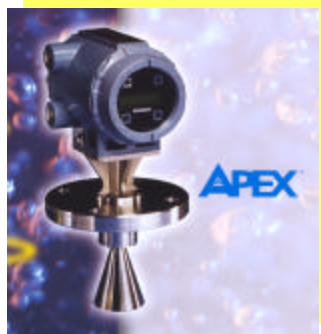
Outline

- ❑ **Introduction** - Micro- and Millimeterwave Modules
- ❑ **Radio Links and Wireless Access**
- ❑ **RF Module Design - Today**
Components and Cost Issues
- ❑ **Advanced Module Technology – Trends and Vision**
- ❑ **SMD Based Module Architecture**
RF PC Boards, Packaged MMICs, Macro Modules
- ❑ **Transceiver Modules and Key Components**
Examples, Experience, Results
- ❑ **Benchmarking Issues**
- ❑ **Summary - Outlook**

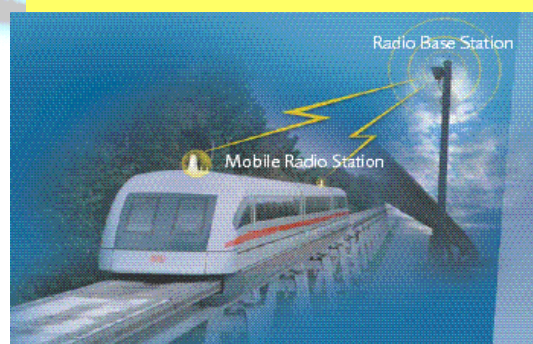
Application Areas of Micro- and Millimeterwave Modules



Communication



Sensors
Industry, Automotive

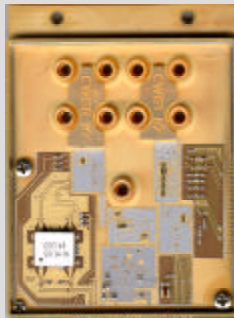


Active Phased Array Radars

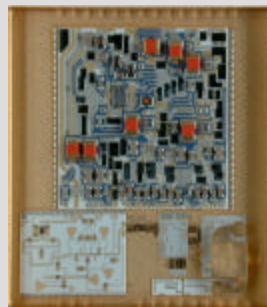
Commercial Communication Modules

Applications:

PtP	Point-to-Point	26 - 38 - 64 GHz
LMDS (PMP)	Local Multipoint Distribution Service Point-to-Multipoint)	23 - 43,5 GHz
VSAT	Very Small Aperture Terminals	20/30 GHz



mm Wave Transceiver-Modules

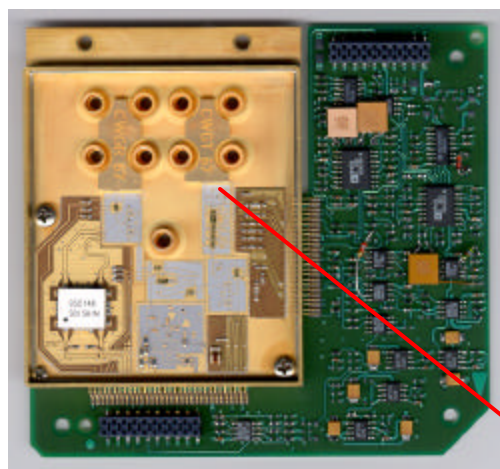


Radio Links

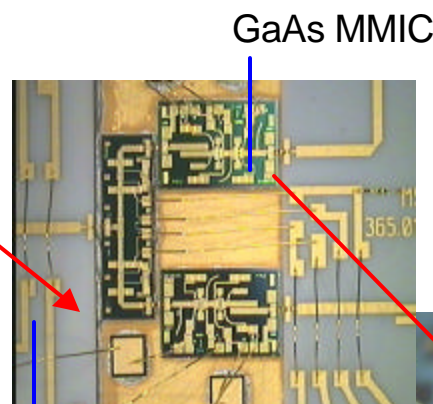
RF Module Design and Components

Status 'today'

RF Module (Sub Unit Technology):
Ceramics, Soft-Substrates, FR4
Assembly: Chip&Wire, SMD
Housing: hermetical, Kovar
Interconnects: Flat-Pack, solderable

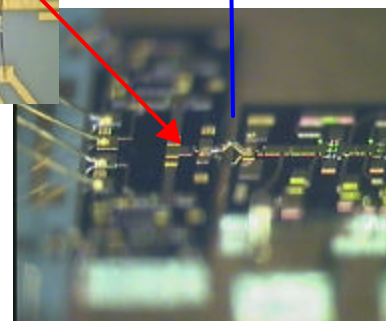


mm Wave Transceiver-Module
mmW unit and PCB



Alumina Substrate

GaAs MMIC

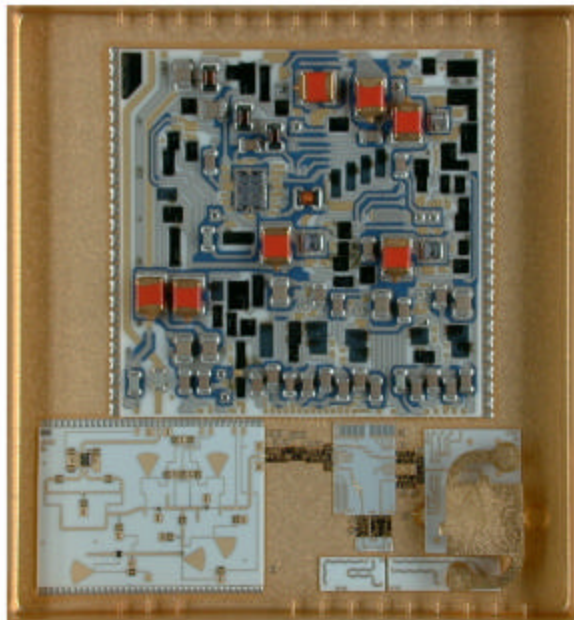


RF bonds, 60 GHz,
Ribbon

Interconnection:
MMIC - MMIC - Substrate

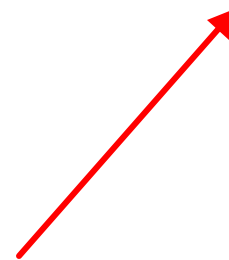
Module Cost Issues and Distribution: **Today's Situation**

Example: 58 GHz, PtP radio



Today's Module price:

'n times higher'
than expected and accepted
in near future



Technology:

- Patchwork-Design
- GaAs, Alumina
- 100 Bonds, 40 Block-MIMs
- Flatpack housing

Costs:

- | | |
|-----------------------|-----------|
| • Material and MMICs: | 35 - 50 % |
| • Package/Assembly: | 25 - 35 % |
| • Testing/Tuning: | 10 - 20 % |

Advanced Module Technology – Trends and Vision (1)

Approach A: **SMT (Surface Mount Technology) BGA, LGA**

RF-Packages	HEI, Hittite, DLI, Labtech, Sophia Wireless US Monolithics, Stratedge, NTK
Packaged MMICs	UMS, Alpha, Hittite
RF-PCBs	Optiprint, Labtech, Astrium (TESAT), Merrimac, Vogt Electronic Fuba
Module Assembly	Ericsson, Nokia, Astrium

Indicators for New Module Generation

SMT Transceiver Demonstrator	EuMW, 09-2001, London THALES, EADS
Broadband Wireless SMD Chipsets	UMS, Press Rel., 09-2001
25 µm li/sp on PCB	Filtran Microcircuits, 01-2002



Advanced Module Technology – Trends and Vision (2)

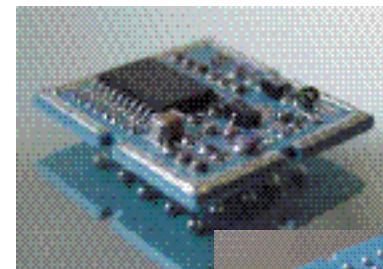
Approach B: **MLC (Multilayer Ceramic) in LTCC, LTCC-M, HTCC**

Target: Substrate / package integrated RF functions
e.g. filter, wave-guide, housing, passives

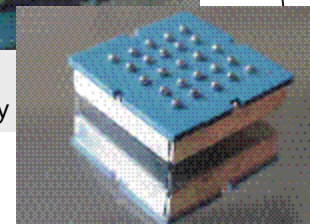
Company activities:

MSE, Kyocera, Zentrix, THALES, IMST, M/A-COM, C-MAC (Solectron)

Driving Applications: < 2 GHz
e.g. Bluetooth Modules, Mobile Phones
(Ericsson, Nokia, EPCOS)



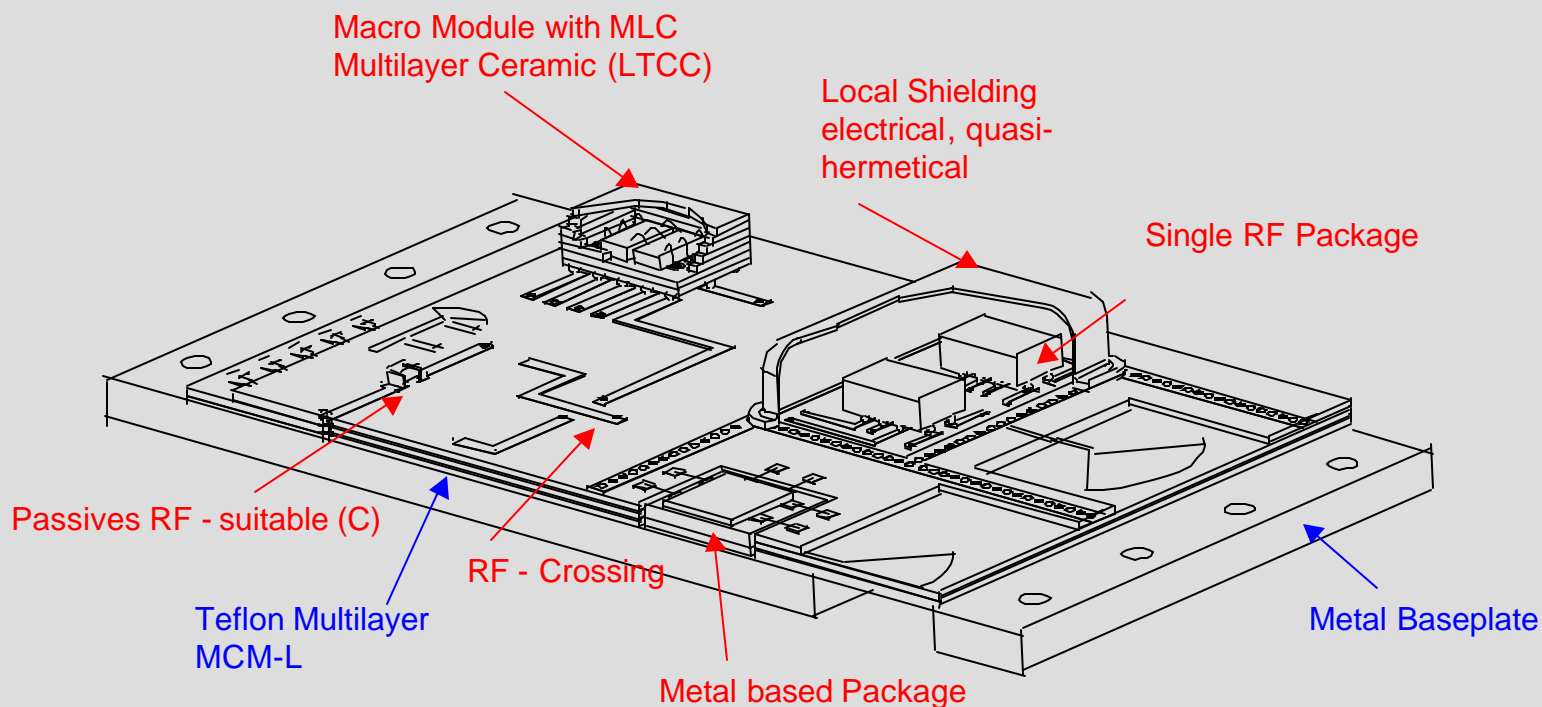
Source:
MSE/Germany



SMD Based Module Architecture *Artist's View*

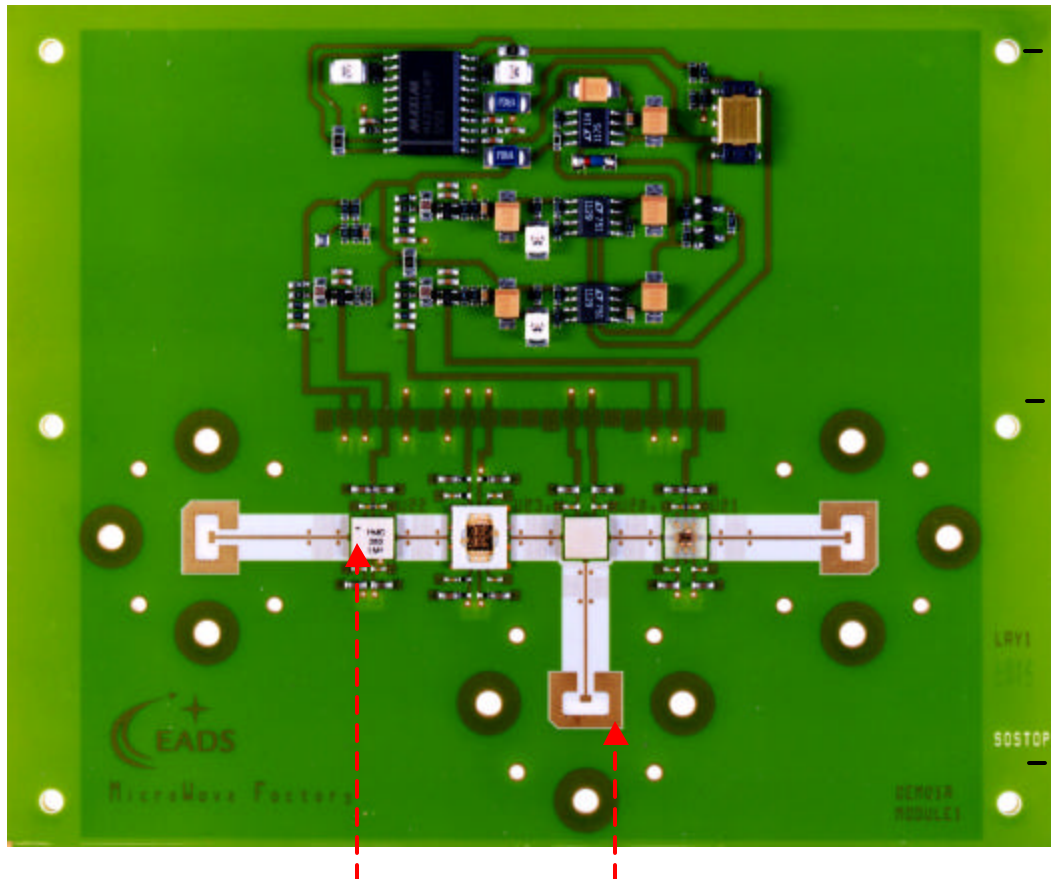
Module Technology:
Assembly :

RF Multilayer on Metal carrier
SMD Packages, Soldering, Gluing (μ BGA, LGA)



R&D Project, PROKOSMOS (EADS/BMBF Funding contract: 02PP2060)

SMD Based Module Architecture Reality



Assembly on one PCB:

Electronics
Power, Signal, Logic

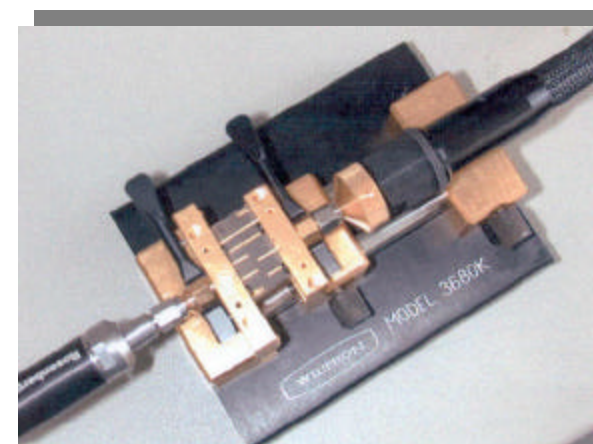
RF Components

RF Package

WG-MSL Transition

PCB Characterization RF Parameters up to 50 GHz

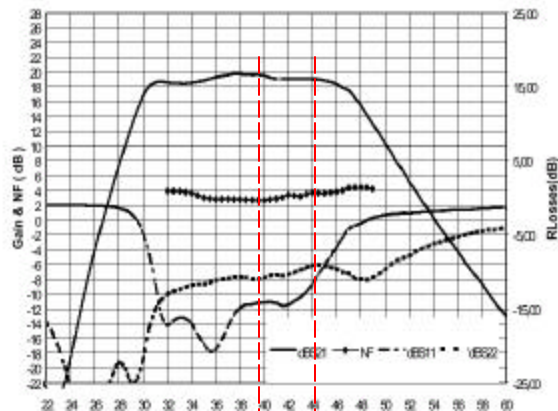
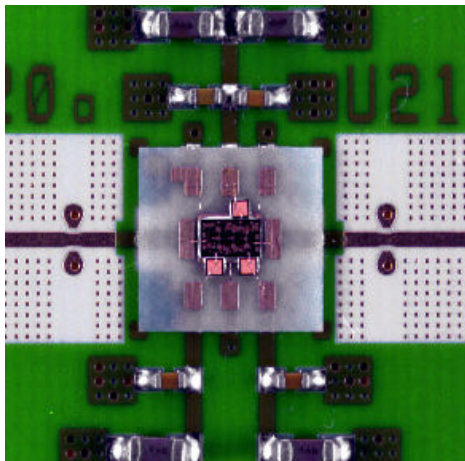
Material/ Parameter	Taconic TLE95 h=254 μm		Rogers R04003 h=203 μm	
	(1)* 10 GHz	EADS 50 GHz	(2)* 10 GHz	EADS 50 GHz
e	2.95	3.11	3.4 \pm 0.05	3.6 \pm 0.1
tand	0.0028	0.0058	0.0027	0.004
Ins. Loss dB/mm	n.a.	0.052	n.a.	0.07
* Remarks: (1) Datasheet Taconic (2) Datasheet Rogers n.a.: not available				



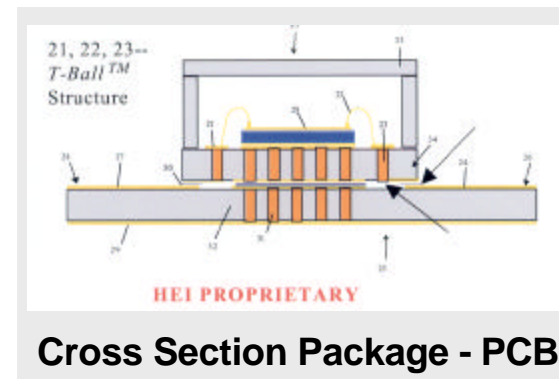
Test-Fixture: WILTRON

SMT Packages up to 50 GHz

e.g. Low Noise Amplifier (LNA)

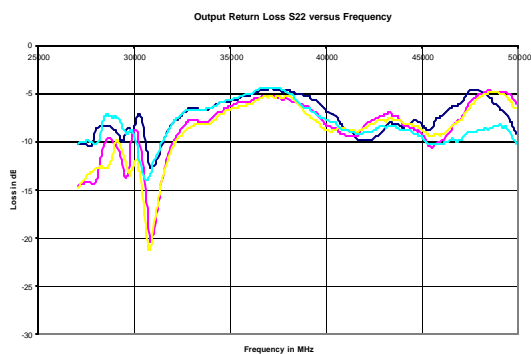


Data Sheet Bare Die

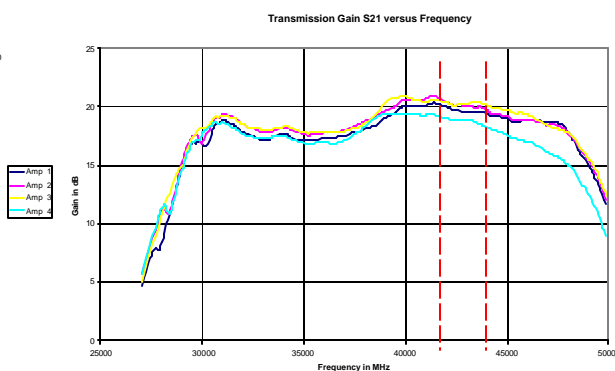


Cross Section Package - PCB

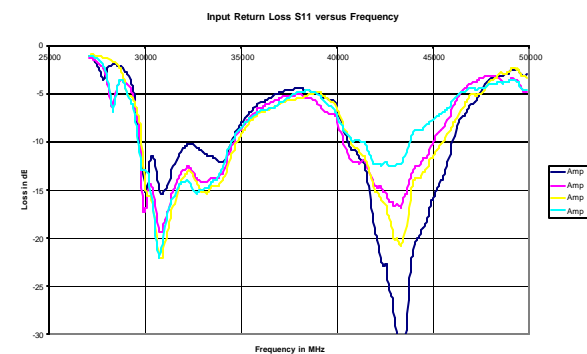
Measurement and Characterization Dr. K.-E. Schmegner, EADS



Input Return Loss



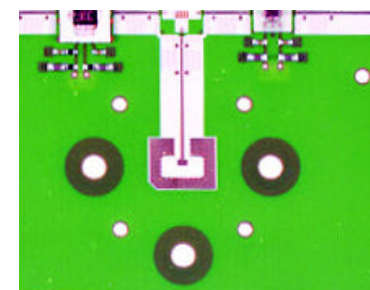
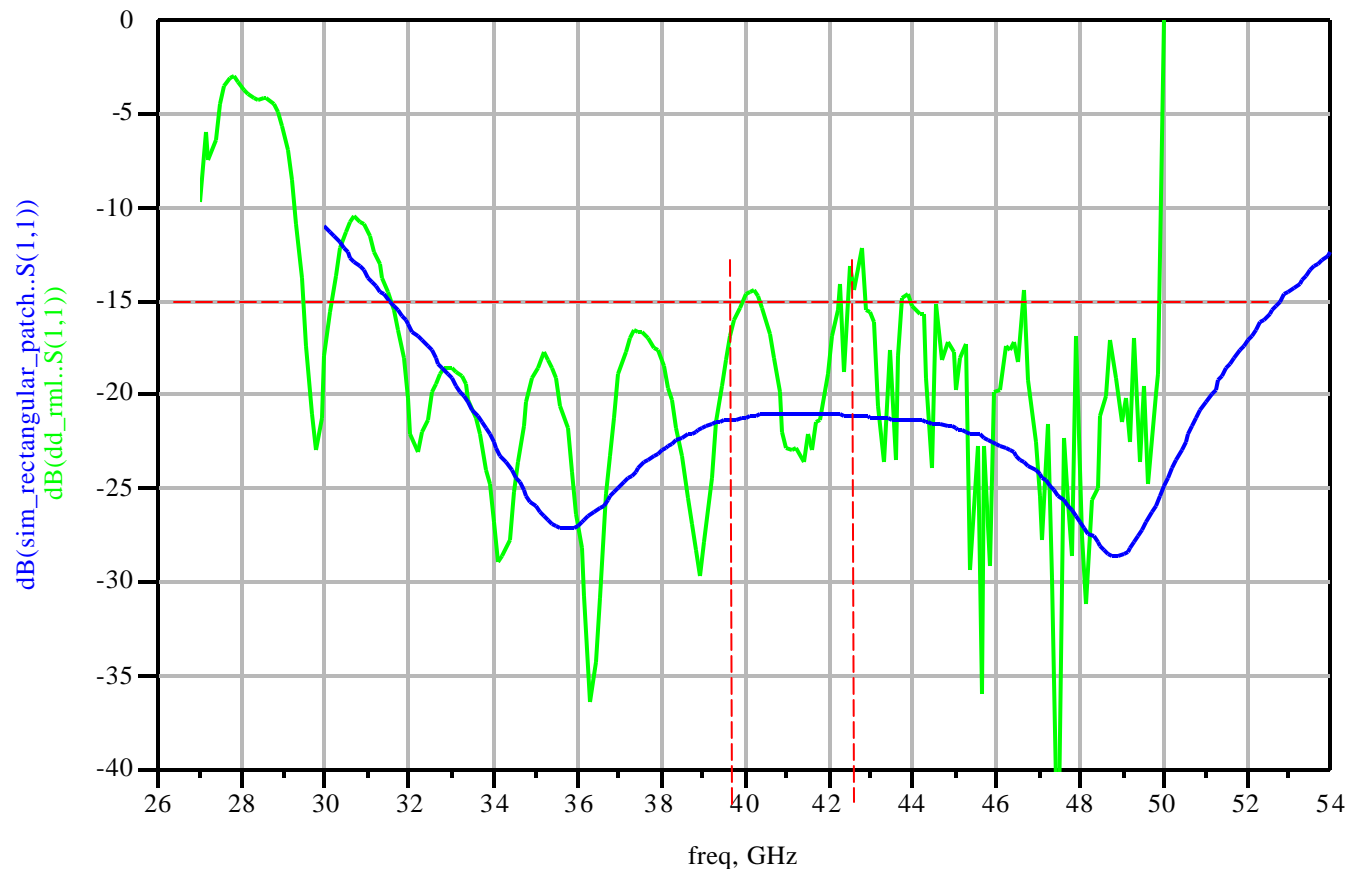
Transmission Gain



Output Return Loss

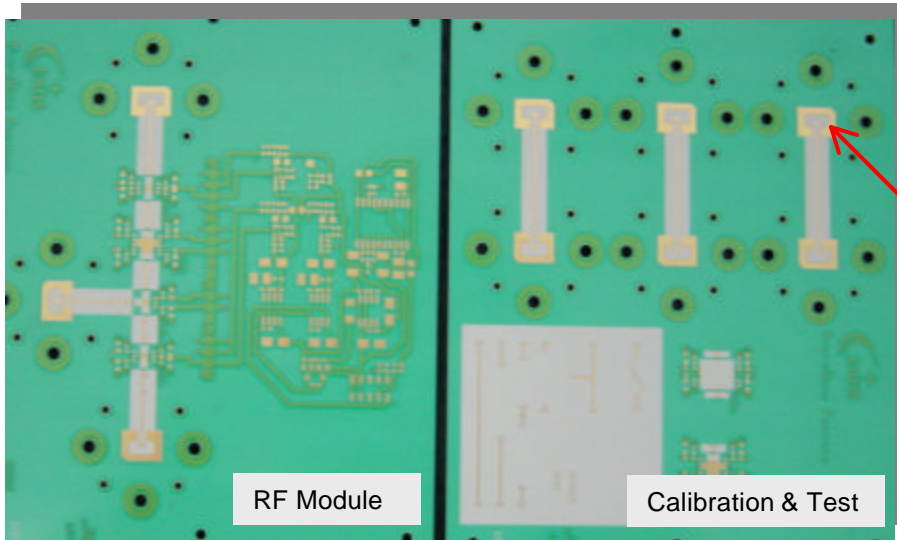
PCB integrated Wave Guide to Microstrip Line (WG-MSL)

Example: 42 GHz WG-MSL Transition - Reflection

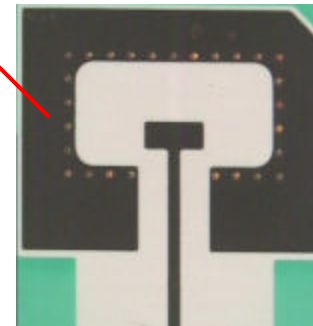


WG-MSL Transition on RO 4003, 8 mil

RF PCB: TacLam Plus (150 μm) on FR4



Material Support Manufacturing TACONIC, IRL
VARIOPRINT, CH



Detail (5x)
Front Side
WG-MSL

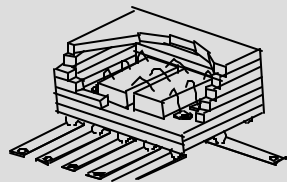


Detail (10x)
Back Side
metallised Cavity
TacLam/FR4

Courtesy @VARIOPRINT AG (25/11/2002)

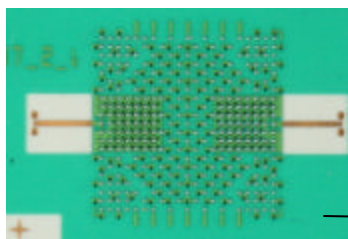
SMD Macro Module based on Multi Layer Ceramic (MLC)

Macro Module based on MLC
(Multilayer Ceramic), e.g. LTCC

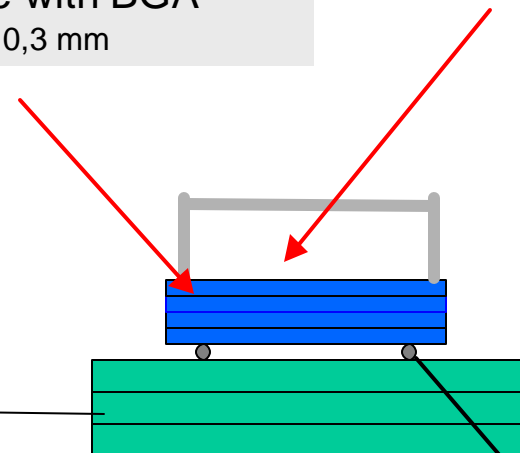


LTCC plus Thin Film 'on top'
(e.g. Filter, Resistor, Coupler)
LTCC backside with BGA
pitch: 0,7 mm, Ball: 0,3 mm

Inside Assembly:
Chip&Wire, Flip-Chip
Ball-, Stud-Bumping

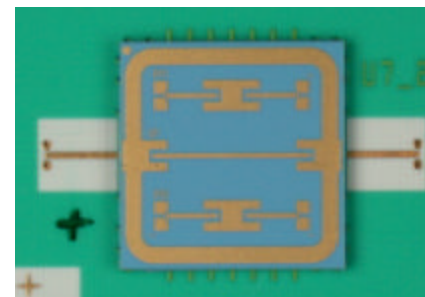


Footprint on RF PCB



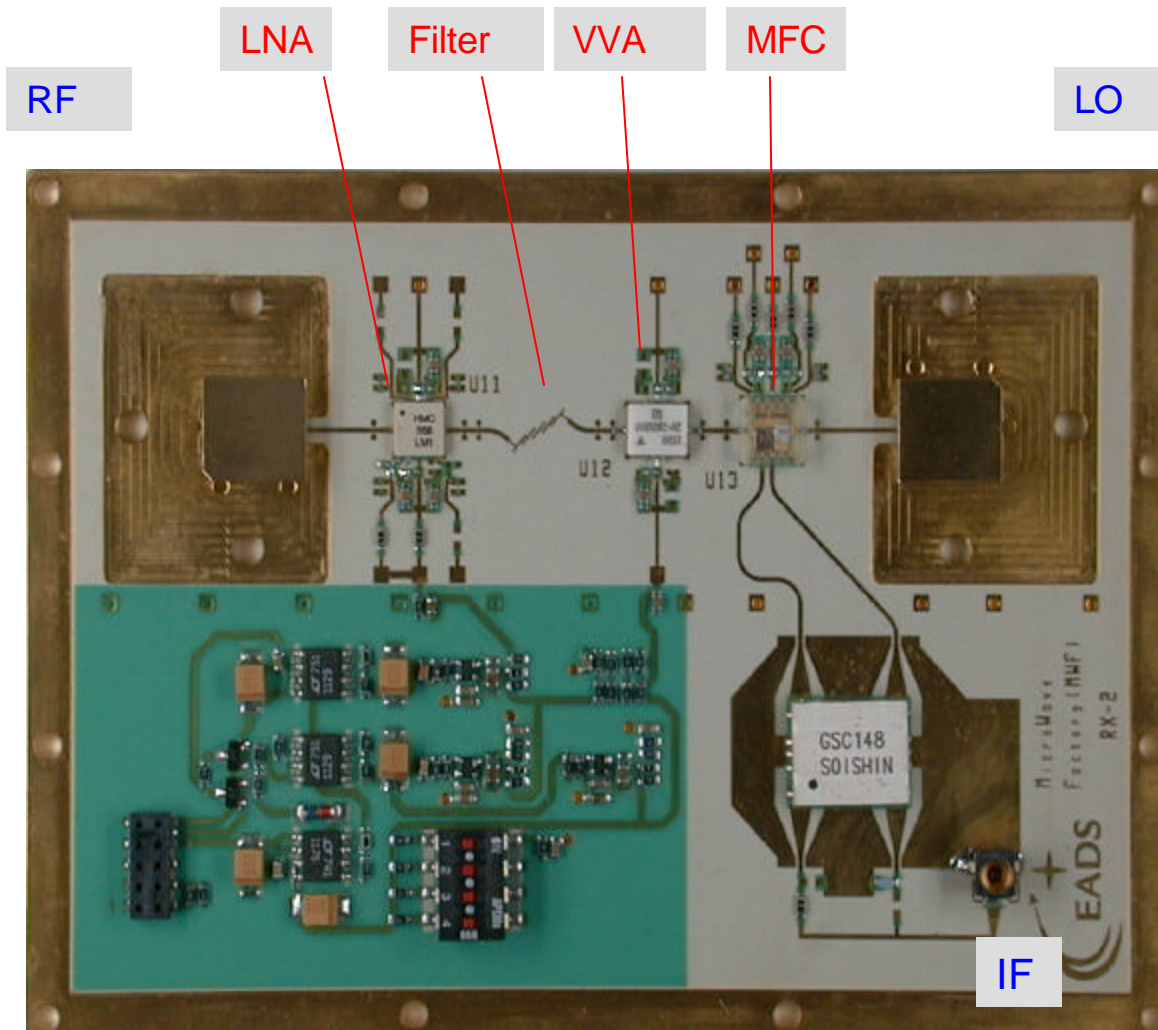
BGA (Ball)
CGA (Column)

LTCC package mounted on PCB
(through line teststructure)



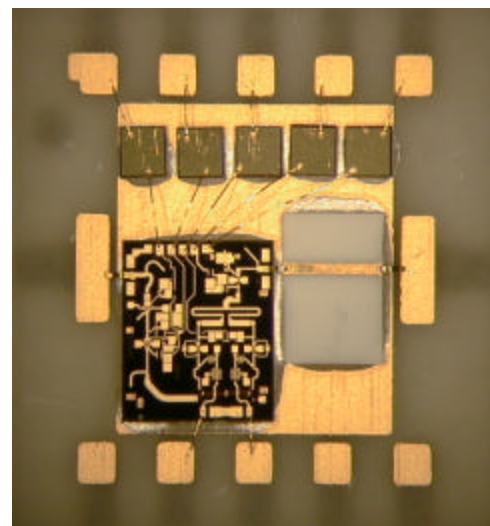
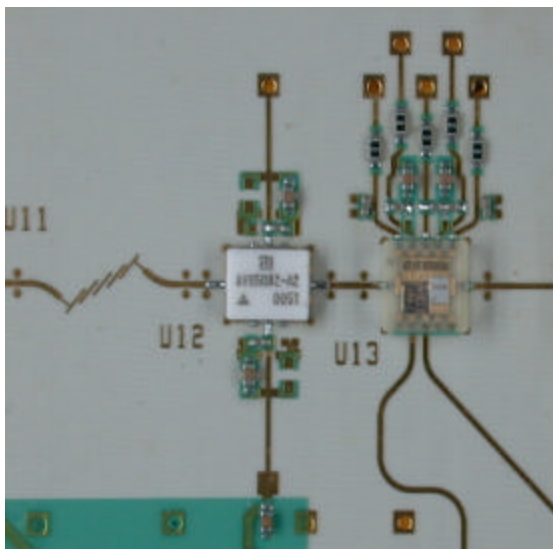
Design T. Müller, EADS

RO4003 laminated on Brass and FR4 multilayer (Demonstrator)

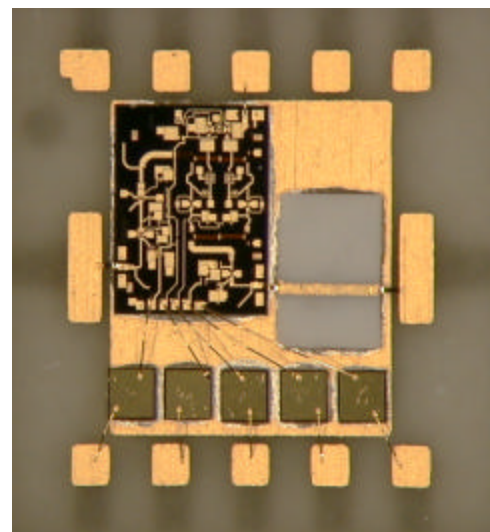


LMDS 42 GHz Receiver Module
RF SMT Devices

- Low Noise Amplifier
- Variable Voltage Attenuator
- Multifunction Chip (MMIC)



Down Converter
DO42, UMS



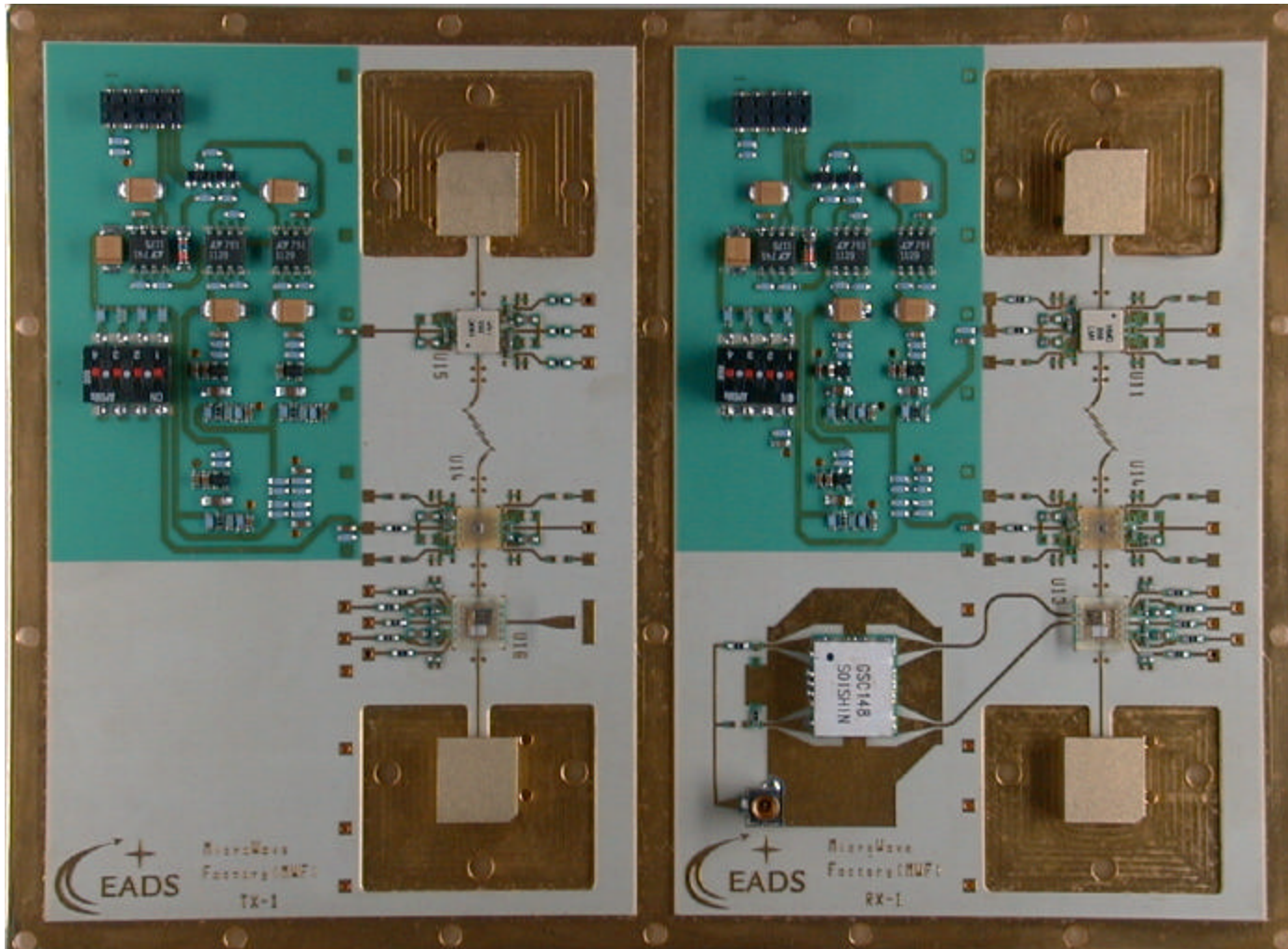
Up Converter
UP42, UMS

LMDS 42 GHz
Demonstrator
Detail of RO4003 layer

Airborne Systems MicroWave Factory



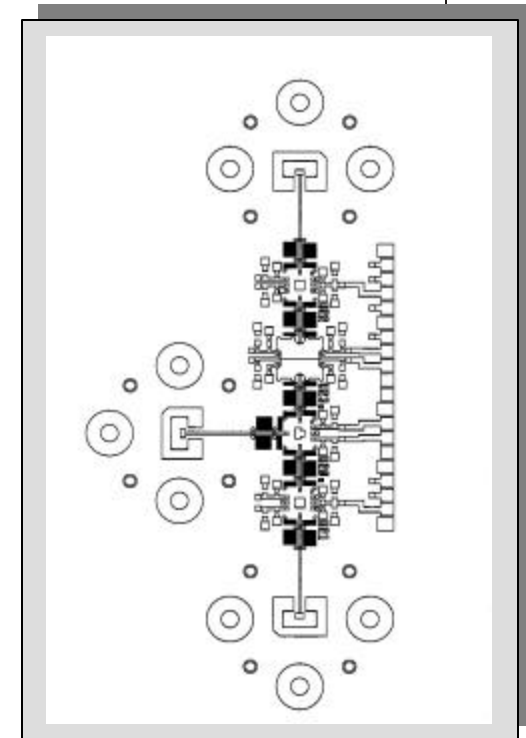
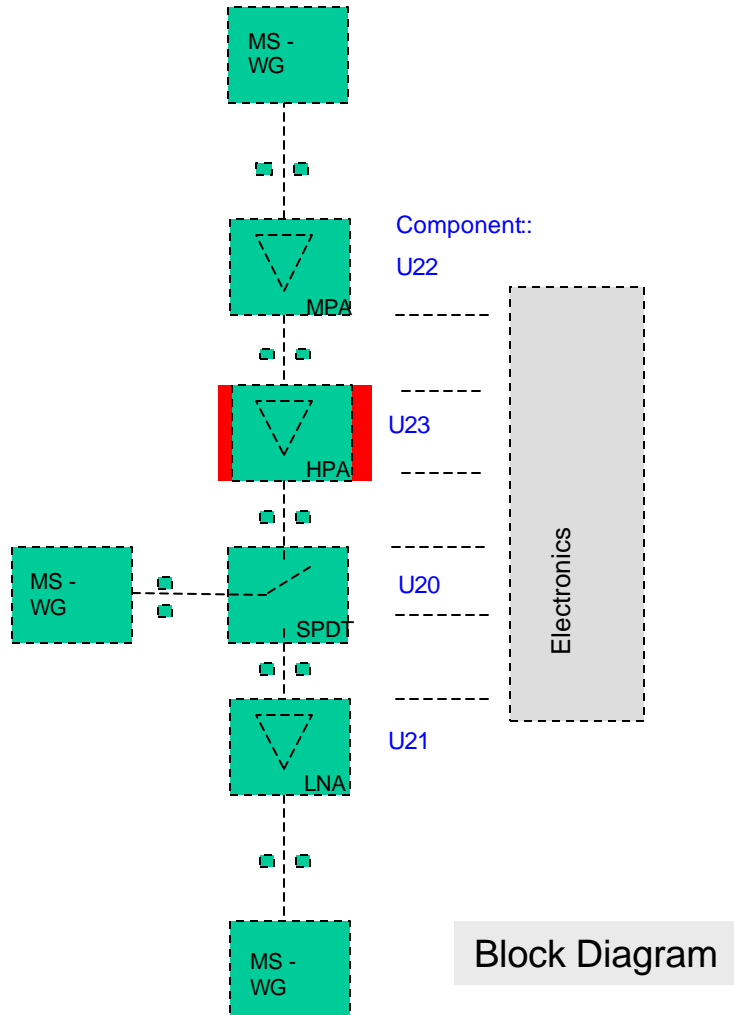
Main Characteristics	RF frequency range	40.5 - 42.5 GHz
	LO frequency range	39.5 - 40.5 GHz
	IF frequency range	0.9 - 2.15 GHz



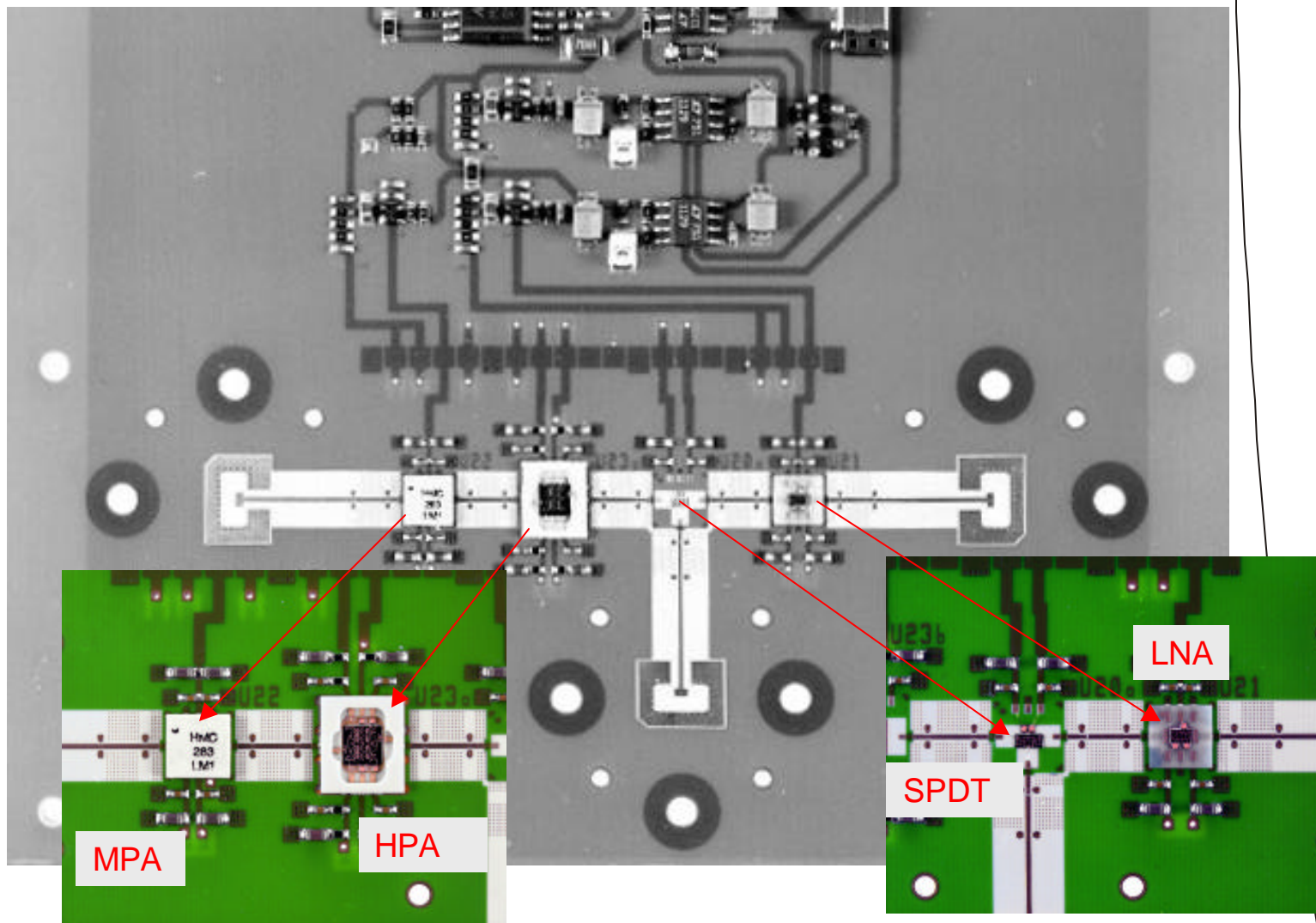
LMDS 42 GHz
Transceiver

SMT components
RF and Electronics

LMDS Key Components on RF PCB (1) (Demonstrator)



LMDS Key Components on RF PCB (2) (Demonstrator)



Antennas for Broadband Wireless Access and High Data Rates



Directive Antenna
Nokia, 58 GHz

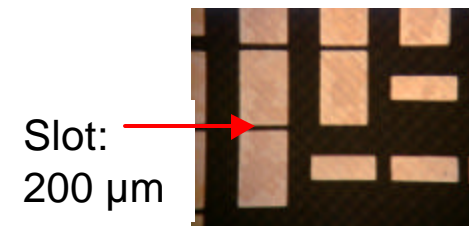
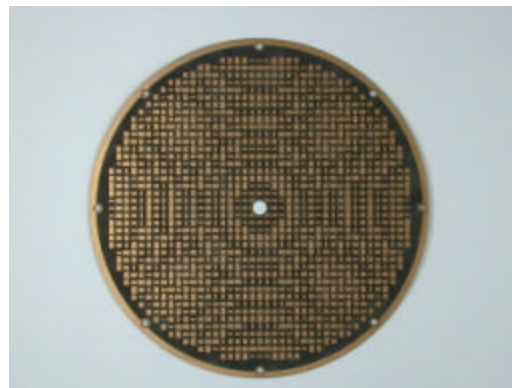
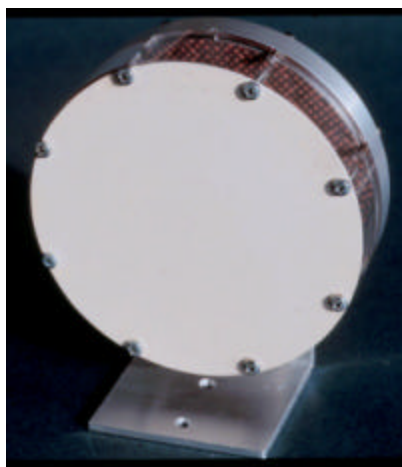


Basestation Antenna
Transrapid, 38 GHz

Technology based on planar printed structures

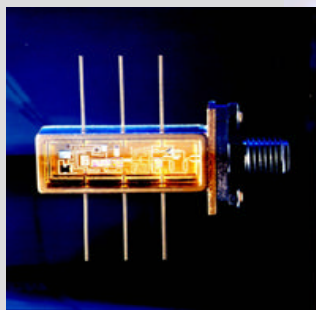
Demonstrator

Folded Reflector Antenna, 58 GHz (Dr. W. Grabherr, EADS in co-operation with University of Ulm)

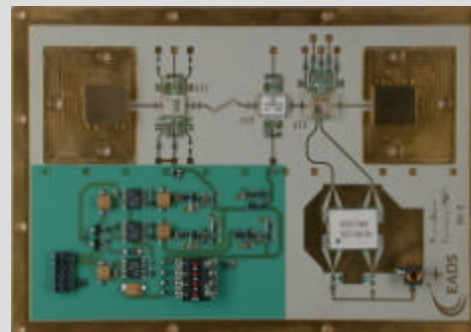


Benchmarking Issues (1) - Where will Module Costs go for?

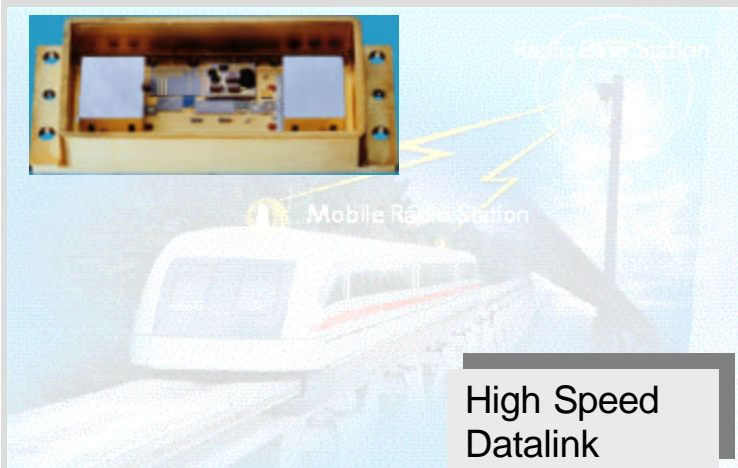
Modules in Focus



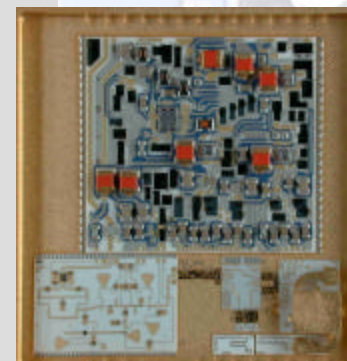
Industrial Sensor



Com LMDS

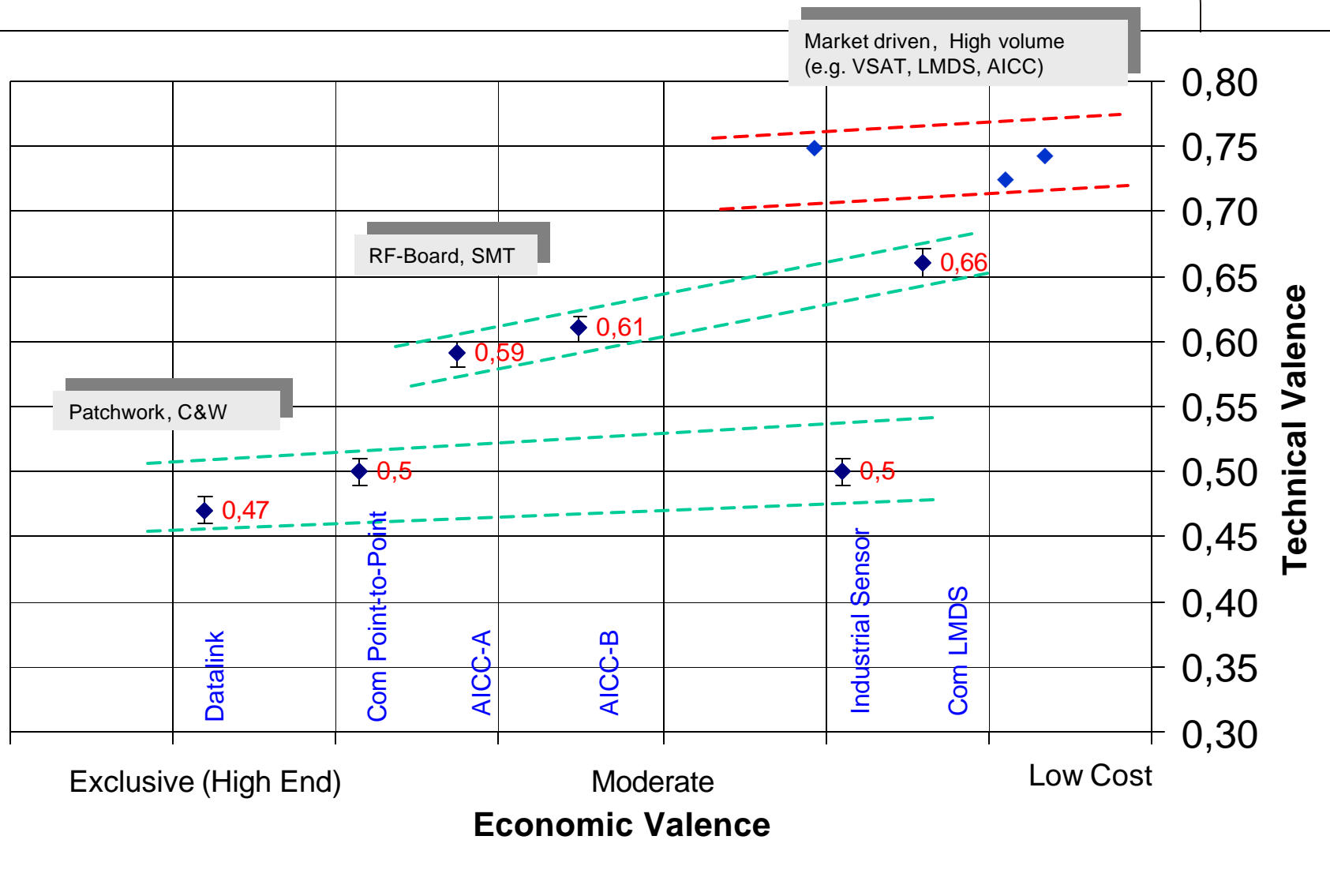


High Speed Datalink



Com Point-to-Point

Benchmarking Issues (2)



Summary - Outlook

New Materials and Components available

- RF Soft-Substrates (MCM-L)
- SMD like Assembly for RF and DC
- Multilayer Ceramics, MCM-C (Optimized Thermal Management)
- Packaged MMICs and Chip Sets

Challenge for Universal 'Box of Bricks', Core-Components and Sub-Units

- Rx, Tx Architectures very similar
- Layout and Redesign of PCBs in Short Cycle Times
- RF Design with "Catalogue" Products

Identification of Critical Tasks for Module Manufacturing

- Reliability (Components, Materials)
- Usage of 'Known Good Submodules', e.g. Single RF Packages

Optimized Module Architectures (Power Consumption, Size, Modularity)

Communication of Strategy and Roadmaps to the Customer very essential to 'Win the Module Evolution'

MicroWave Factory

