



High Density Packaging for Mixed Signal Applications

Art of Technology

- **Experts in Miniaturization of Electronic Systems**
 - Follow up of the EC-Project EUROPRACTICE MCM
 - Founders are active in miniaturization since 1995
 - Demonstrated in many successful projects
- **AoT supplies the practical skills needed to make HDP/MCM-technologies available**
 - Consulting and contracting at detailed technical level
 - AoT is NOT a hardware manufacturer
- **Company Headquarters in Zürich Switzerland**



EUROPRACTICE
MCM SERVICE



Agenda

- **Design Challenges of Today**
- **What is High Density Packaging?**
- **HDP/MCM Advantages**
- **Best Practice Application Examples**
- **How you can benefit from HDP/MCM**



Design Challenges of Today

- **High **SYSTEM** performance**
 - IC performance is only one factor in SYSTEM performance
 - System performance is strongly affected by packaging
- **Small Size and Weight**
 - A vast number of applications require or benefit significantly from small size and light weight of electronics
 - Can't always put everything on one ASIC
 - Especially in the "mixed-signal" environment
- **Total System Cost**
 - „It's the overall cost that counts!“
 - Minimizing the cost of each component without regard to the total system can result in a higher than necessary total cost



Today's application areas: Mixed-Signal

- **Medical**
 - Pacemakers, Internal Defibrillators, Hearing Aids, Drug Dispensers, Heart Rate Monitors, Flow meters
- **Consumer**
 - Handhelds (Cell Phones, PDAs), Security Sensors (GPS locator in lifejacket), Toys, Remote Controls Cameras, Sporting Gear (Body-function Monitors), GPS devices, Sensor telemetry through GSM
- **Industrial/Aerospace/Automotive**
 - Automotive parts (GPS, toll tags), Wireless Systems Pressure & Flow Meters, Security Systems, Industrial Process Control (Temp., Pressure Sensor), Laser Barcode Scanners, Intelligent Sensors, Communication



Mixed Signal: Not easy to integrate...

- Low noise requirements in sensor applications
 - High power needed to drive motors or heavy loads
 - Optical coupling for isolation
 - When only a certain volume and limited design time is available
 - **Incompatible technologies needed in a single device**
 - Communications: GaAs for serial data, Si CMOS for parallel logic
 - RF applications: SiGe for the RF, Si CMOS for the rest
 - If you are using optical communications or interconnects
 - Lasers and LEDs are made from III-V and II-VI alloys and cannot be made from Si
 - If you need opto-isolation of some inputs
- ➔ **High Density Packaging (HDP/MCM) helps in solving these issues, thus achieving system objectives**

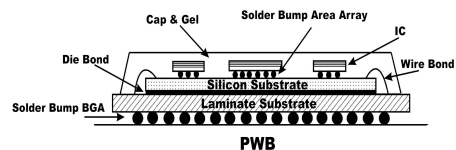


What is High Density Packaging ?



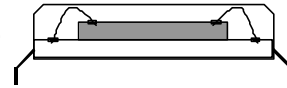
What is High-Density Packaging (HDP/MCM)

- **Mount unboxed chips („bare dies“) directly onto a highly integrated circuit board („substrate“)**
 - Think of this as an advanced PCB or as a high-function IC package
 - Requires more precise assembly technologies than traditional PCB
 - The substrate provides very efficient interconnections
- **An HDP/MCM-Module can be**
 - a complete System
 - or part of a System
- **Very significant advantages over SMD/PCB:**
 - Size reduction (up to 5x)
 - Smaller than PCB/SMD, larger than ASIC
 - Performance improvement over SMD/PCB approach



What is High-Density Packaging (HDP/MCM)

- **Until now** every single Chip has been packaged into a package (SCP) and was then assembled onto a PCB board (through hole, SMD)

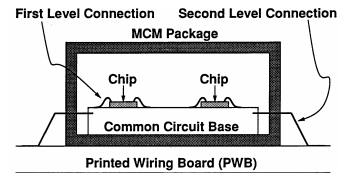


Single - Chip - Package



Chip - on - Board

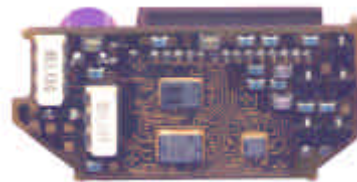
- **Now unpackaged Chips are used. They will be assembled:**
 - either directly onto the PCB board (COB) or
 - several Chips together into a package (MCP) and then onto a board.



Multi - Chip - Package

What is High-Density Packaging (HDP/MCM)

COB



MCP



Module Substrate Alternatives

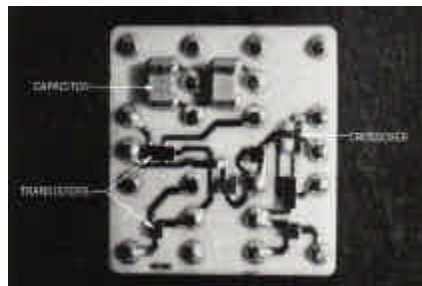
- **Many alternative substrate technologies:**
 - **PCBs (e.g. Reinforced Epoxy FR4/5, BT)**
 - Poor thermal dissipation
 - Line width 75-750 microns, pitch 100-1000 microns
 - Cost per cm² low
 - **Ceramics (e.g. Al₂O₃, AlN)**
 - High thermal dissipation
 - Line width 90-125 microns, pitch 125-375 microns
 - Cost per cm² moderate
 - **Thinfilm on various bases (e.g. Cu/BCB on Glass)**
 - Thermal dissipation high
 - Line width 15 microns, pitch 25 microns
 - Cost per cm² high



HDP/MCM is NOT a New Idea

- **IBM “SLT” Technology 1963**

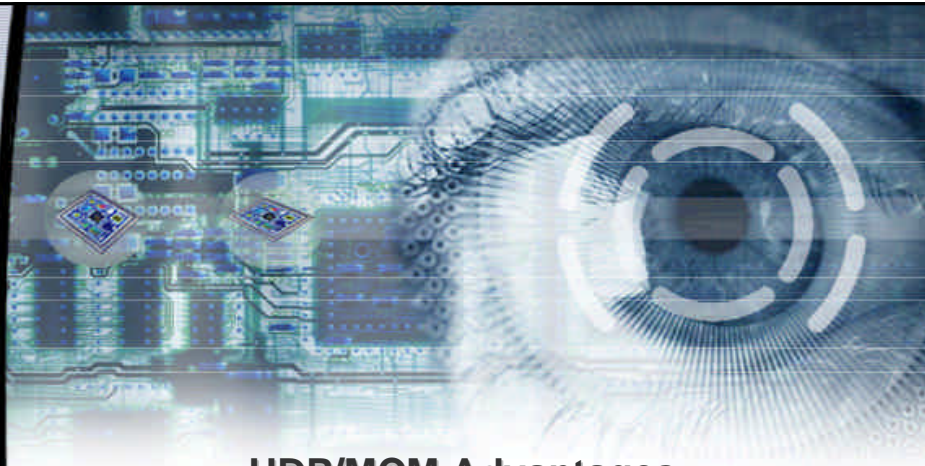
- Discrete components mounted without encapsulation onto a ceramic PCB ½ inch square by means of solder bumps
- In a 1971 internal IBM study “SLT” was shown to have been significantly more cost-effective than early IC technology.



An IBM Internal study in 1971 concluded that SLT was:

- **Since 1963 IC technology has developed a great deal... but so has packaging technology!**

“The major technological factor in IBM’s success in the 1960s”



HDP/MCM Advantages



Advantages of HDP/MCM over PCB/SMD

- **Small Size**
 - 20%-60% of PCB/SMD designs
 - Improved package efficiency
- **Improved Performance**
 - Short interconnection lengths
 - Reduced time of flight, Lower power supply inductance, Lower capacitance loading, Less power required
 - Lower cross talk, Low noise
 - Lower off-chip driver power, High wiring density, Less complex board
- **Cost benefits realized at system level**
 - Less complex system PCB, meeting a given form factor



Advantages of HDP/MCM cont'd.

- **Better protection against EMC and EMI**
 - Shorter Connections between IC's (less "antenna" effect)
 - Smaller areas to shield
- **Increased Modularity and Reusability of subsystems**
- **High Reliability**
 - Fewer solder joints in package
 - Smaller modules are easier to protect from harsh environments
 - Smaller (lighter) modules less prone to damage from physical shock (dropping etc.)



Advantages of HDP/MCM over ASICs

- **Faster time-to-market than ASIC**
- **Investment cost for HDP/MCM is much less**
- **HDP/MCM modules can include**
 - RF Receivers or Transmitters
 - Sensors operating on very low currents (sensitive to noise)
 - Power control or management devices (Zeners, Diodes etc.)
 - Large Memories
- **Simplify ASIC Design**
 - Sometimes routing signals in substrate can substitute for long heavily RC loaded on-chip lines.
 - Memories and other cores can be added as off-the shelf components instead of integrating into a large ASIC.
- **When you need very high performance...**
 - Used by IBM (and others) for high-end multiprocessors



Application Examples



HDP/MCM – Best Practices

- **Wearable Health Monitor**
(Size, Weight, Power consumption)
- **GPS-MS1**
(Modularity, Performance)
- **Antenna Switch**
(Cost, Complexity, Performance)



Wearable Health Monitor - System

International Research Project AMON (AoT responsible for system integration)

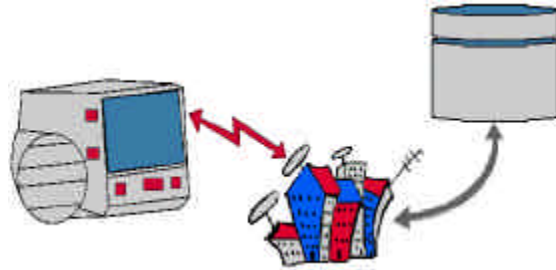
- Wrist Wearable Medical Device for heart patients
- Communication interface to telemedicine center
- Need to meet certain form factor („wrist“)

Variables Measured

- Temperature
- Pulse
- ECG
- Blood Pressure
- Blood O₂

Special Features

- Emergency Button



Health Monitor Prototype - Technologies


- Communication
 - **GSM (SMD)**
- Sensors
 - **Still bulky**
- Data Processing / Control
 - **COB w/ ASIC**
 - **Height reduction**



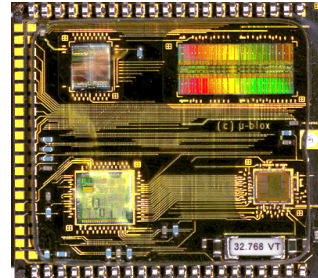
**HDP enables to meet
wrist form factor
already in
prototyping phase**



GPS Receiver Module

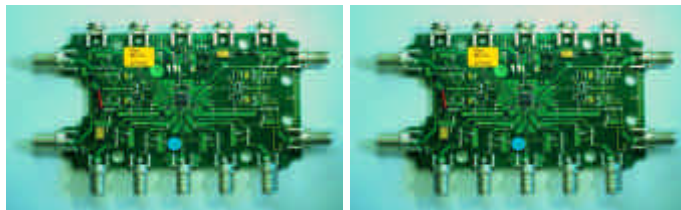
- Product of the ETH-Spin off Company  AG
- Global Positioning Receiver
“from the antenna to position output”
- HDP enabled them to gain market segment since 1997
before actually developing their own chip set

1st generation of μ -blox receiver family

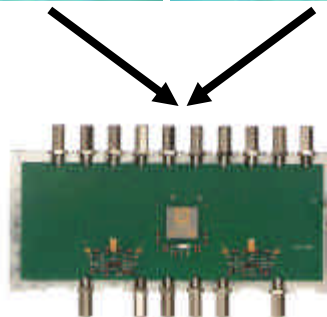


DBS Satellite Multiswitch - System

2 Original PCBs
with 5:4 Switch
@ 2.5GHz



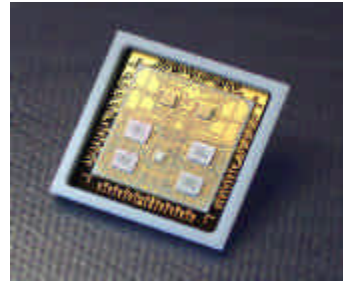
1 PCB with 9:4
Switch @
2.5GHz:
Same
functionality





DBS Satellite Multiswitch - Technology

- AoT development for Hirschmann Electronics GmbH&Co KG, Germany
- Thin film on Ceramic, Termination resistors and coupling capacitors integrated
- Switch for satellite receiver (7 Chips)



9:4 Switch Module

1st level interconnect	Wire bond, cap & gel	Number Layers	2	Designrules	40/60/60
2nd level interconnect	Wire bond to BGA carrier	Size Substrate	17 x 17 mm ²	Specialities	Integrated Passives



HDP/MCM Example Advantages

- **Personal Health Monitor**
 - Standard Components for uC and Memory
 - Mixed with Analog Processing ASIC to minimize component count and minimize noise sensitivity
 - Reduced volume and power consumption
- **GPS Receiver**
 - High Performance Receiver with signal processing unit
 - Provides a complete (sub) system working @ 1.575GHz
 - Minimized volume, easy to design in
- **Antenna Switch**
 - Combined existing ASICs to a larger component (9 instead of 5 inputs)
 - Avoid new ASIC development
 - ASICs can be used for 5 to 4 and 9 to 4 switches
 - Added intelligence to the component (Analog and Digital Protocol instead of Analog only)



Summary

- **Mixed Signal Systems**
 - Often require several IC technologies
 - Are sensitive to noise
 - Often used in mobile Applications (size, weight and power)
 - **HDP/MCM**
 - Combines technology mix without compromising performance
 - Reduces parasitic loads and therefore radiation
 - Eases shielding
 - Reduces size, weight and power consumption
 - Redesign is usually used to increase the functionality
 - **Cost benefits realized at the system level**
 - **Comparison very difficult;**
 - GPS: same price as the larger modules
 - Antenna switch: saves one PCB
- **New products can arise and new markets can be opened by using HDP/MCM**



How you can benefit from HDP/MCM

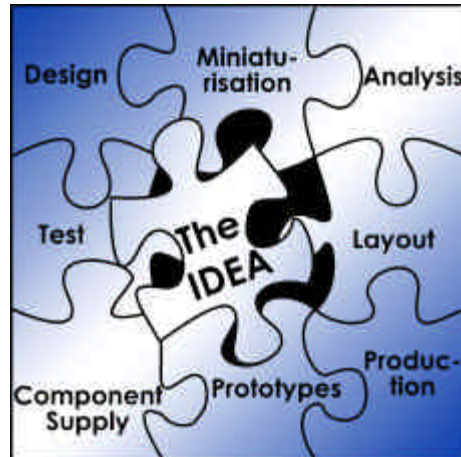


Service of Art of Technology

Art of Technology offers a one stop service to transfer a customers idea into a product

- Development of ideas & solutions
- Feasibility studies
- Component supply
- Technology evaluation
- Design & layout
- Evaluation of manufacturers and continuously accompanying the manufacturing process
- Test & qualification

... using HDP/MCM -technologies



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