

WEMA23

Overview of Integrated Passive Devices (IPD) for RF Front-end Application

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Outline

- ☐ Introduction of IPD
- ☐ IPD Process evolution
- ☐ IPD for NR RF front end
- ☐ IPD for IoT RF front end
- ☐ Summary

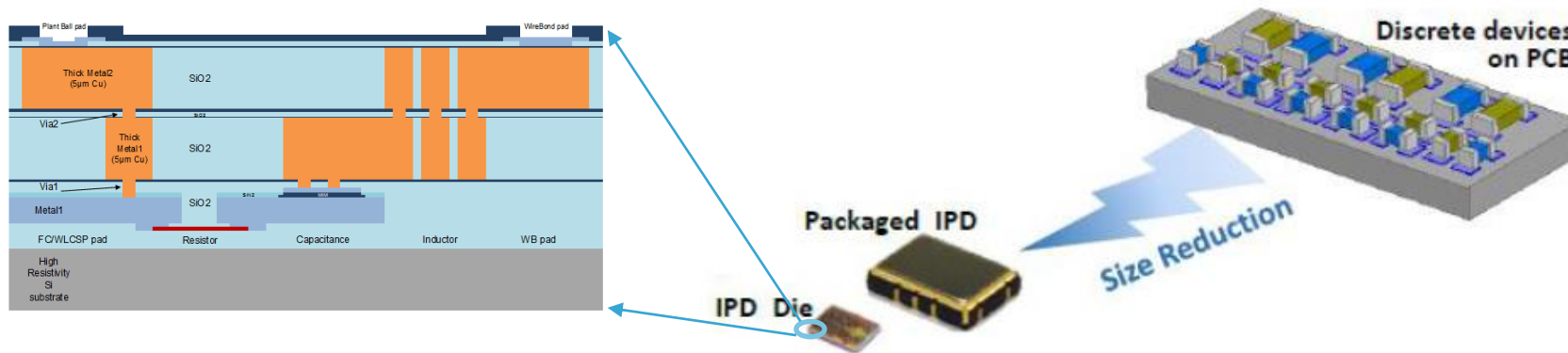
Introduction of IPD

- Integrated Passive Device

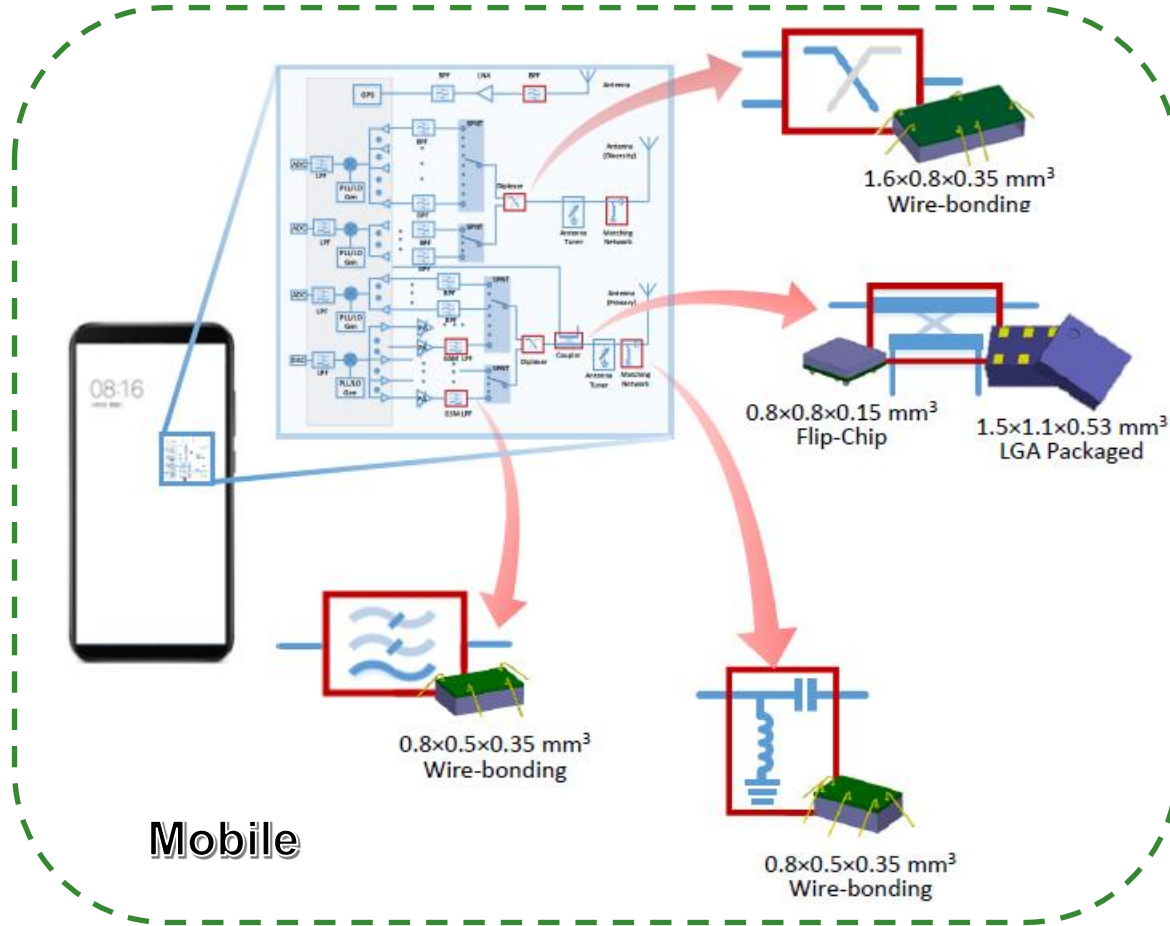
- Thin film process
- High metal conductivity, high substrate resistivity
- Thin film resistor, MIM capacitor, through substrate via, magnetic material...

- IPD advantages

- Small size, low profile, integration friendly, great consistency, low cost
- Size and cost reduction for hand-held, wearable applications

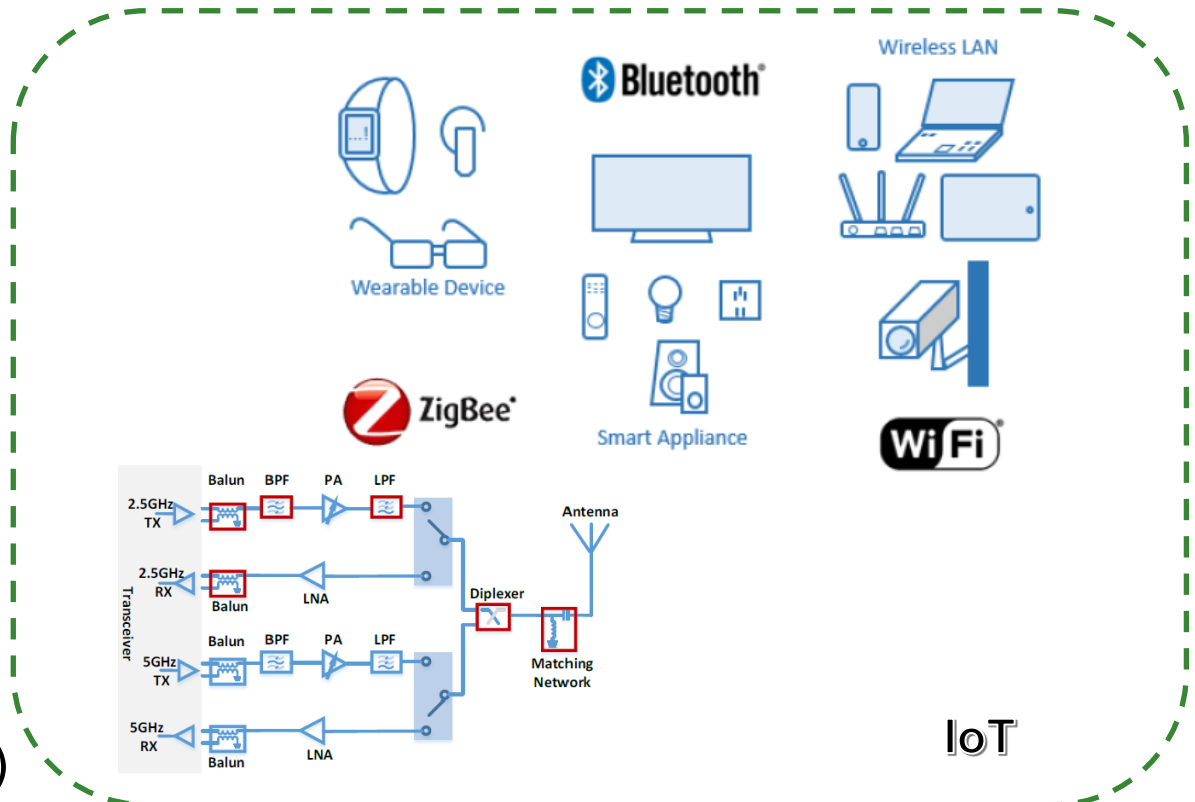


IPD Applications



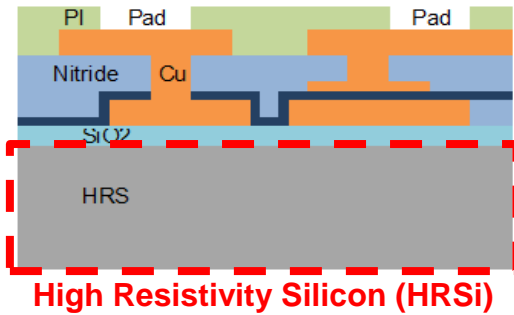
- Constant need for size reduction
 - especially for passives (usually large BOM)

- IPD reduces size
 - Small size, low profile, friendly integration, great consistency, low cost in massive production



Xpeedic's IPD Model

IPD Foundries

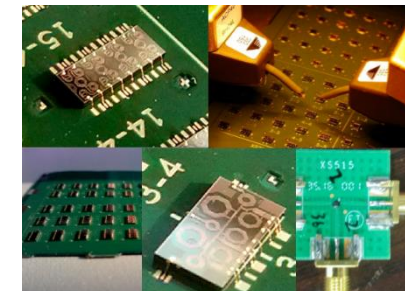
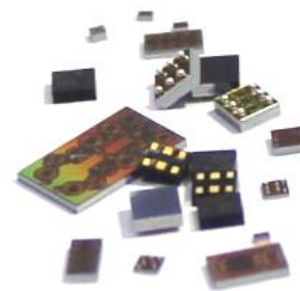
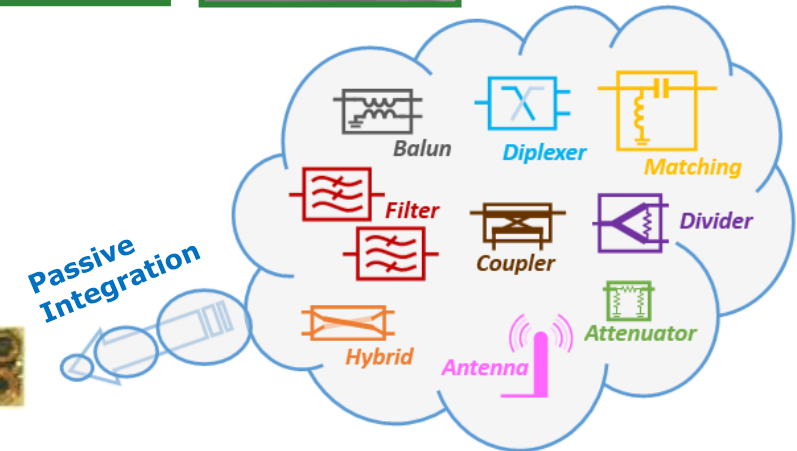
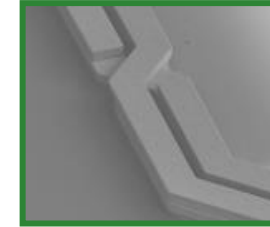
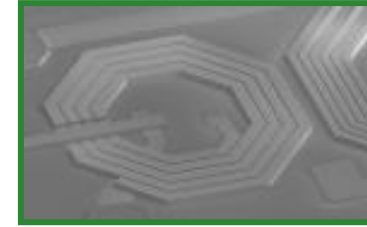
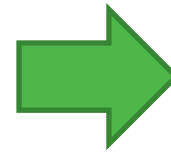


Dedicated EDA Tools

IPD Suite

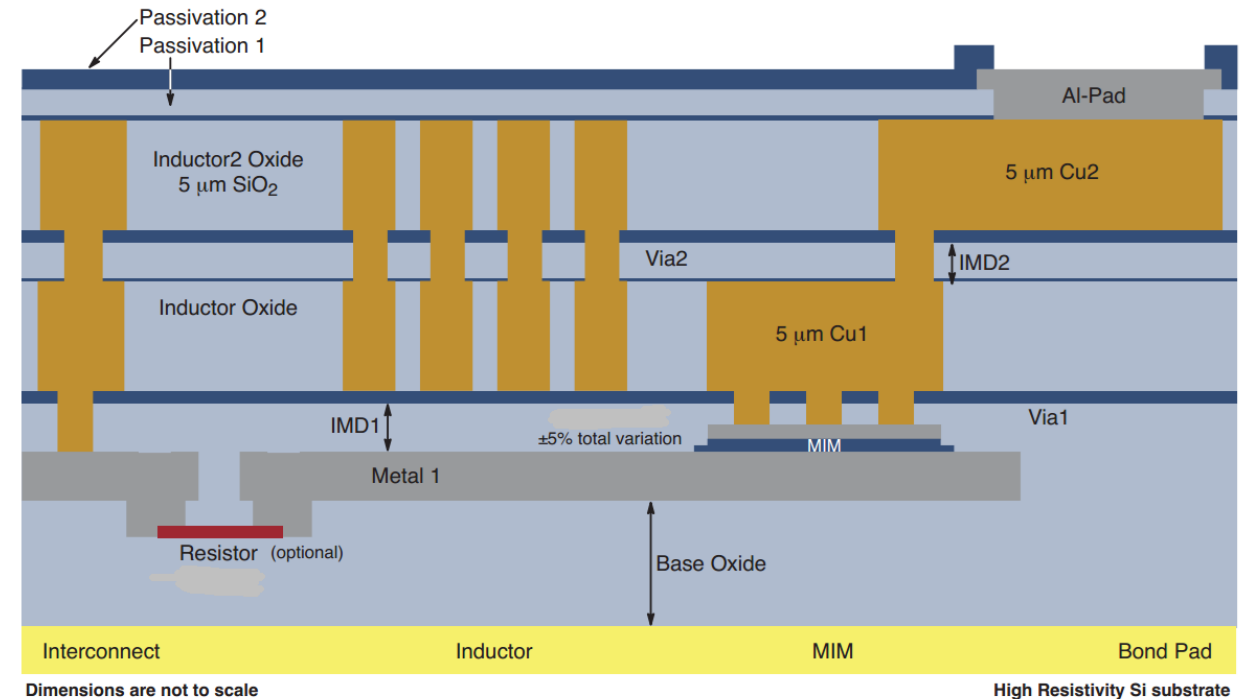


SiP Suite

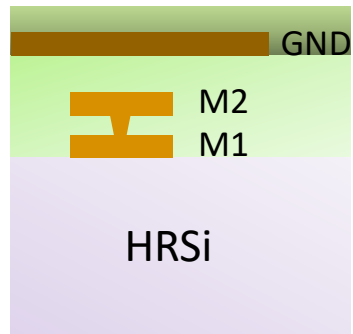


IPD 1.0: HRSi IPD Process

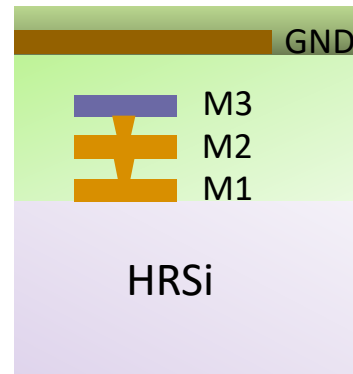
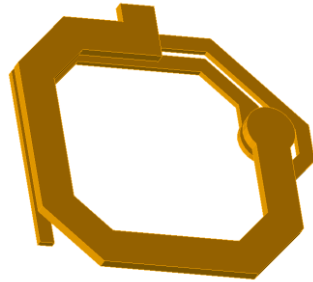
- Thin film process
 - MIM cap with CVD dielectric
 - Ultra thick copper with Damascene process
 - Optional Thin film resistor
- Mostly HRSi
 - Stable and efficient mass production



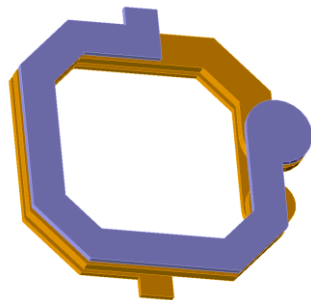
IPD 1.5: HRSi + RDL



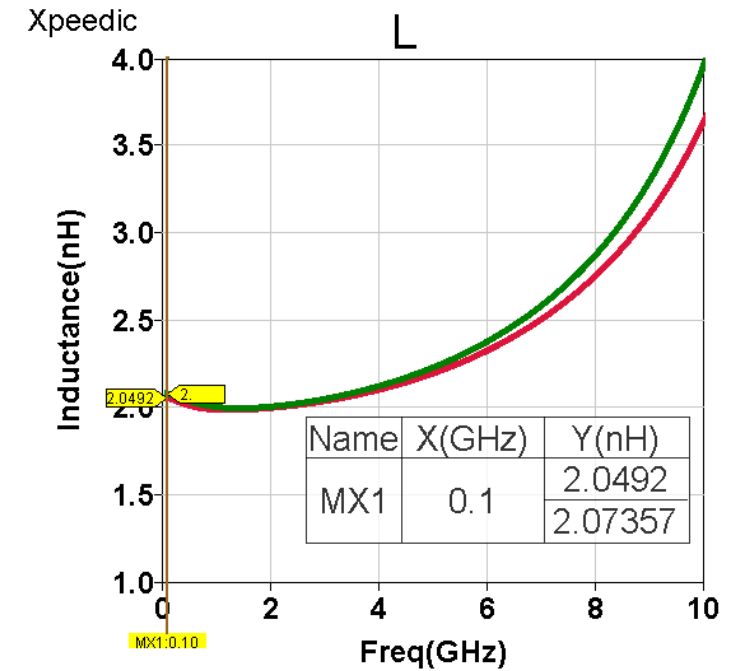
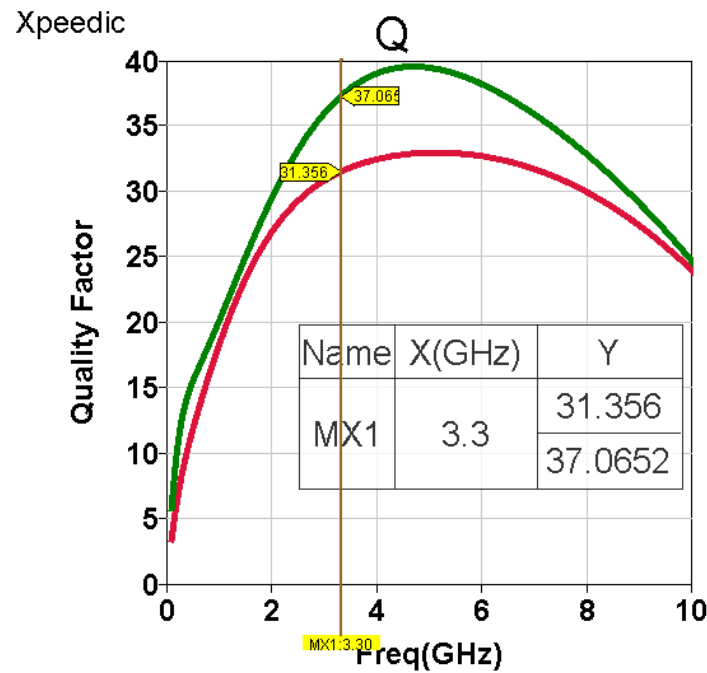
2 layer Cu



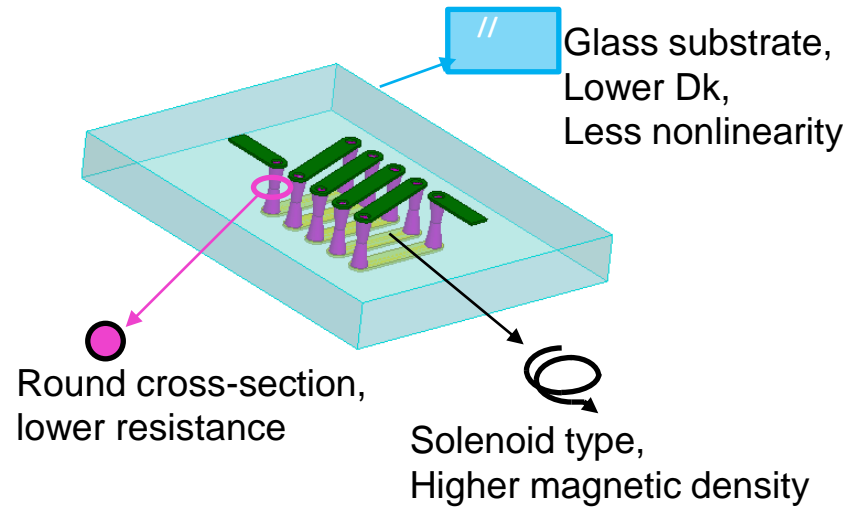
3 layer Cu



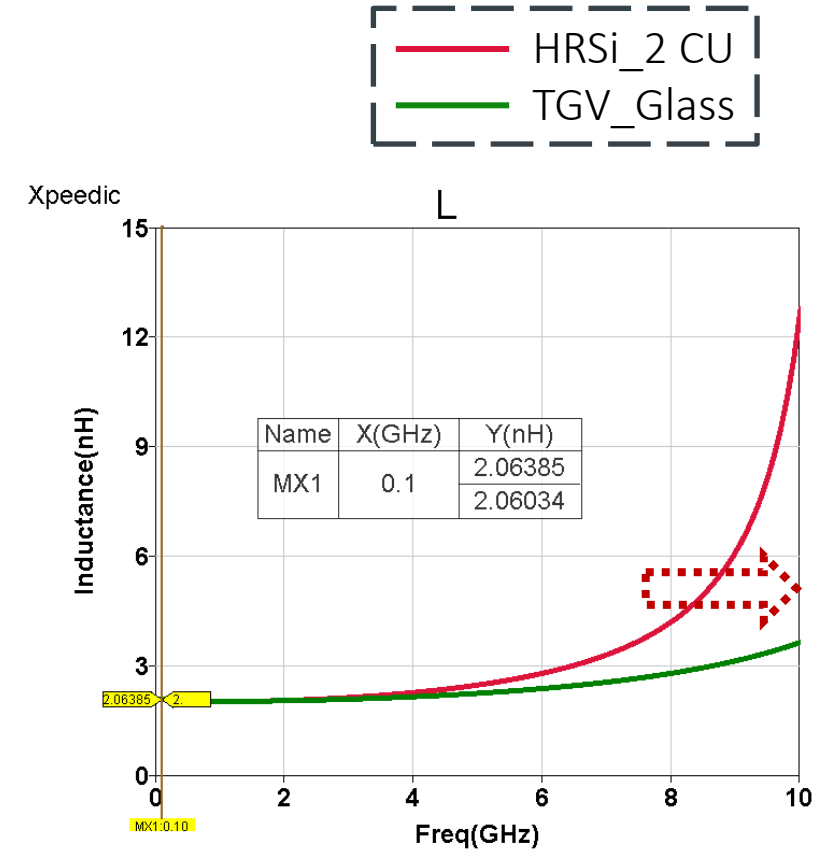
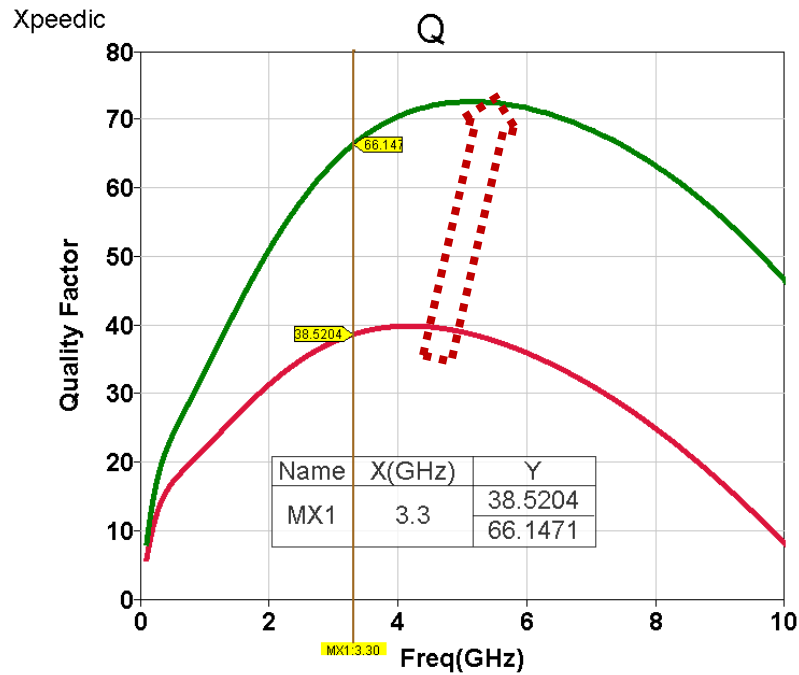
Q improvement ~20%



IPD 2.0: Solenoids by TGV

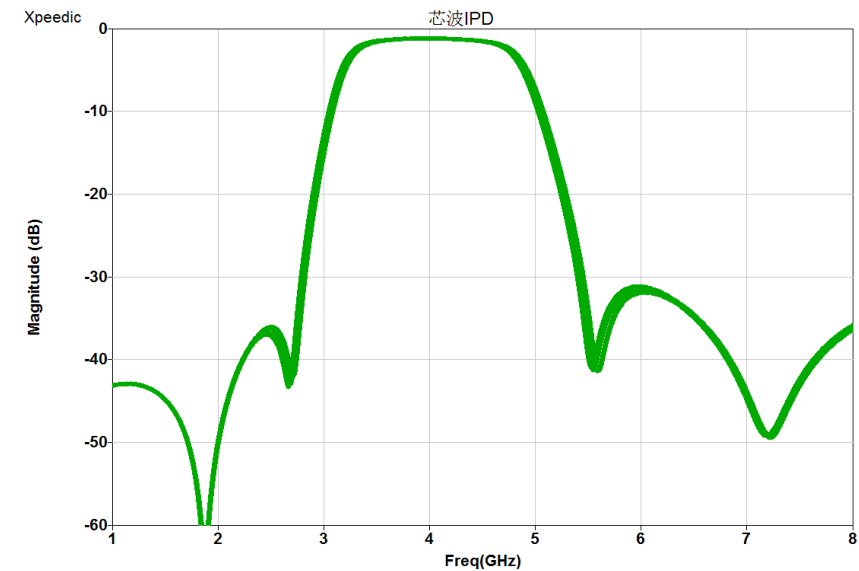


Q improvement >50%



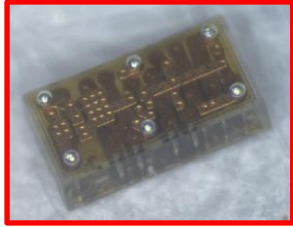
IPD for N77 & N79

- N77 & N79
 - Wide bandwidth, Higher freq.
 - Difficult for acoustic filters
 - Right for IPD
- IPD vs. LTCC for N77 & N79
 - Lower profile
 - Better consistency
 - More for integration
 - evolving process

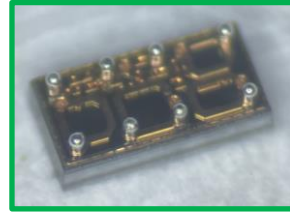


Consistent performance of IPD

TGV vs. HRSi for N77



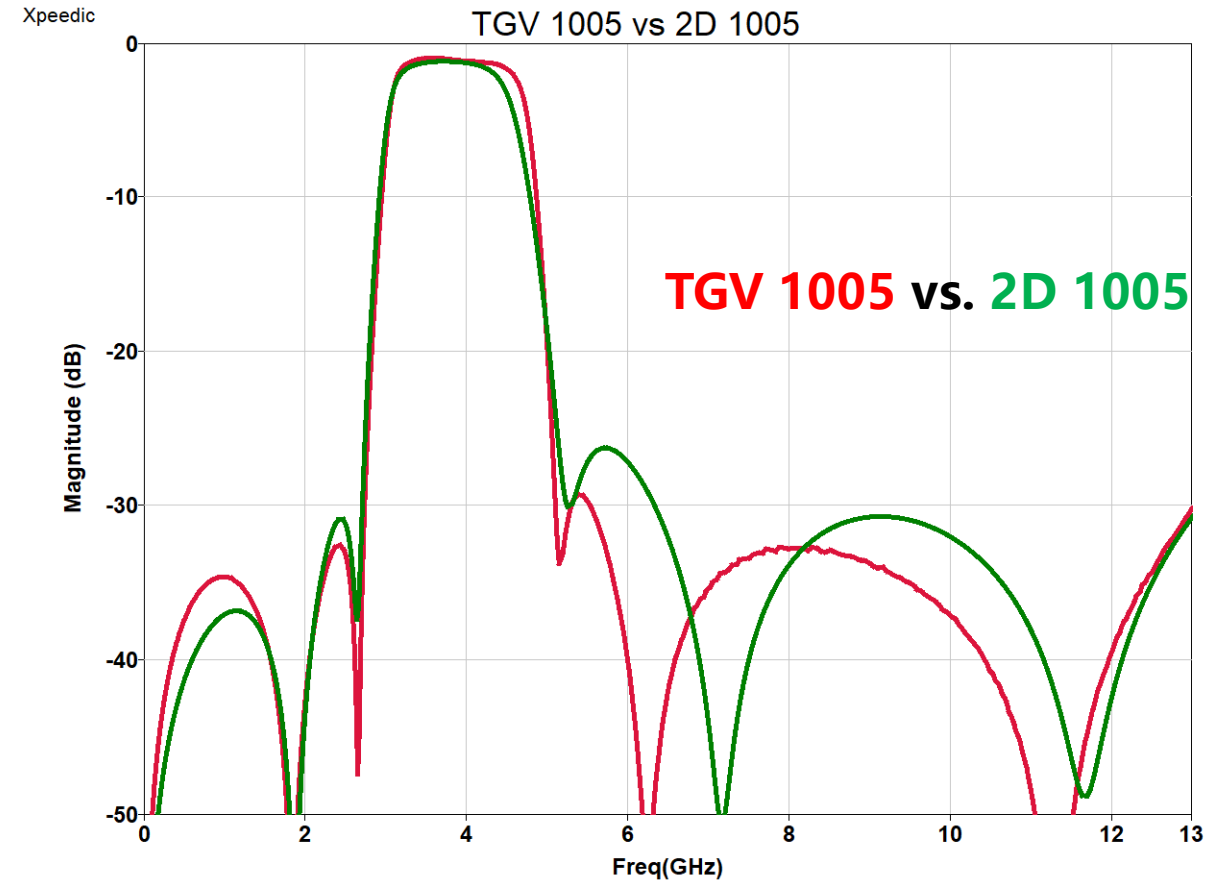
TGV 1005



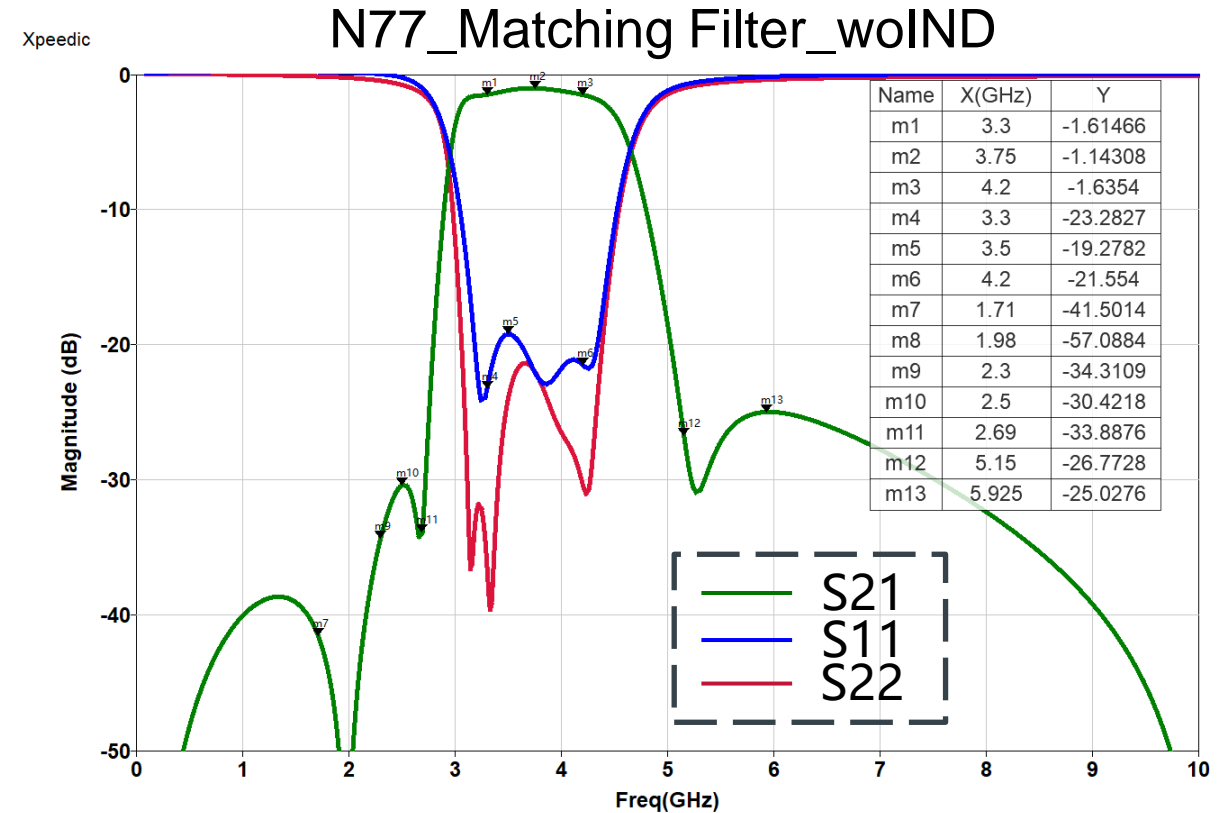
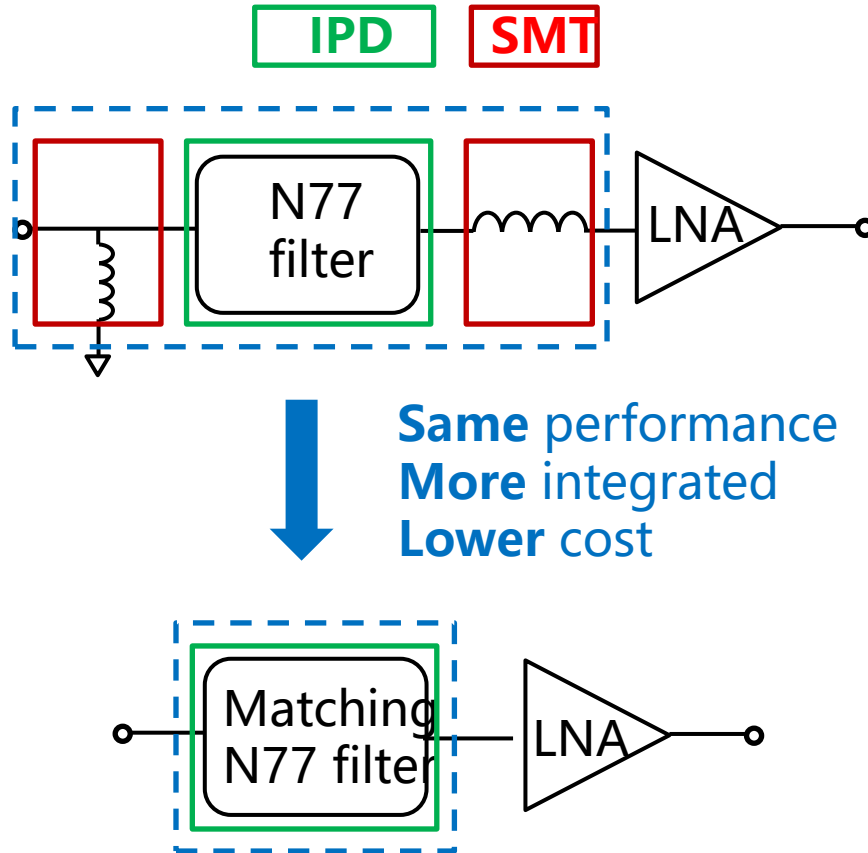
HRSi 1005

20% better IL while 10% better Rejection

Item	Freq.(MHz)	IPD 1005	TGV 1005	Comparison
IL(dB)	3300~4200	1.6	1.3	↑0.3
RL(dB)	3300~4200	20	20	--
RJ. (dB)	1710~1850	42	45	↑3
	2400~2500	30	32	↑2
	2620~2690	33	35	↑2
	5150~5850	27	29	↑2
	5850~5925	30	35	↑5
	6600~8400	32	33	↑1
	9900~12600	31	35	↑4

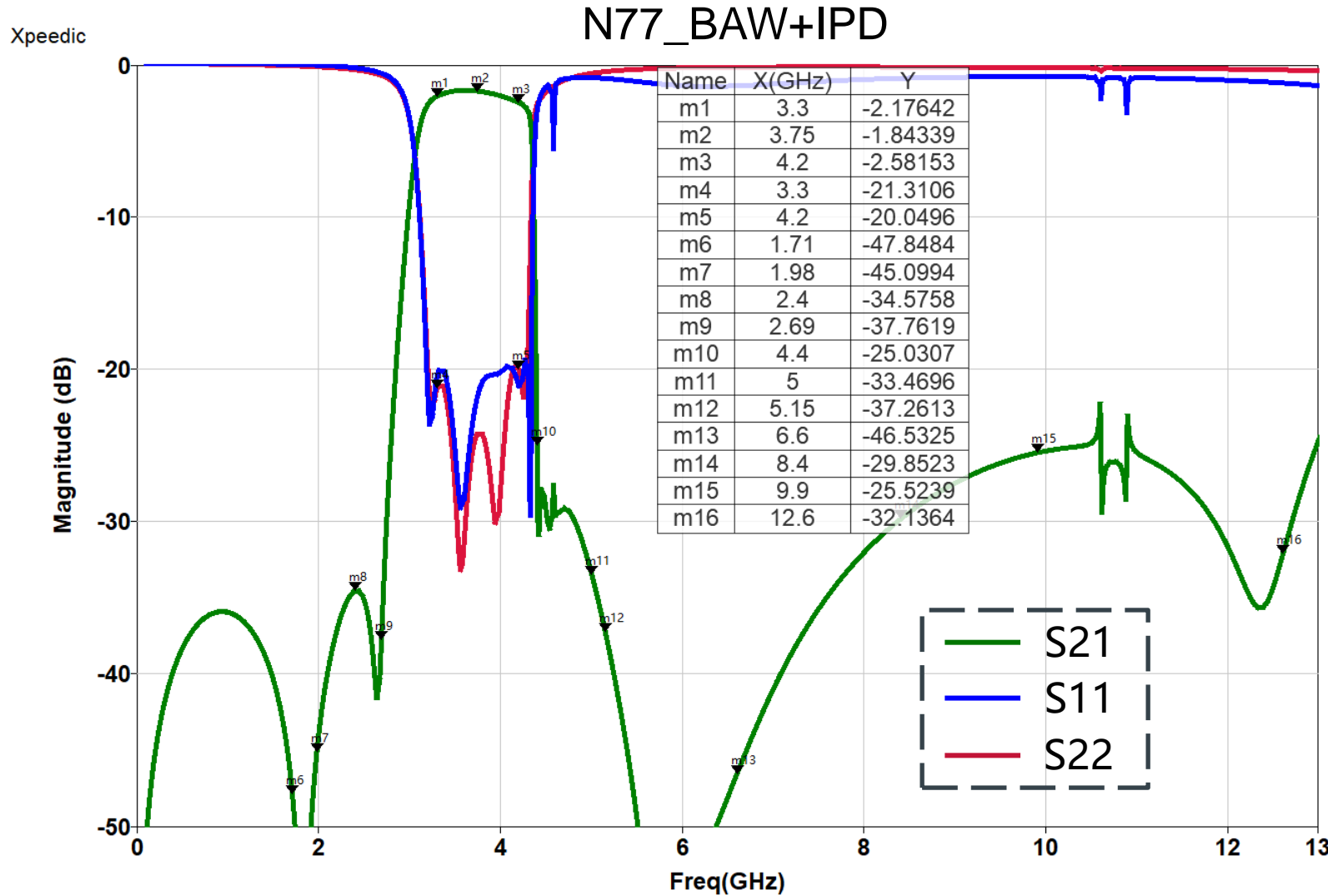


Matching Filter for N77

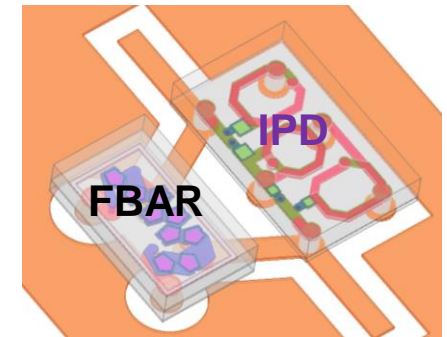


Same 1005 size IPD, but with matching integrated

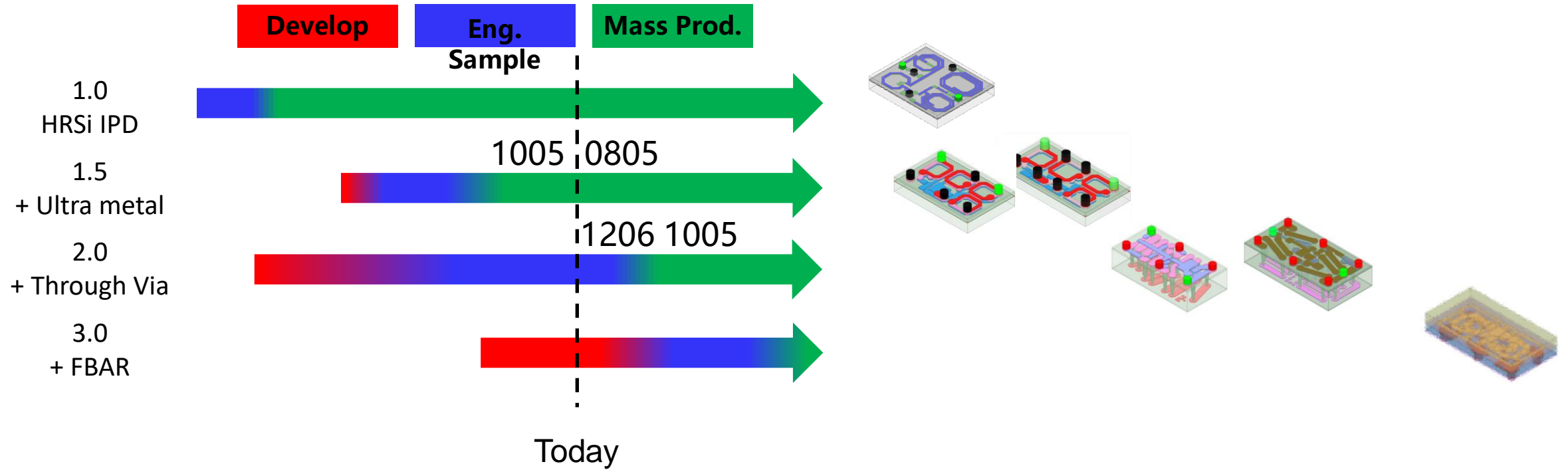
Hybrid for N77



- Hybrid solution
 - IPD + Acoustics
- to achieve both
 - wide bandwidth
 - close-in rejection for Wi-Fi co-exist

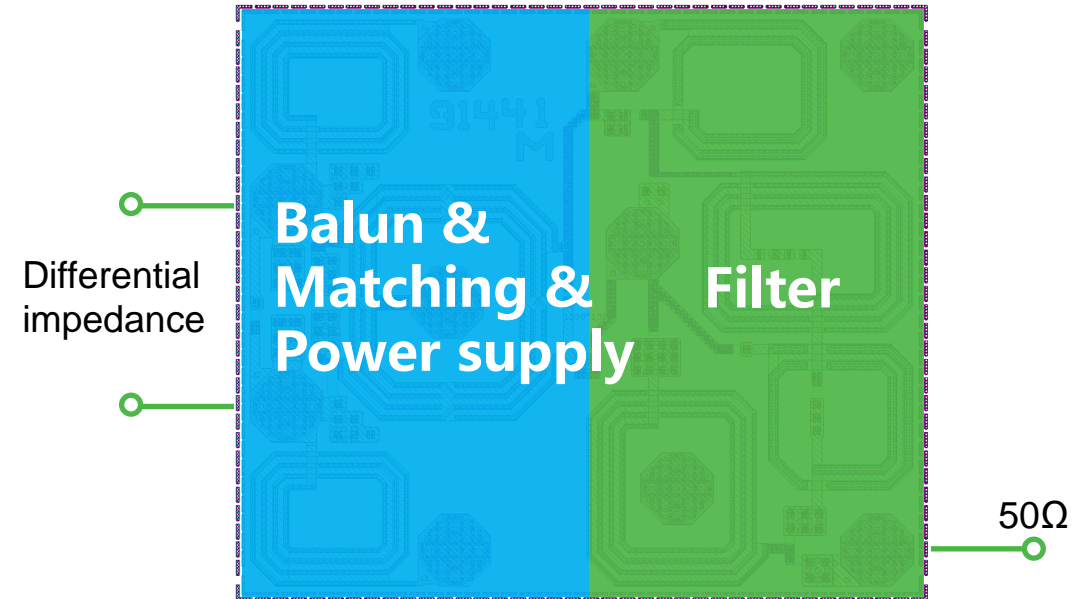


Roadmap



IPD for IoT

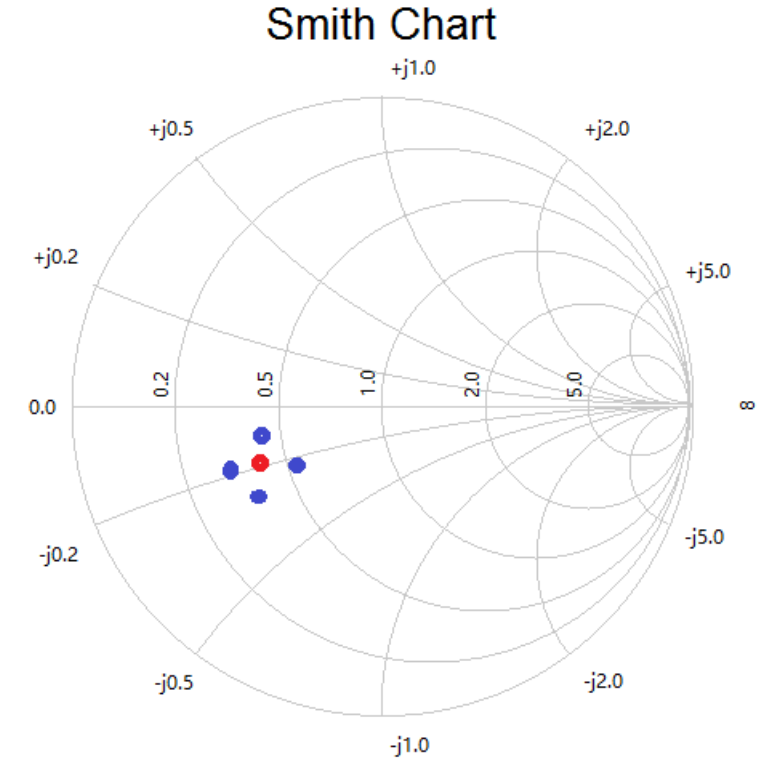
- All-in-one typically
 - Balun + Matching + Filter...
 - Wire-bonding / Flip-chip
- High integrity, low profile
- BOM reduction for IoT module



an IPD IoT Die

Design Challenge

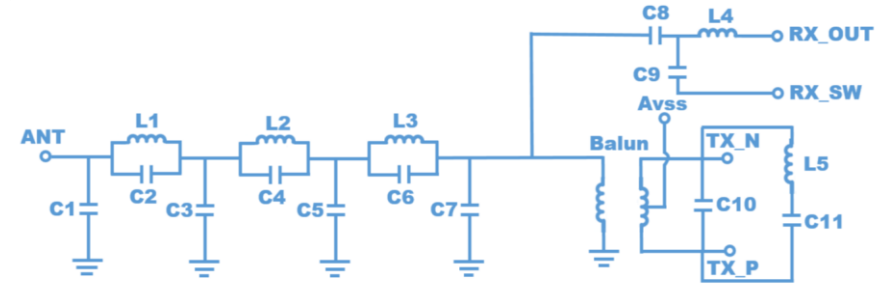
- Usually unknown impedance
 - Initial impedance from discrete component design
 - Design coverage for impedance uncertainty
- Usually no specific passive specification
 - Co-design & Co-simulation
 - Trade-off between key system requirements



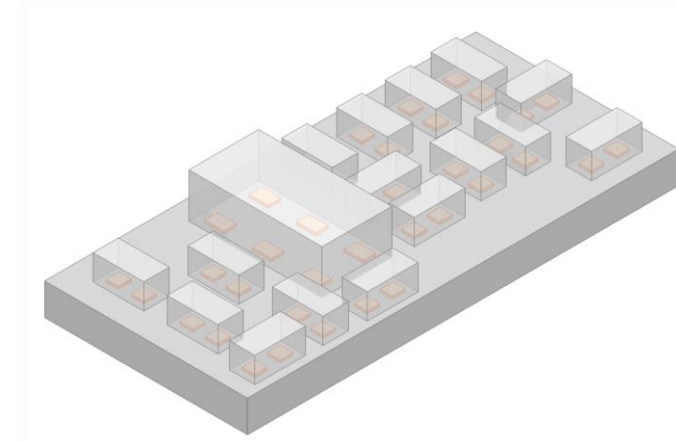
● Initial impedance
● Design coverage

A Typical Device

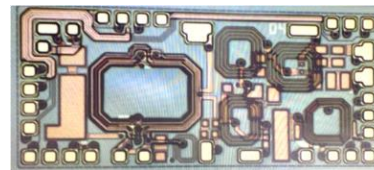
- IPD vs. SMT
 - 2×size reduction
 - 1.5×height reduction
 - Dozens → 1, device qty. for BOM



Schematic



SMT Size: 3.4mm×1.6mm ×0.35mm



IPD Size: 2.44mm×1.17mm ×0.15mm



Summary

- Constant need for passive integration
- Process evolves for greater performance
- IPD gets into more modules for 5G NR and IoT front-ends
- All-passive-in-one adopted for more RF front ends
- Co-design / simulation helps complex integration