DPC 2021

Magnetic Core Inductor Embedded in Laminates for 3D Integrations

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Arizona State University

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Speaker's Bio

Current position: Research assistant at Arizona State University

Research Interests:

- Integrated inductor with magnetic core on flexible substrate
- Semiconductor fabrication process
- Packaging technology
- Electromagnetic FEM simulation

Education Experience:

2011-2015: BS of EE, Shanghai Jiao Tong University, China
2015-2017: MS of EE, National Chiao Tung University, Taiwan
2017-present: PhD of EE, Arizona State University, USA

Outline

- **Motivation**
- Simulation
- Fabrication Process
- Measurement Results
- Future Work & Conclusion

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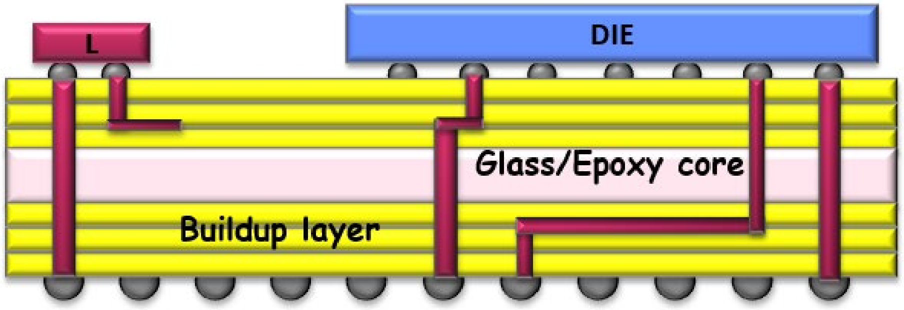
On Package/backside of package



In Package

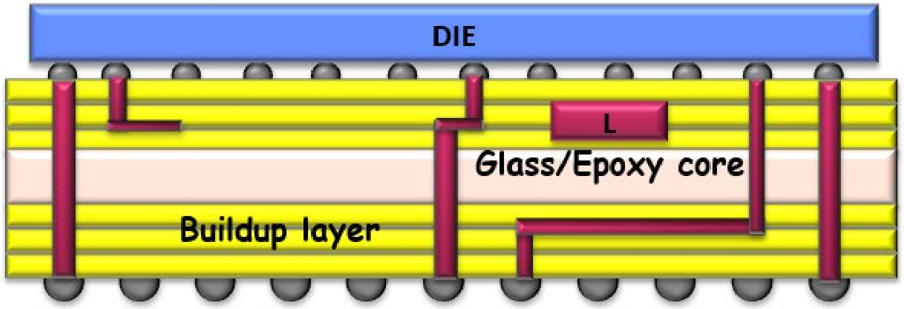


Figure.1 Two methods to achieve the integration of inductor into package

Requirement for the integration of inductor into the advanced packaging technology:

- Compatible with the semiconductor process
- Low profile
- Device size scaling-down
- performance

Solution

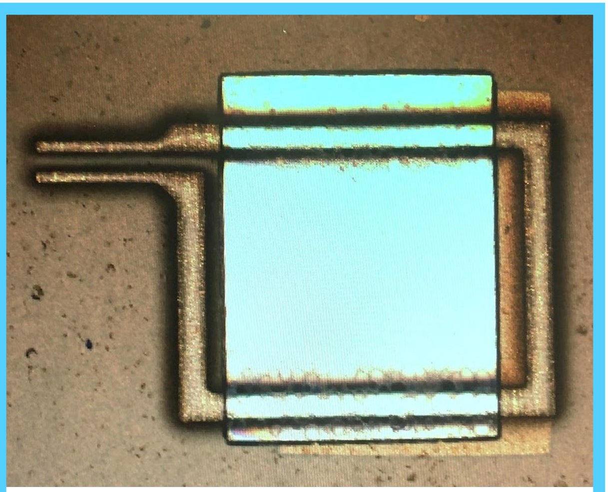


Figure.2 Prototype of a magnetic core inductor

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Simulation Settings

Table1 The device dimension of the two designs(μm)

	design-1	design-2
L_1	430	1116
L_2	3460	1410
W_{Cu}	130	130
W_1	3000	1000
W_2	400	1330
t_{Cu}	18	
t_{mag}	3	
g *	15	

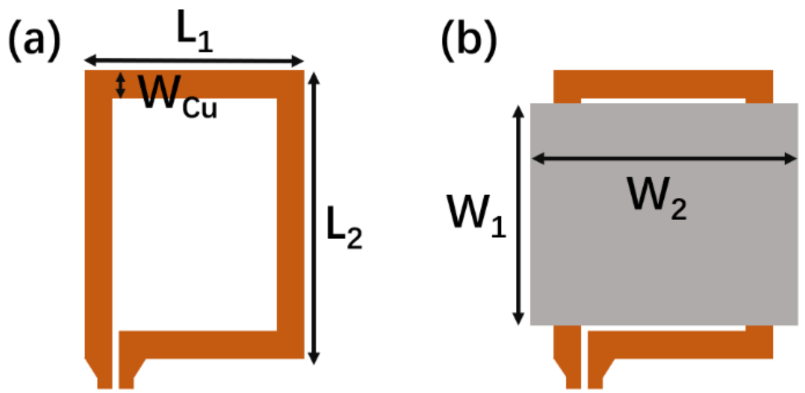

Table2 Other parameters used in the simulation

	Value
Permeability	107
Saturation magnetization	1.4 Tesla

* g is the gap between the Cu layer and the magnetic core layer.

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Simulation Results

Table3 Simulation results (100 MHz)

	design-1		design-2	
	air-core	mag.-core	air-core	mag.-core
L (nH)	3.12	3.67	2.37	3.19
ACR (Ω)	0.086	0.339	0.058	0.203
Q factor	22.86	8.02	25.74	9.18

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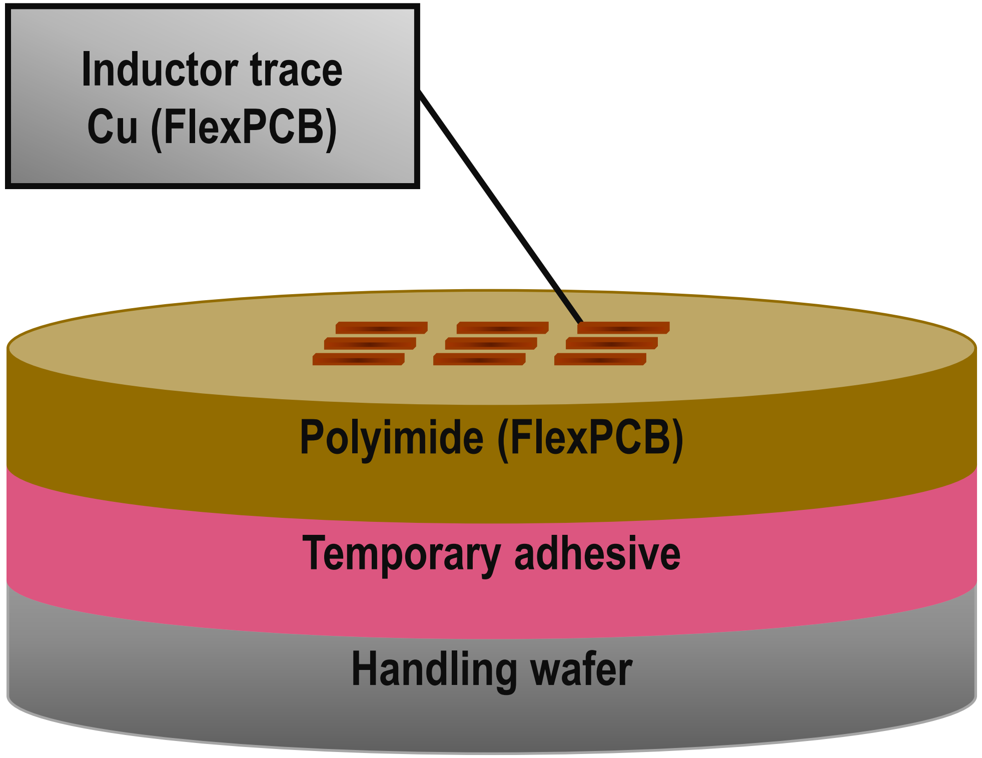
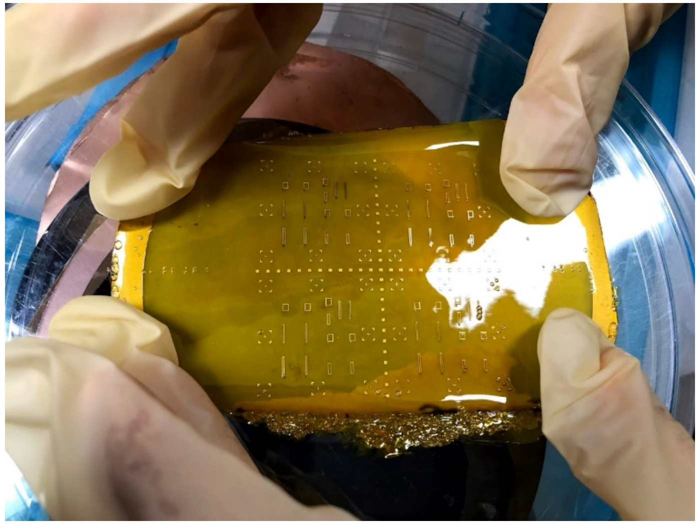
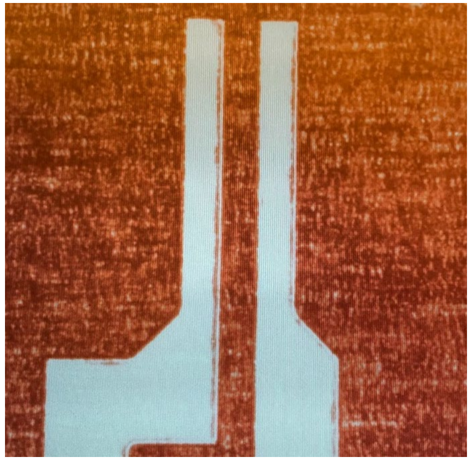
Cu Pattern Preparations (1)







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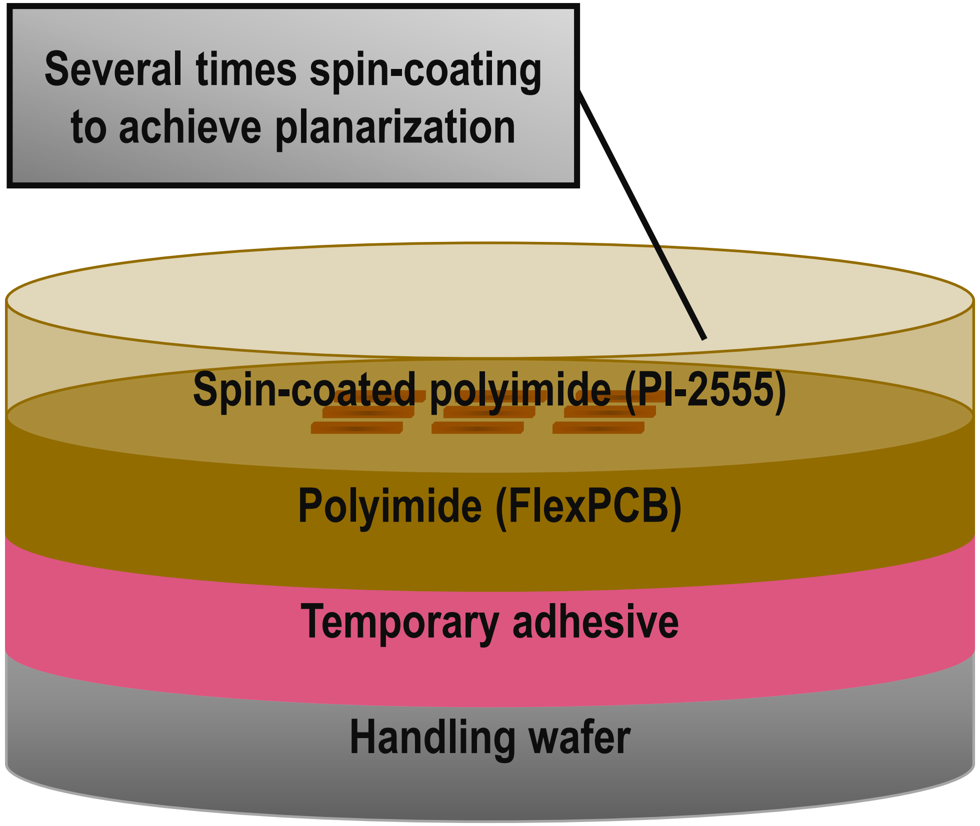
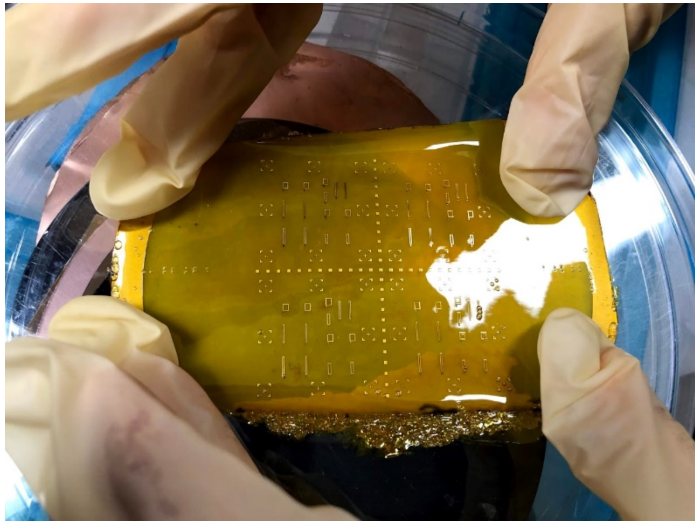
Cu Pattern Preparations (2)





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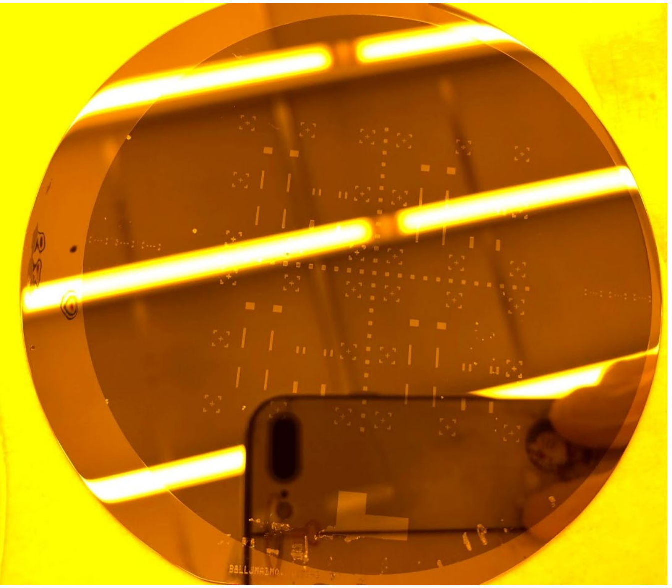
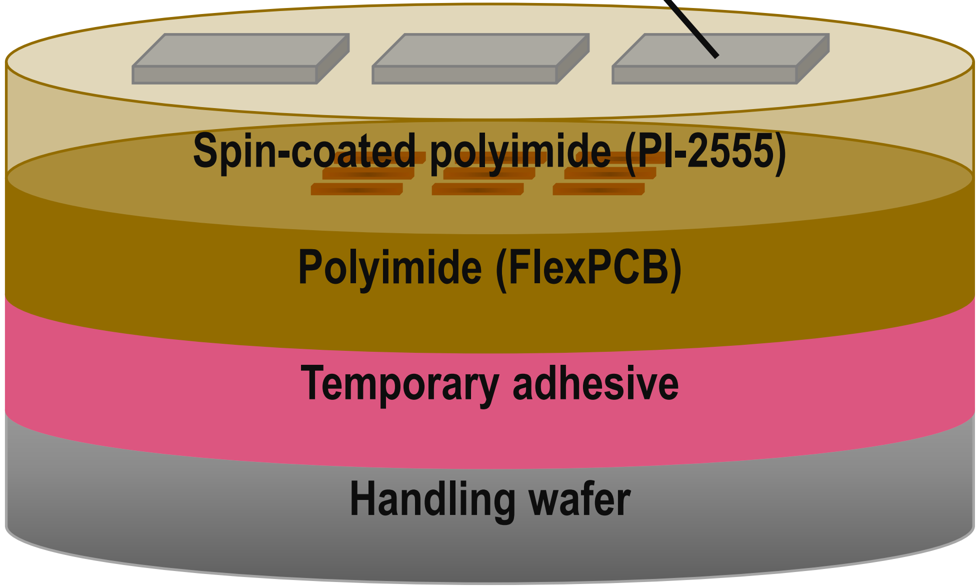
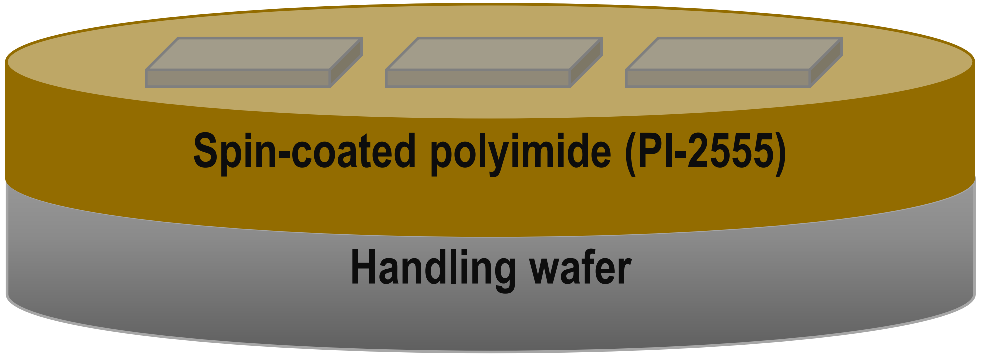
Magnetic core Preparations (1)

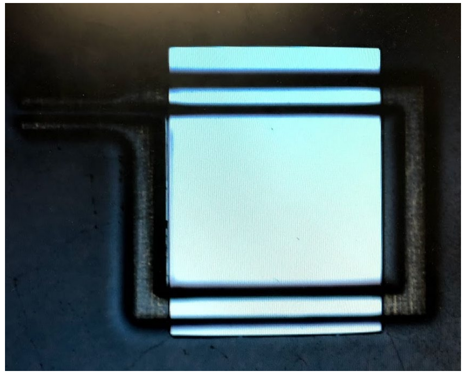
Photoresist (nLOF2070) for lift-off

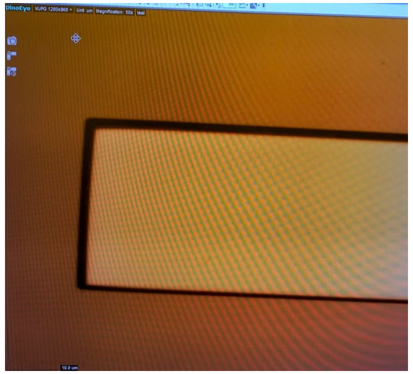


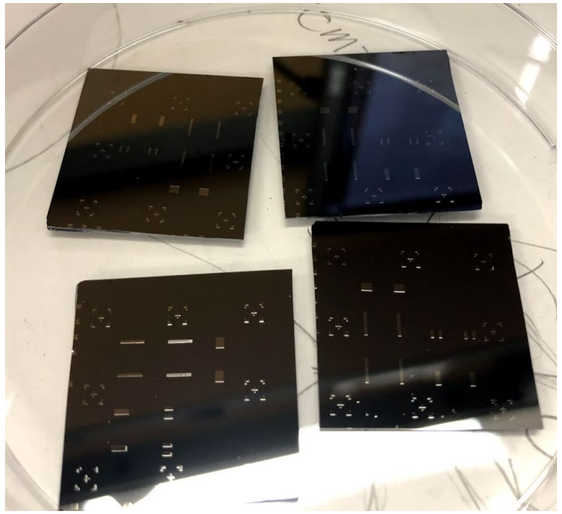


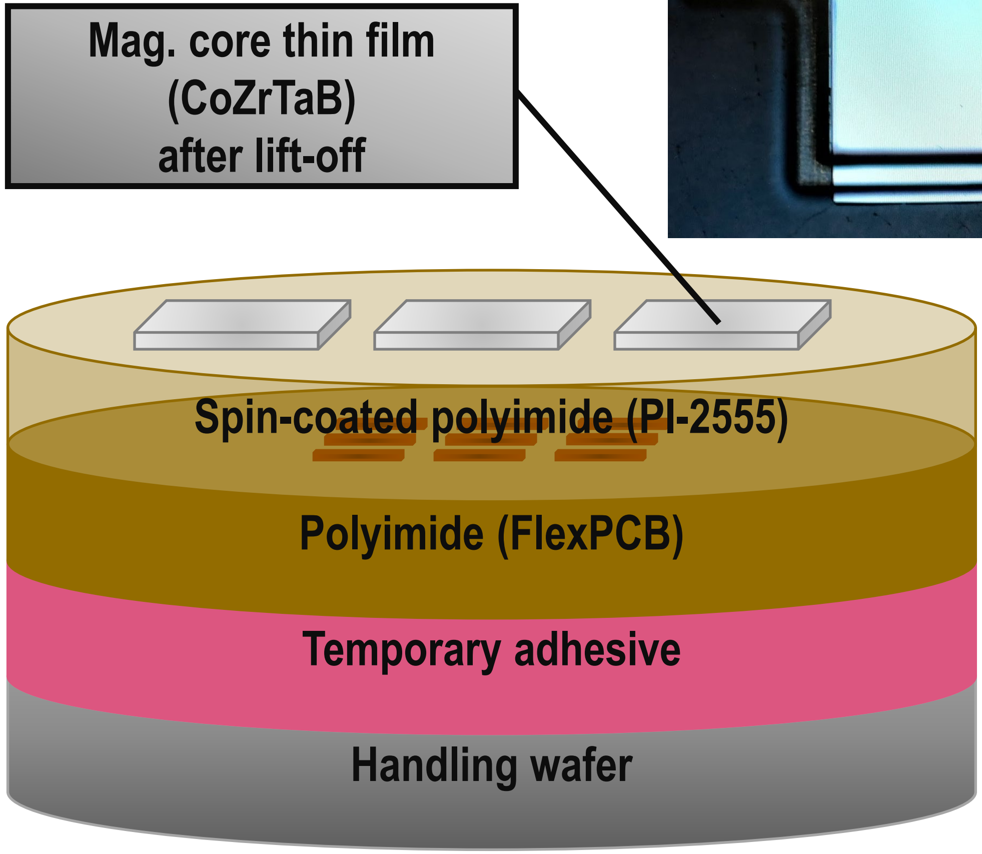


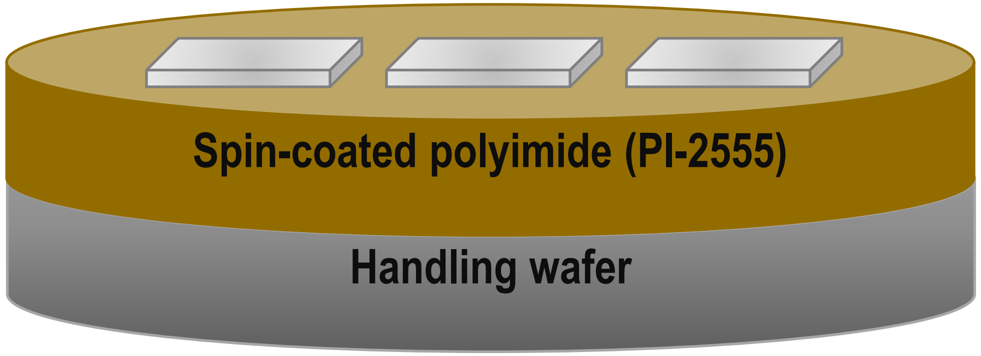
Magnetic core Preparations (2)











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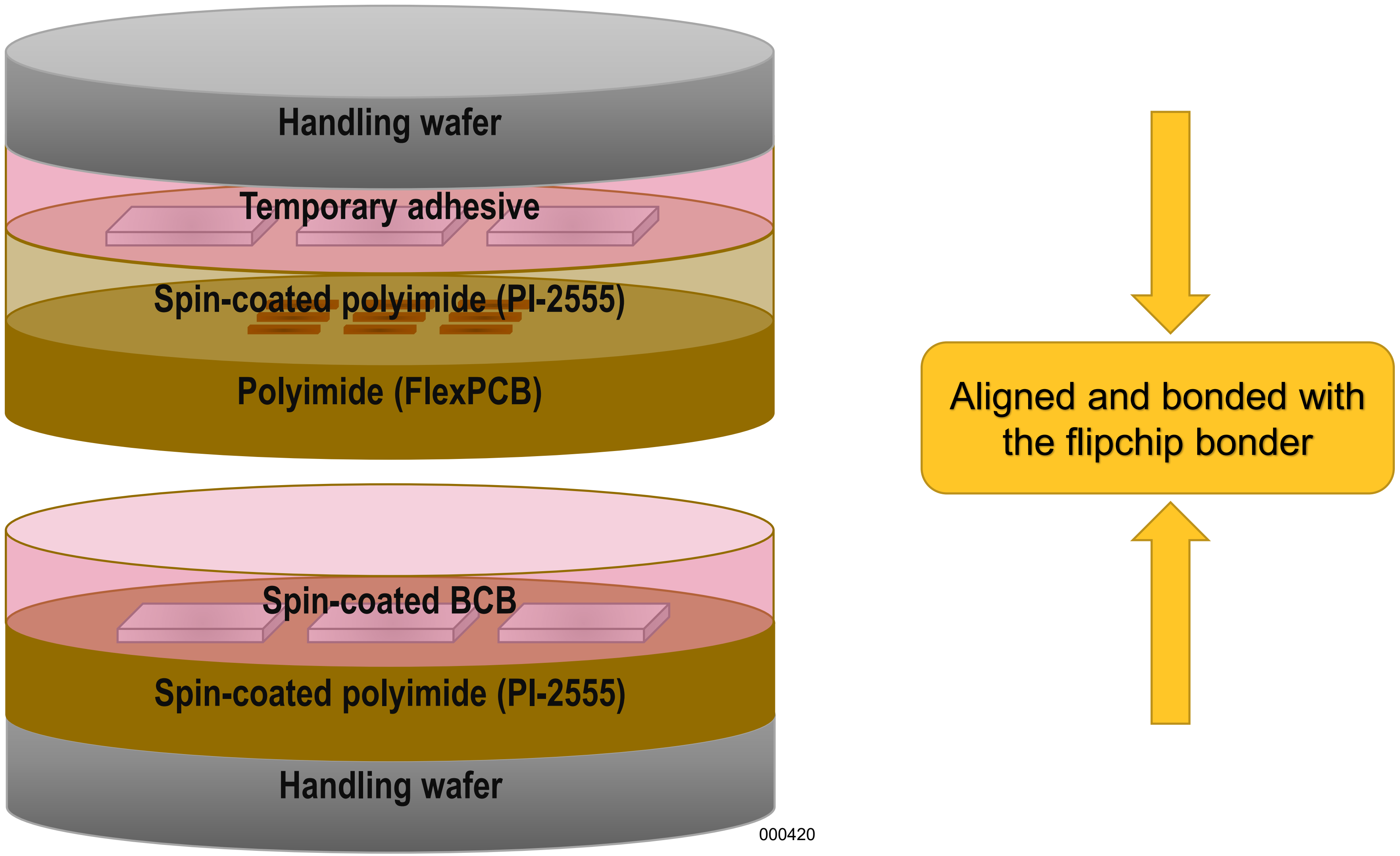
Device Assembly (1)



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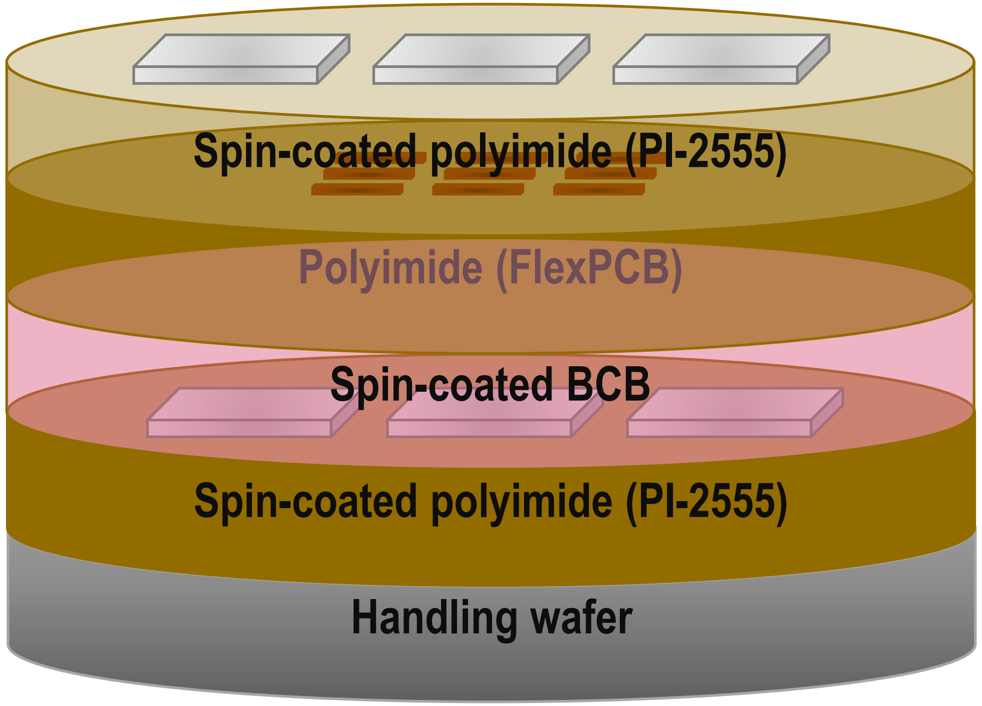
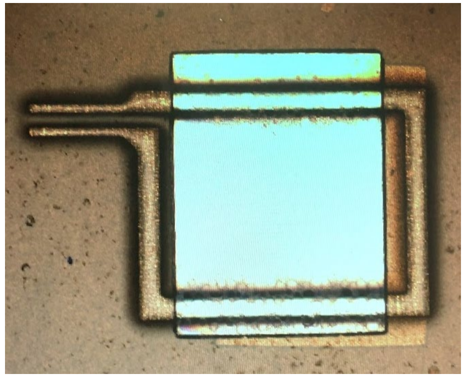
Device Assembly (2)

One more lithography & dry etch to get the measurement windows





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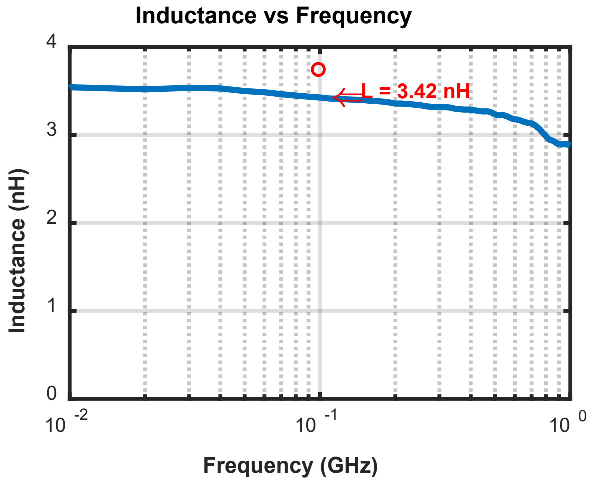
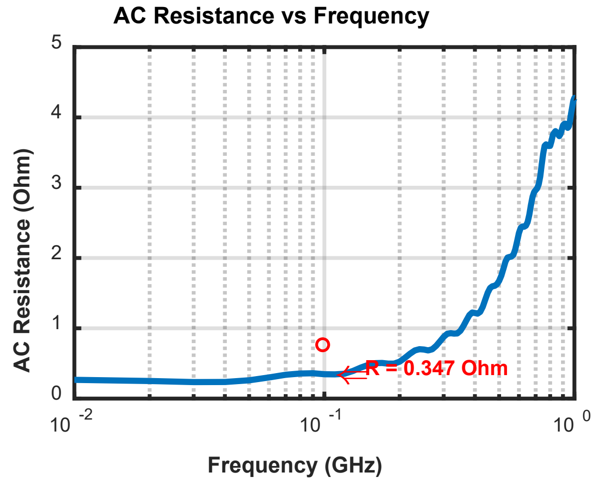
Design-1 Measurement Results (Magnetic Core)





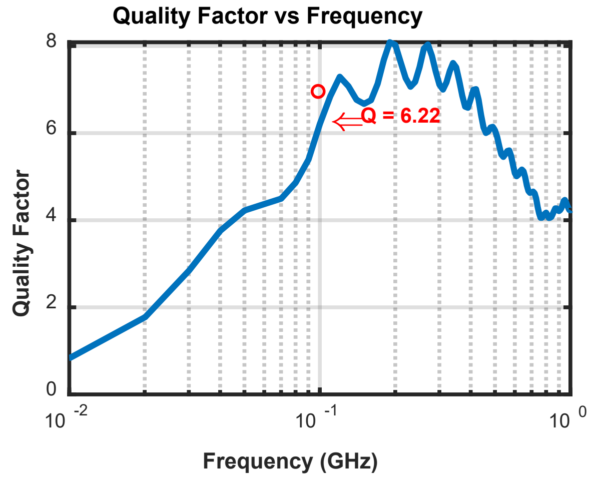


Table4 Design-1 simulation results

	mag.-core	**air.-core**
L (nH)	3.67	3.12
ACR (Ω)	0.339	0.086
Q factor	8.02	22.86

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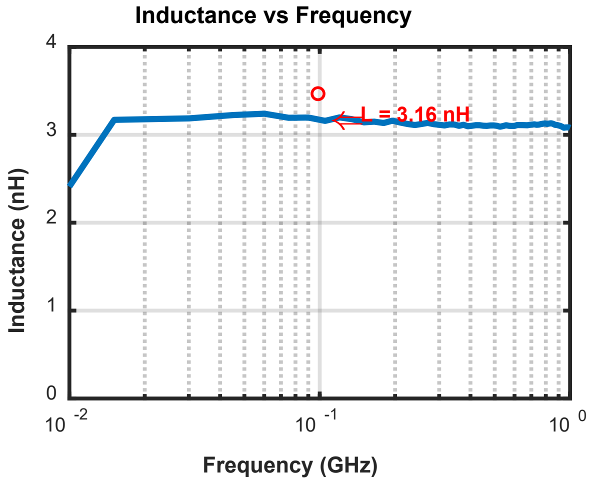
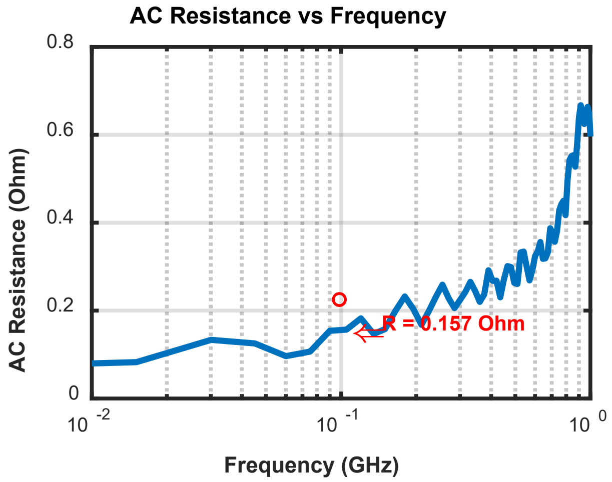
Design-1 Measurement Results (Air Core)





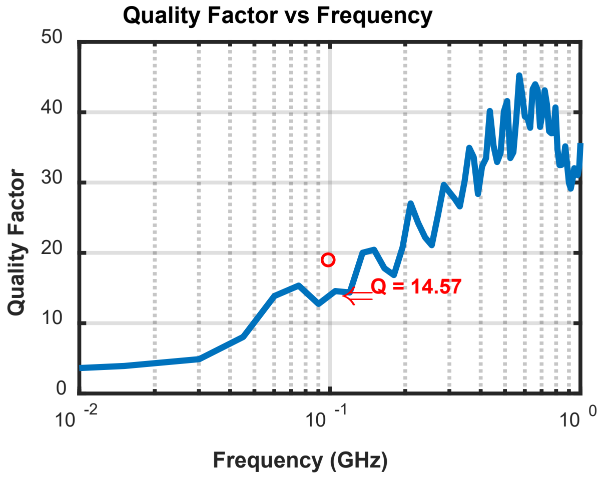


Table4 Design-1 simulation results

	mag-core	air.-core
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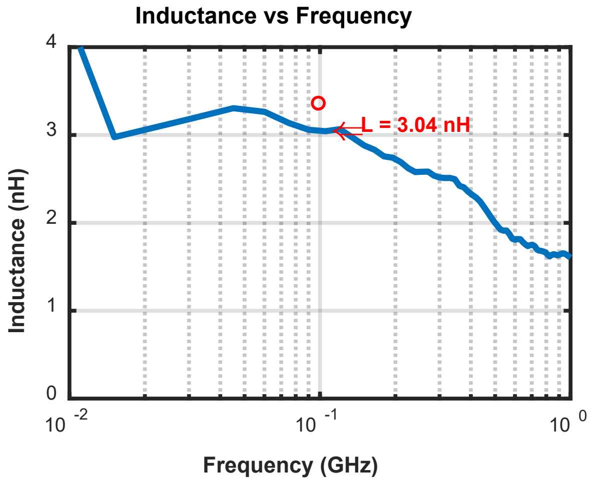
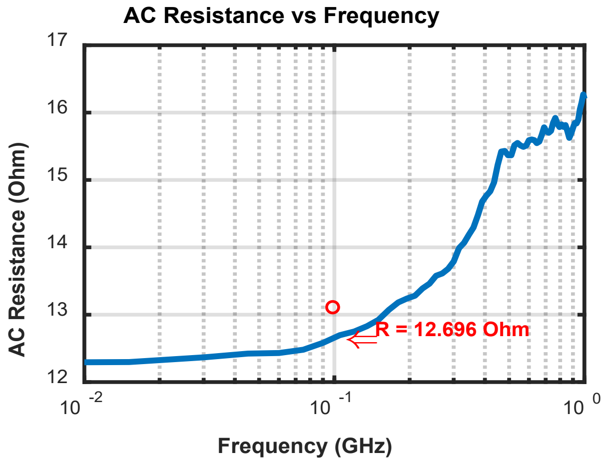
Design-2 Measurement Results (Magnetic Core)





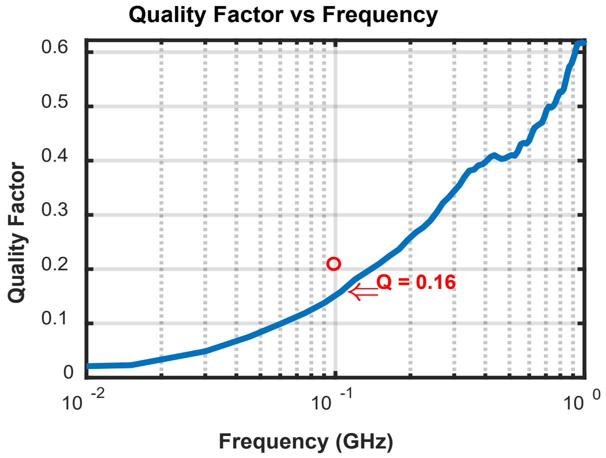


Table5 Design-2 simulation results

	mag.-core	air.-core
L (nH)	3.19	2.37
ACR (Ω)	0.203	0.058
Q factor	9.18	25.74

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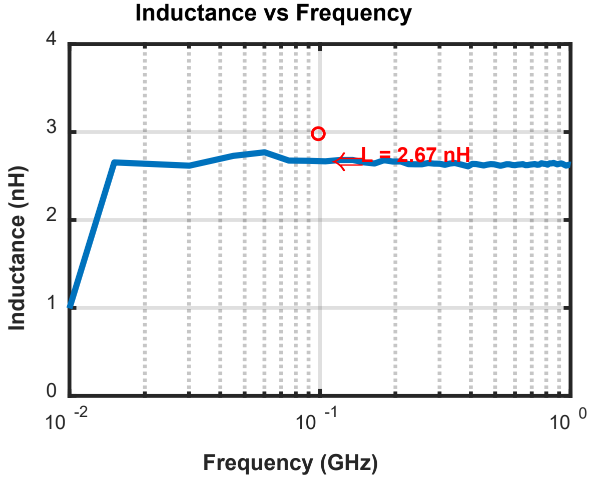
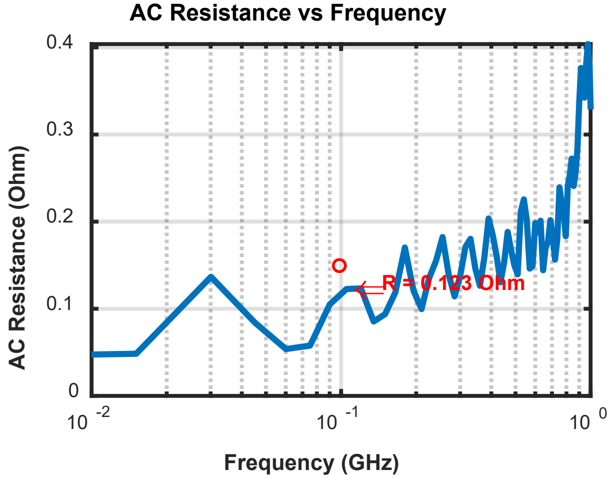
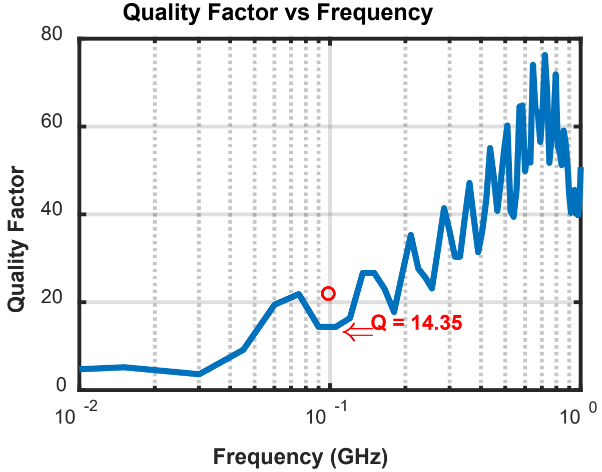
Design-2 Measurement Results (Air Core)







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Future work:

- Simplify the process of making the measurement windows → Use the photo-definable polyimide to replace the current polyimide precursor.
- Improve the planarization on Cu layer → Add the commercially available organic film on Cu layer.
- Optimize the properties of magnetic thin films → Explore the best fabrication condition.
- Enhance the attachment between each layer → Possibly replace either the temporary or the permanent adhesive materials which can form a stronger bonding.

Conclusion:

- The utilization of flipchip bonder can finish the device bonding effectively. This low cost fabrication method can provide a integrated inductor device with high performance, low profile, and good compatibility to different package technology.
- To increase the precision of the bonding, more factors need to be considered, such as the stretching of the polyimide after curing,
- The properties of the magnetic thin film on polyimide need optimum.

Q&A