Advances in Integrated Magnetics for High Frequency Power Conversion Applications

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PWR SoC 16

Tyndall National Institute
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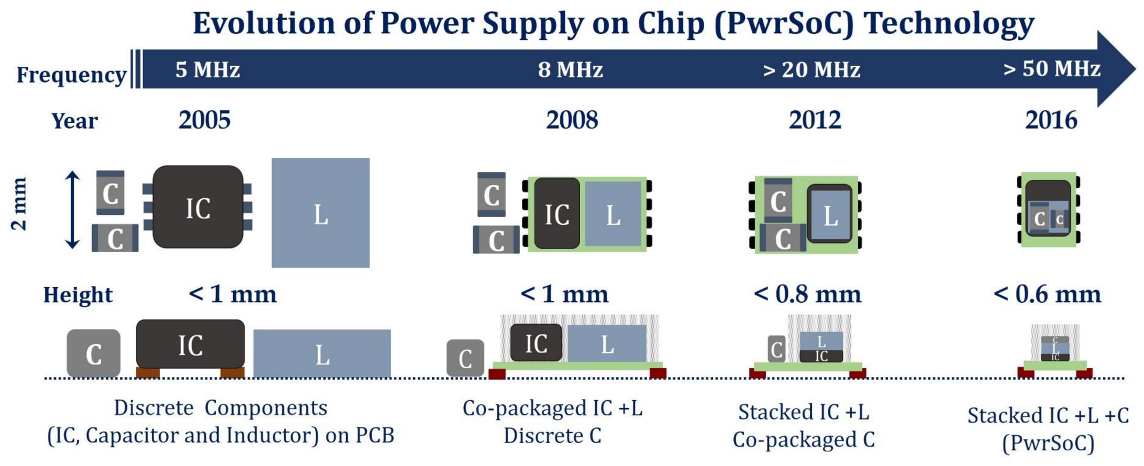
Introduction

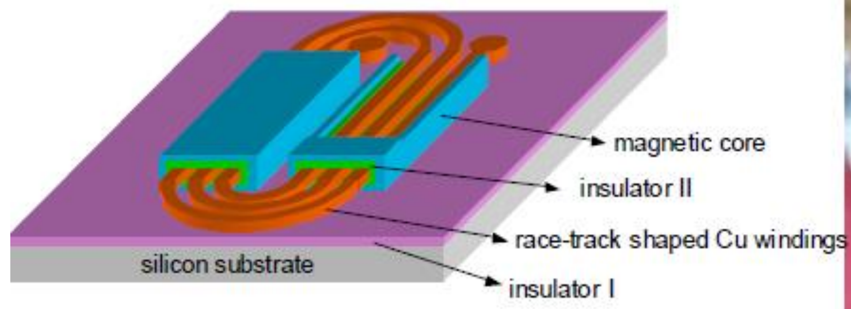
- Increase in DC-DC converter frequencies have enabled passive magnetic components to be **fabricated on silicon (< 2 mm² foot print area)**.
- **Windings** and **Core -losses** reduce the efficiency of these devices.

Possible solutions ?

(a) High aspect ratio micro-windings.
(b) Resistive & Ultra soft magnetic films (c) Magnetic laminations.

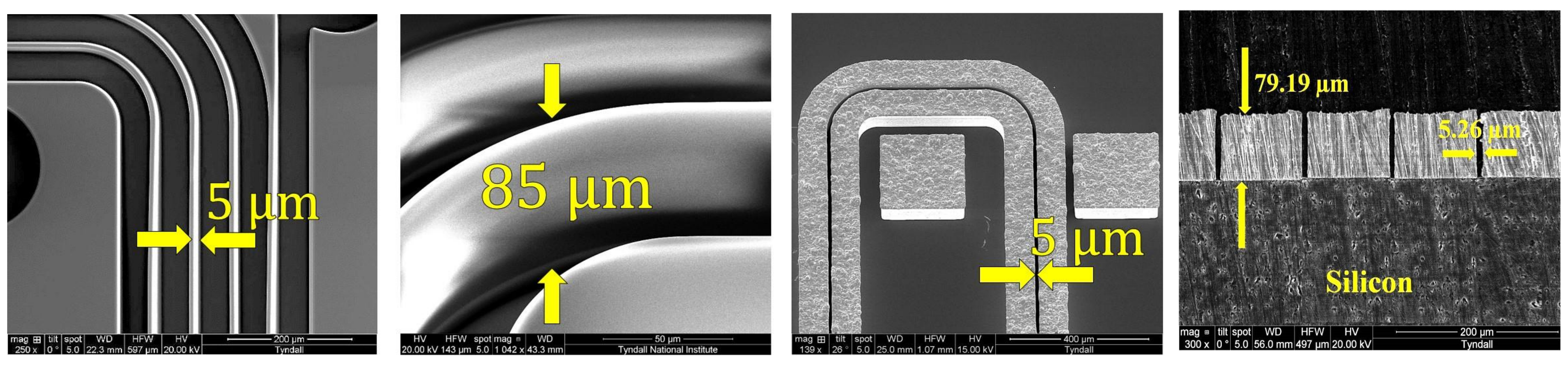
Evolution of Power Supply on Chip (PwrSoC) Technology



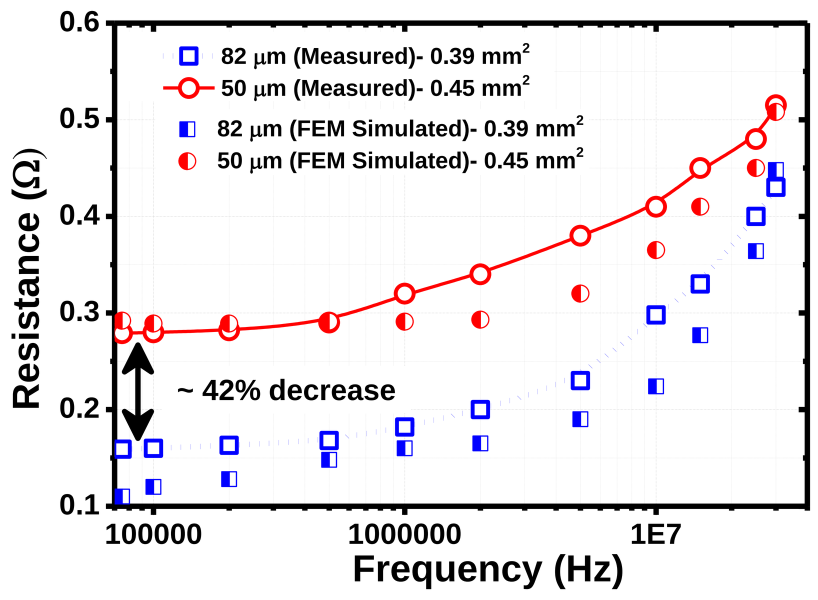


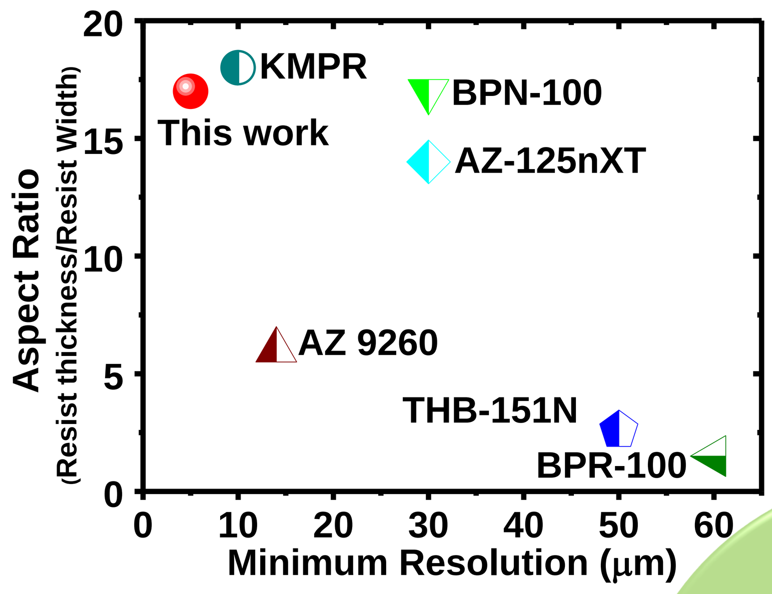
I. High-Aspect-Ratio & Resolution Windings

High-aspect-ratio (17:1) and resolution (5 µm) process



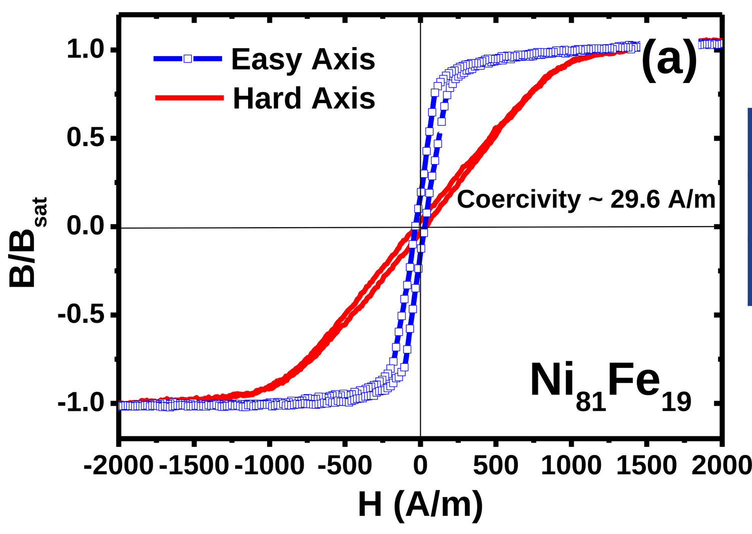
Fabricated windings with 5 µm gap with THB-151N.





II. Variable and Ultra-soft Magnetics

Electroless DMAB bath to achieve variable Ni-Fe compositions.

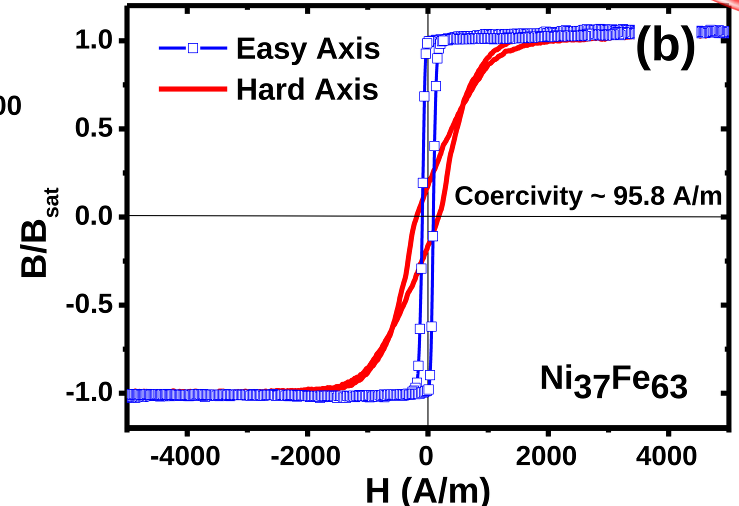


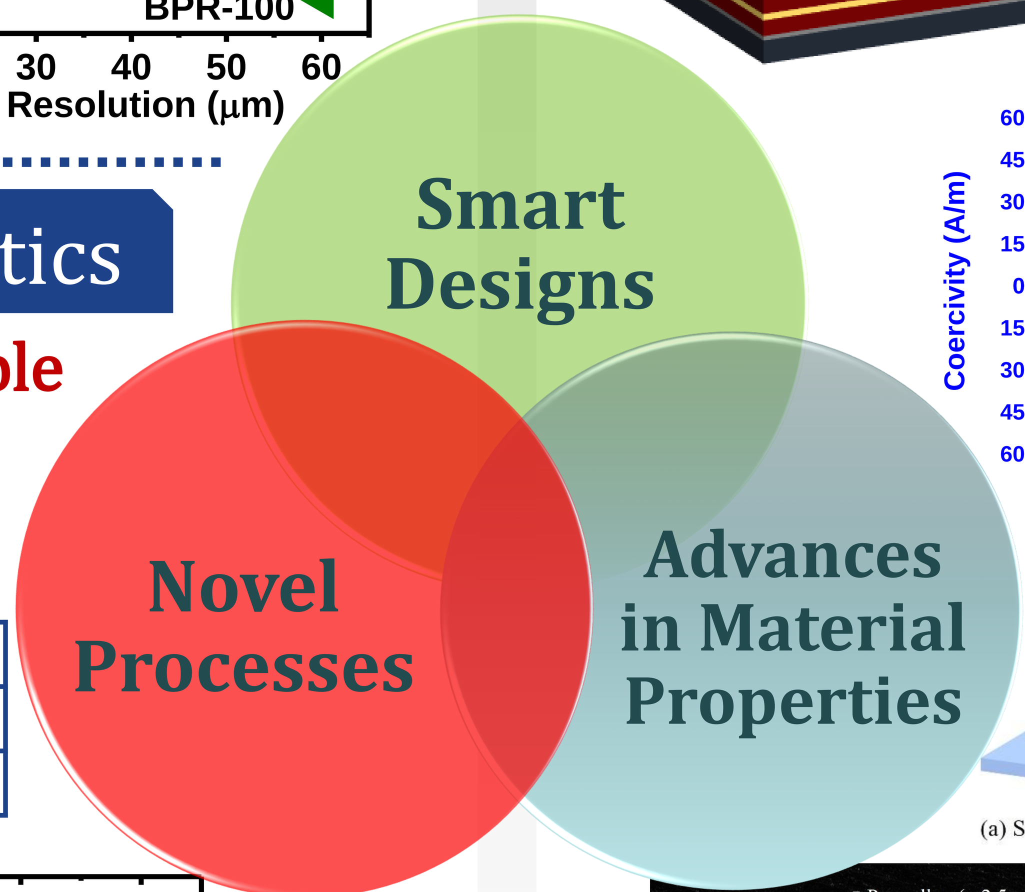
$Ni_{81}Fe_{19}$

Coercivity	29 A/m
Resistivity	26 µOhm-cm
Anisotropy	960 A/m

$Ni_{37}Fe_{63}$

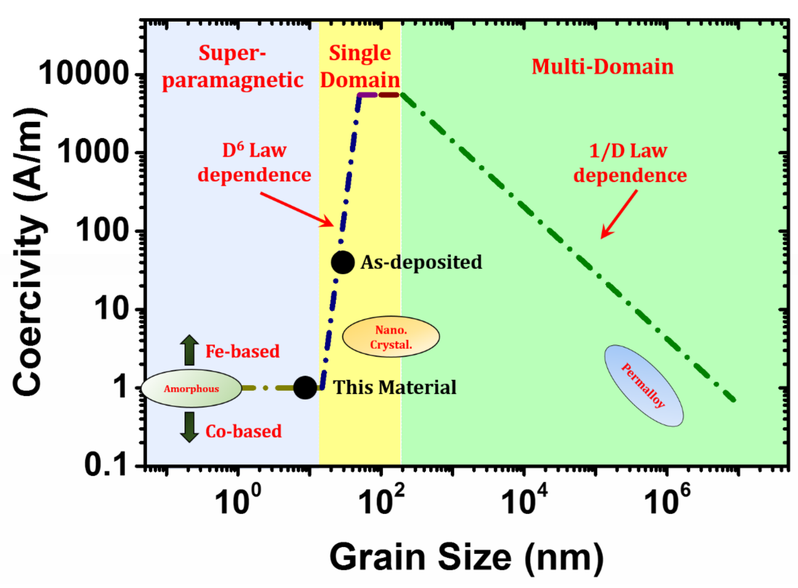
Coercivity	96 A/m
Resistivity	62 µOhm-cm
Anisotropy	600 A/m





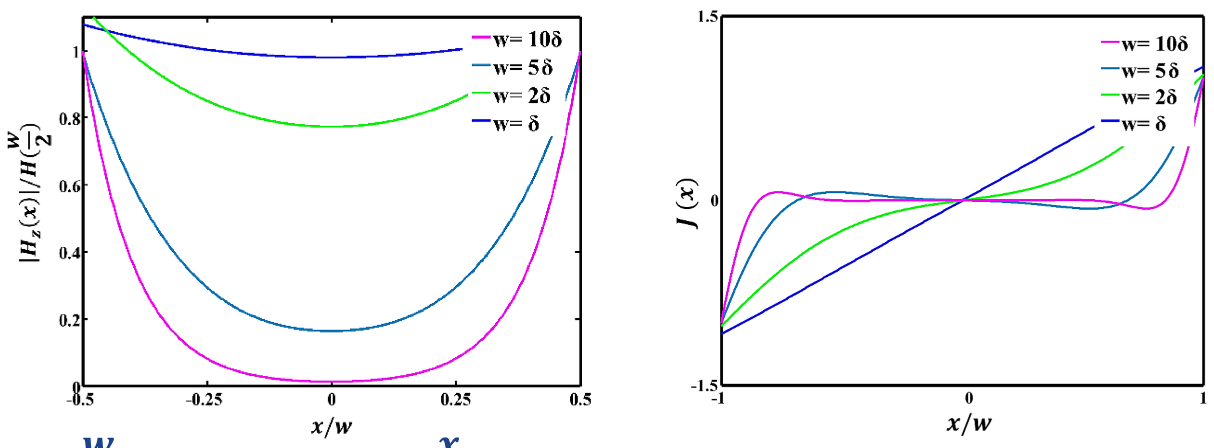
* Ultra-soft material

Soft to Ultra-soft Transformation



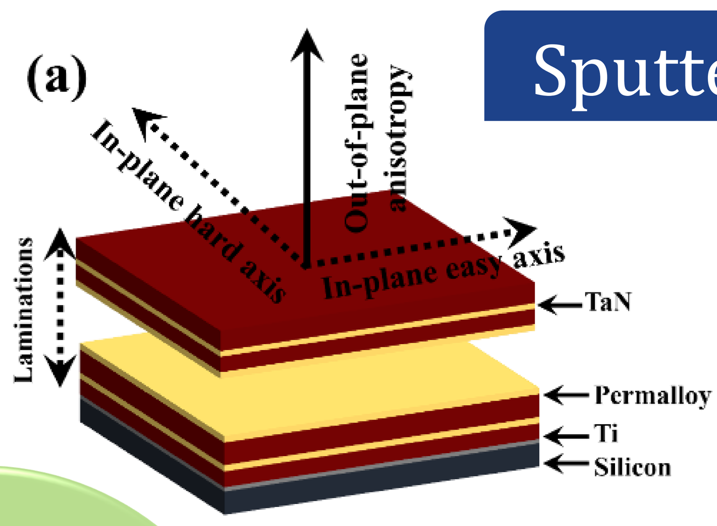
Coercivity	2 A/m
Resistivity	70 µOhm-cm
Anisotropy	900 A/m
Thickness	1 µm -1.8 µm

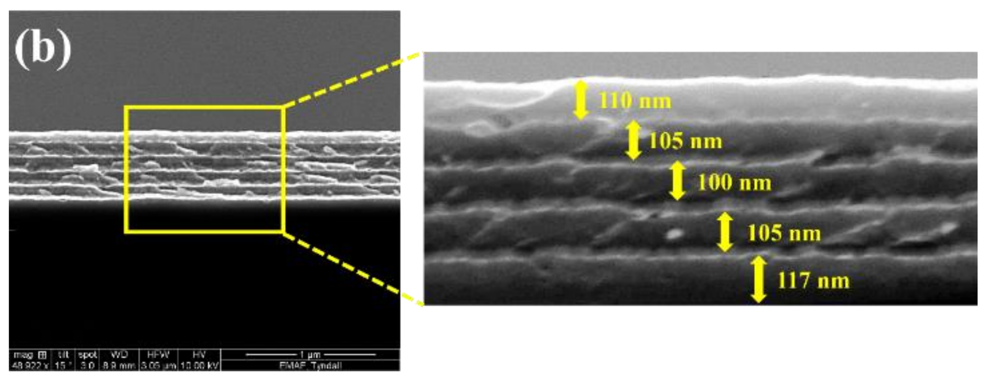
III. Magnetic Laminations

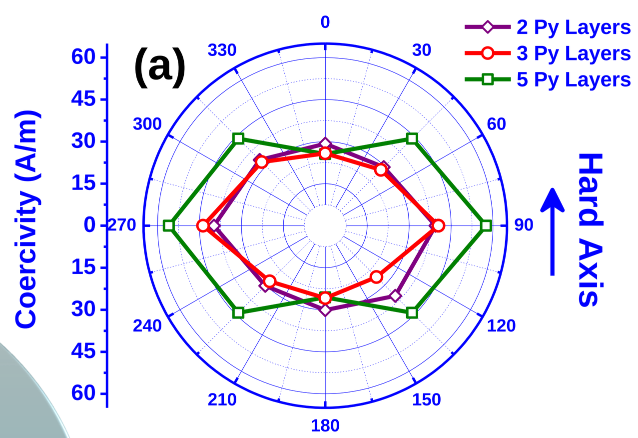


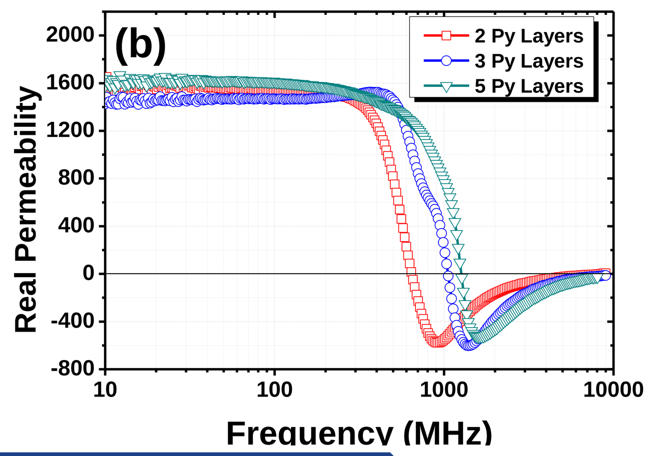
$|H_z(x)|H(\frac{w}{2})$ and $J(x)$ vs $\frac{x}{w}$ distribution (analytical) in a lamination.

Sputter deposition Approach

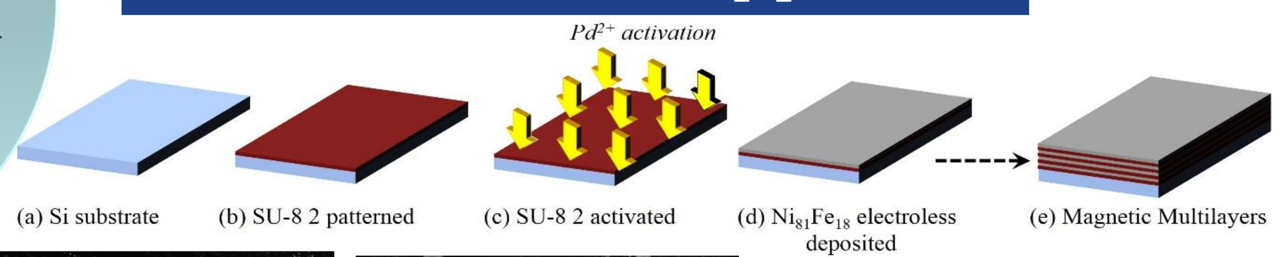


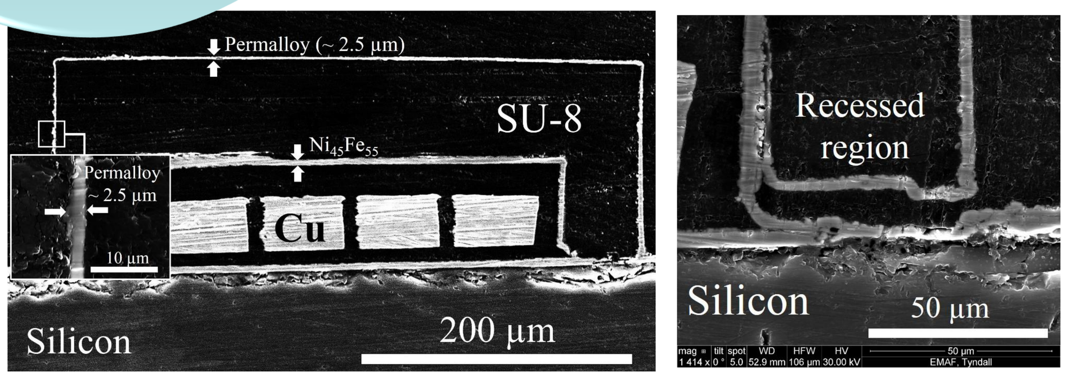






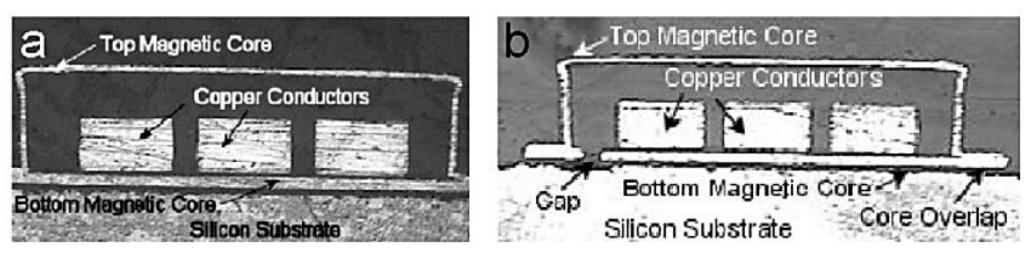
Electrochemical Approach

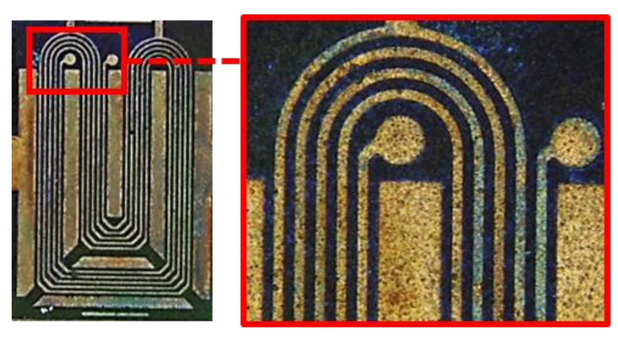




Activation-Catalyzation and Metallization Process

IV. Tyndall Micro-Inductors





Ungapped and Gapped racetrack inductors   Ferrite-core inductors

Summary

- HAR and density micro-windings.
- Variable and ultra-soft core.
- Nano-laminated cores (electrochemical and sputtered).

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European Union European Regional Development Fund

UCC University College Cork, Ireland Coláiste na hOllscoile Corcaigh

PowerSWIPE

[1] R. Anthony et. al., *J. Micromech. Microengg.*, 26 (2016).
[2] R. Anthony et. al., *Appl. Surf. Sci.*, 357 (2015).
[3] R. Anthony et. al., *J. Magn. Magn. Mater.*, 406 (2016).

* Confidential- Cannot be disclosed