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Nano-structured $Ni_{.15}Cu_{.25}Zn_{.6}Fe_{1.96}$ Ferrite

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Abstract

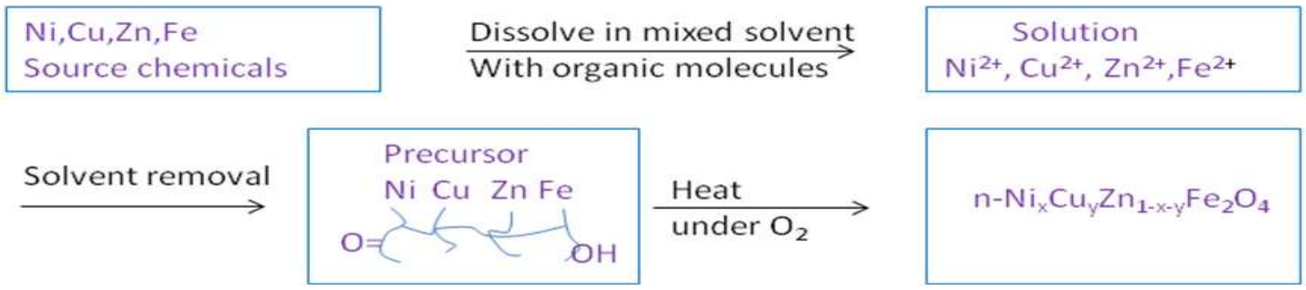
A Nanostructured ferrite soft magnetic material with formulation of $Ni_{0.15}Cu_{0.25}Zn_{0.6}Fe_{1.96}O_4$ has been developed for microelectronic components used in miniaturized devices. This nanostructured material will be primarily used for multilayer low temperature co-fired ceramic (LTCC) based transformers. They are reliable, small in size and can operate in high temperatures. These transformers have applications in fusing, down hole oil exploration and implantable medical devices.

One of the major challenges for above mentioned application is to lower sintering temperature, which is due to low melting temperature of conductive layer. The nano-powder produced in this work was sintered at 930°C to a toroidal magnetic core with density of 5.25g/cm^3, which was 5% higher than that of a microstructured magnetic core sintered at the same condition.

The magnetic properties of the nanostructured magnetic core has been tested and compared with microctructured core. The initial relative permeability of the nano-structured magnetic core is over 444, while it is only 205 for the micro-structured magnetic core. The results have demonstrated that the nano-structured ferrite has advantages on magnetic performances.

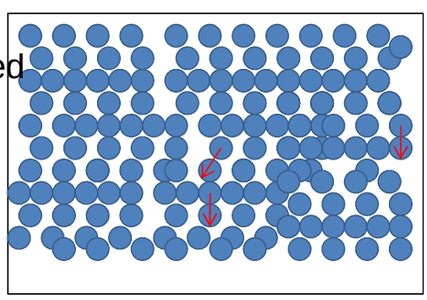
Results and Discussion

Chemical Synthesis of Nanostructured Ferrite Powder



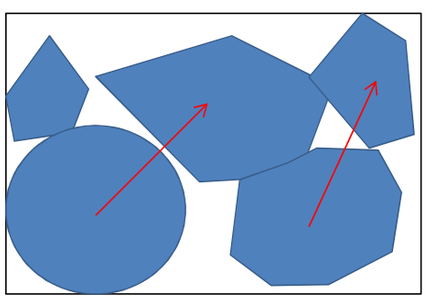
Advantages of Nanostructured Ferrite

Nanostructured



Shorter diffusion distance

Need lower temperature for densification
5.25g/cm^3 density sintered at 930°C

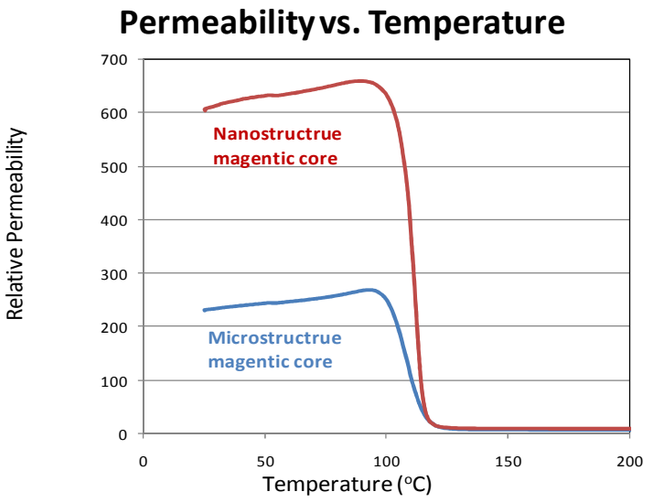


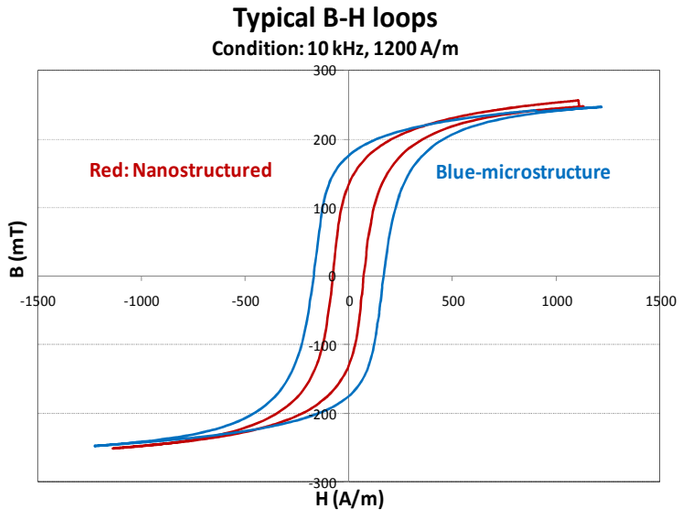
Microstructured

Longer diffusion distance

Need higher temperature for densification
5.00g/cm^3 density sintered at 930°C

Permeability and Magnetic Flux Density of the Sintered Ferrite Core

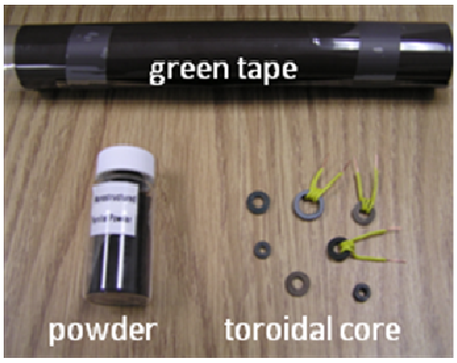




Lower porosity and smaller crystallites allow magnetic domain to align with magnetic field easily, which give higher permeability.

Summary of Magnetic Performance

Parameters	Nanostructured	Microstructured
Initial permeability	444	205
Curie Temp(^{o}C)	115	115
BSat (mT)	256	242
Coercive Force (A/m)	75	170



Conclusion

- A nanostructured ferrite with formulation of $Ni_{0.15}Cu_{0.25}Zn_{0.6}Fe_{1.96}O_4$ can be synthesized with a sol-gel process, which is feasible for mass production;
- The nanostructured ferrite has advantages in terms of lower sintering temperature, high magnetic permeability, lower coercive force, and higher saturated magnetic flux density.
- The developed nanostructured ferrite has potential applications in electronic components, such as: antenna, transformers, DC-DC converters, and filters.

References

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