Analysis of grain growth, densification and reduction of porosity, coercivity and functional properties of Mn substituted Ni-Cu-Zn nanocrystalline ferrites

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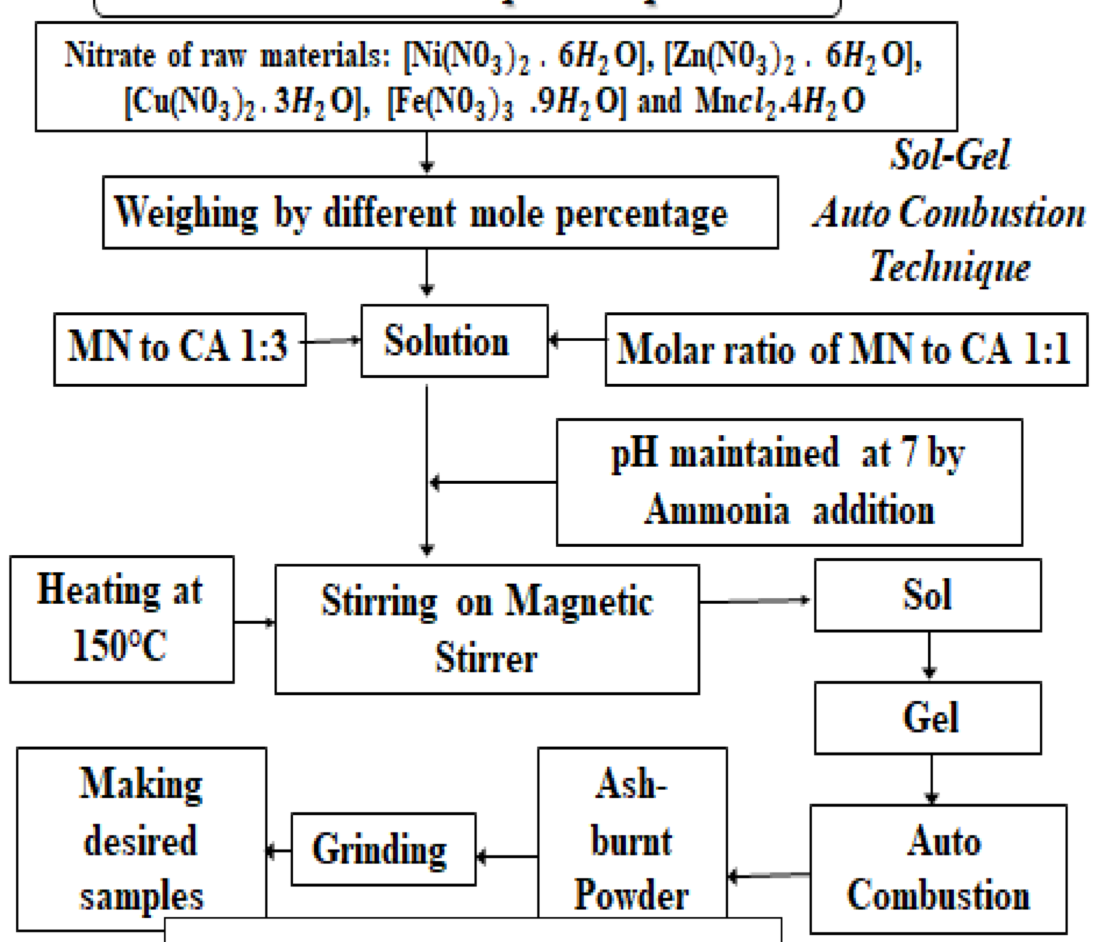
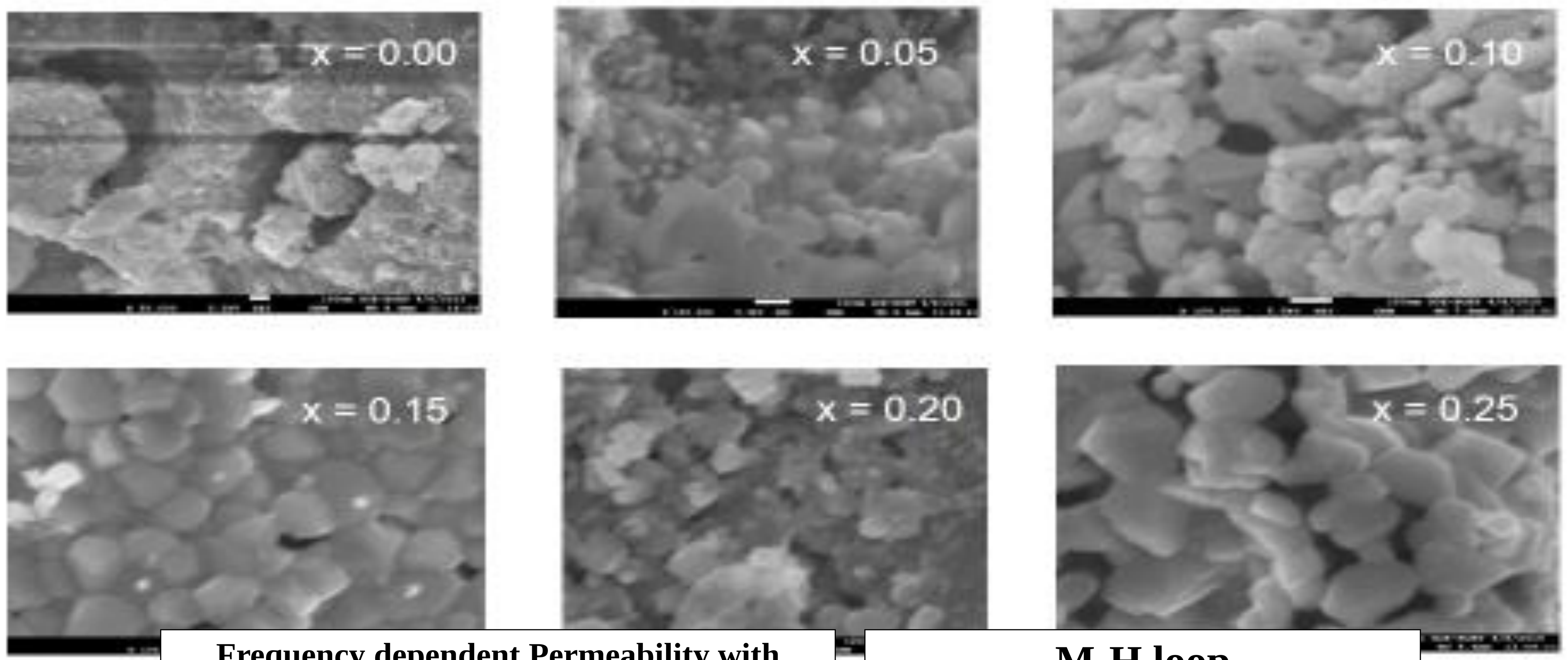
Abstract

Nominal compositions of Mn Substituted $Ni_{0.50-x}Mn_xCu_{0.15}Zn_{0.35}Fe_2O_4$ with x = 0.00 to 0.25 in steps of 0.05 have been synthesized by Sol-gel Auto Combustion Technique. Crystallite size is varied from 20-28 nm as well as average grain size is also varied from 69-126 µm with increasing Mn content. For increasing sintering temperature bulk density increases for all samples. The permeability graph shows that real part of initial permeability is increasing with the increase of Mn content. Temperature dependent permeability graphs show that permeability is increasing while Neel temperature is decreasing with the increase of Mn content. The magnetic hysteresis loop shows that with increasing Mn content saturation magnetization is increasing while coercivity is decreasing exhibits the soft magnetic materials.

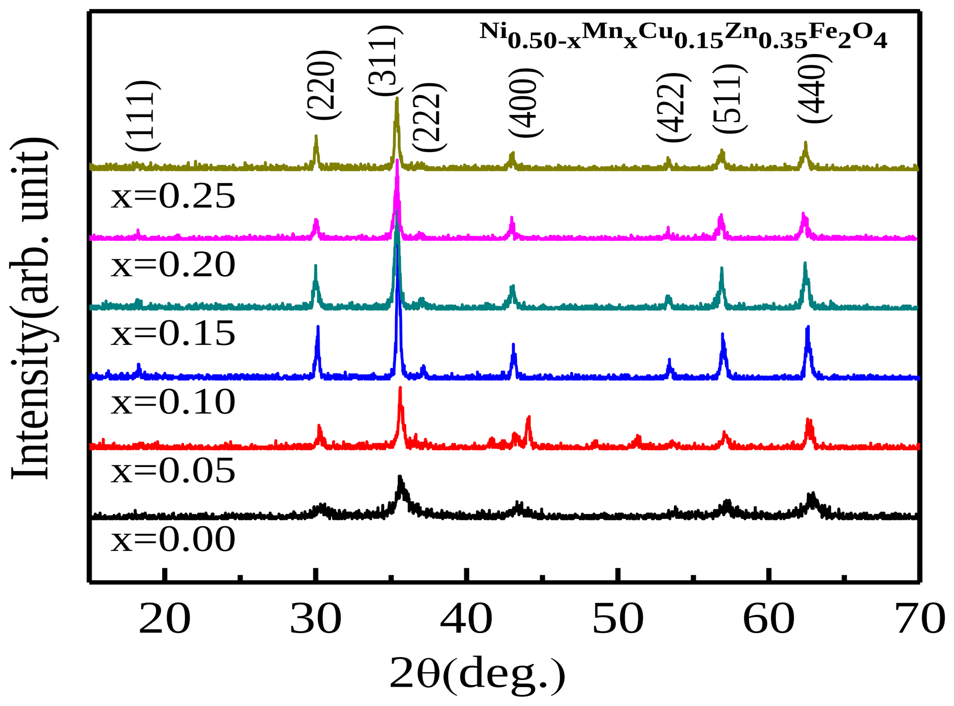
Flow Chart of Sample Preparation



Surface morphology of ash burnt powder



XRD analysis

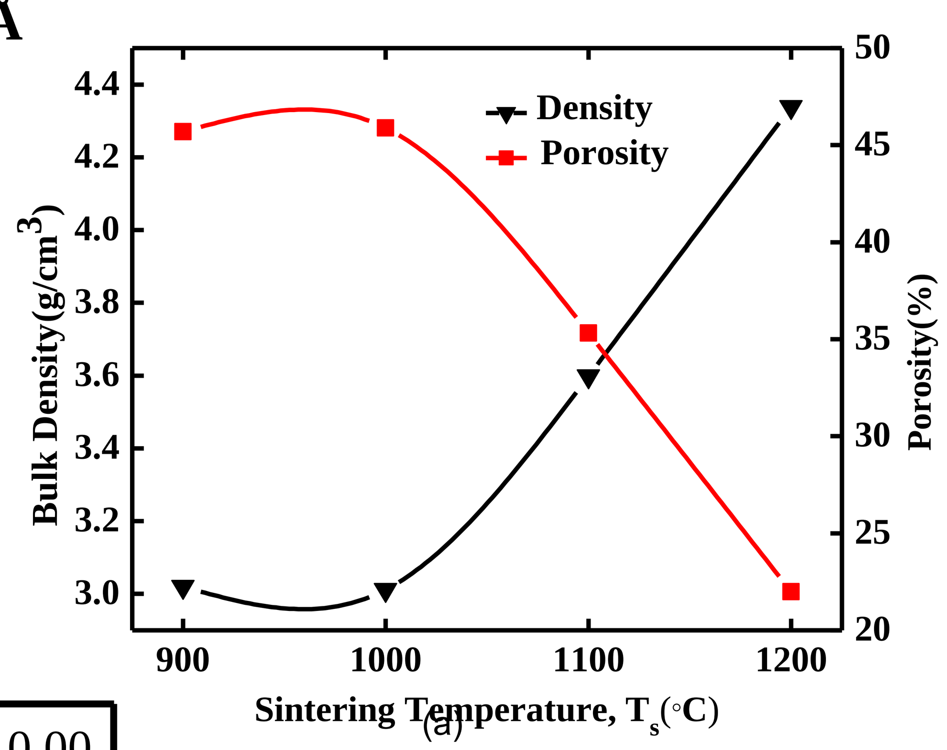


Ionic radii:

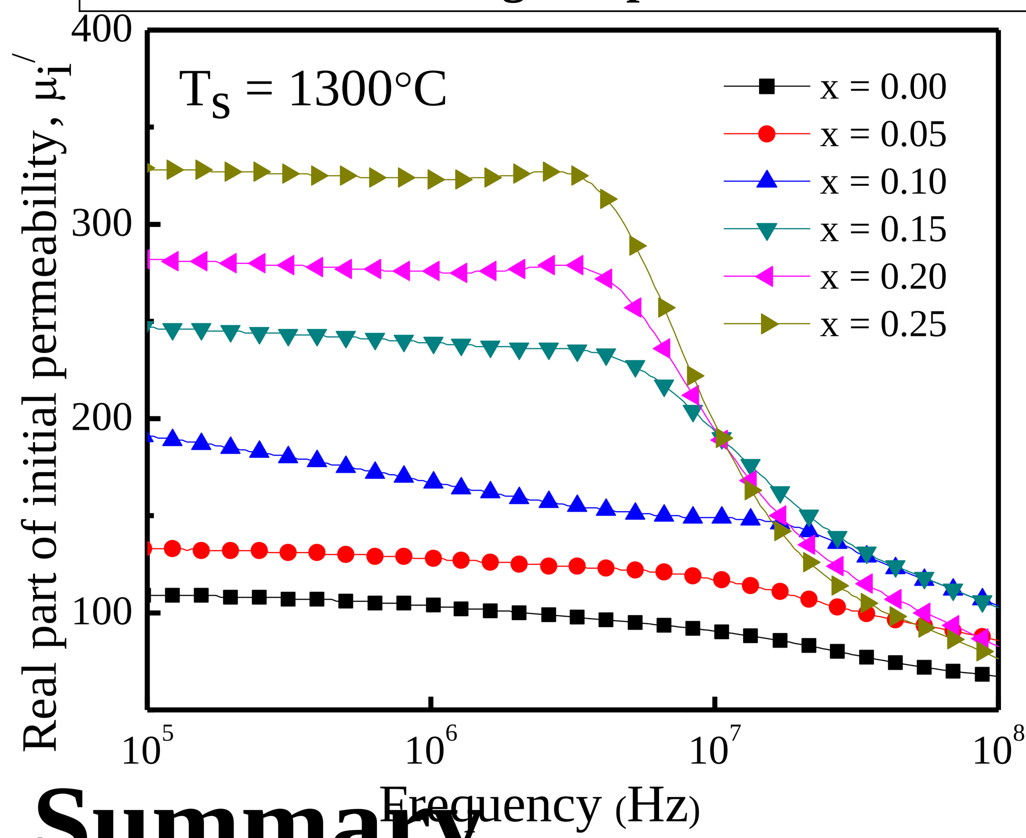
Ni^{2+} = 0.77 Å

Mn^{2+} = 0.89 Å

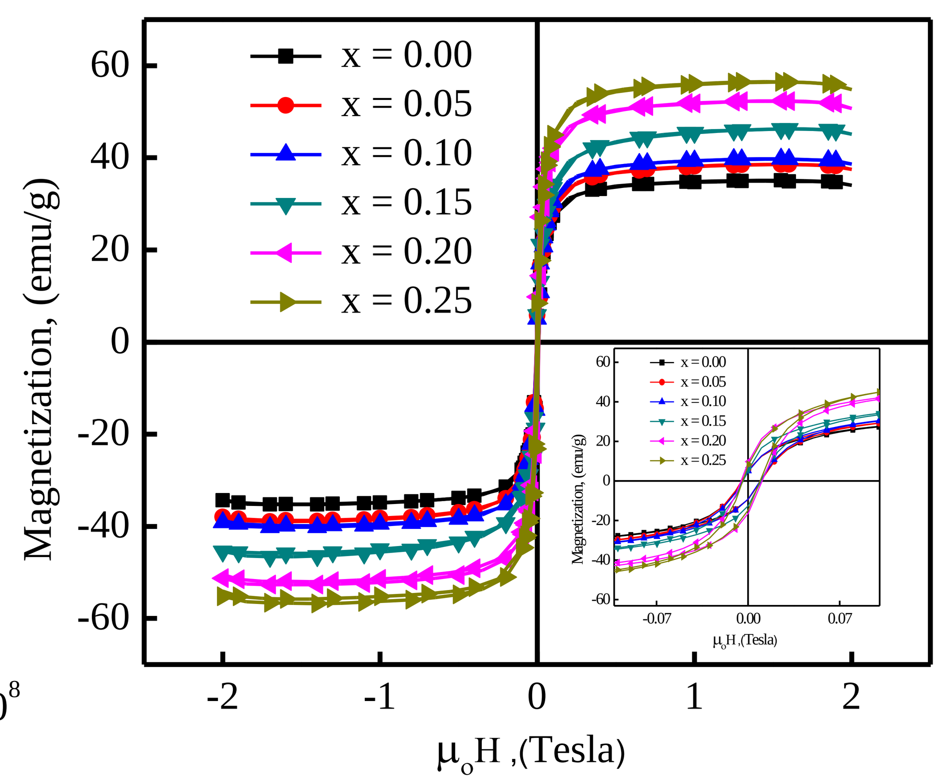
Porosity Vs. Density with sintering Temperature



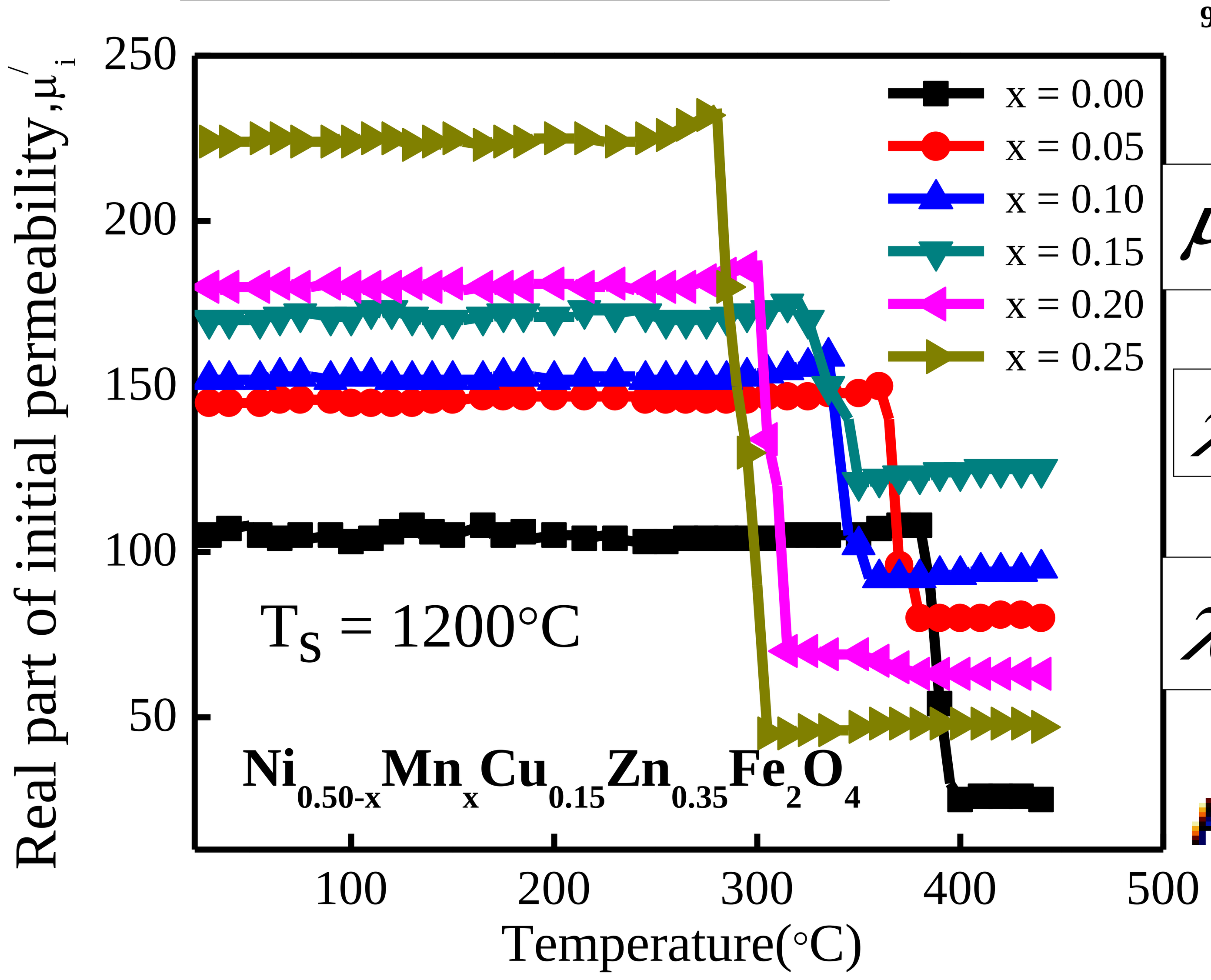
Frequency dependent Permeability with sintering Temperature



M-H loop



Temperature dependent Permeability with sintering Temperature



$$\mu_i = 1 + \chi_w + \chi_{spin}$$

$$\chi_w = 3\pi M_s^2 D / 4\gamma$$

$$\chi_{spin} = 2\pi M_s^2 / K_u$$

$$\mu_i = \frac{3D\mu_o M_s^2}{16\gamma_w}$$

Summary

- The XRD analysis of different ash-burnt powders of $Ni_{0.50-x}Mn_xCu_{0.15}Zn_{0.35}Fe_2O_4$ ensures that all the samples have single phase cubic spinel structure.
- It is found that crystallite size lies in the range from 20 to 28 nm. and FESEM analysis shows that average grain size of ash burnt powder lies in 69-126µm.
- The real part of initial permeability is found to increase with increasing Mn content as well as with sintering temperature. Saturation magnetization, Ms increases and coercivity decreases with increasing Mn content.
- Temperature dependent initial permeability graph reveals that Neel temperature decreases with increasing Mn substitution.