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Isochronal recovery behaviour on electromagnetic properties of polycrystalline nickel zinc ferrite ($Ni_{0.5}Zn_{0.5}Fe_2O_4$) prepared via mechanical alloying

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A new approach through heat treatment has been attempted by establishing defects by the process of quenching towards electrical and magnetic properties in the nickel zinc ferrite ($Ni_{0.5}Zn_{0.5}Fe_2O_4$) sample. The measured property values in permeability and hysteresis characteristic gave their recovery behaviour in which the values, after quenching were recovered after undergoing the annealing. Interestingly, a different trend observed in the permittivity value whereas the value was increased after quenching and subsequently recovered after annealing. The mechanisms which produced the changes is believed to be involved by defects in the form of vacancies, interstitials, microcracks and dislocations created during quenching which gave rise to changes in the values of the complex permeability and permittivity components and hysteresis behaviour.

A remarkable magnetic nanomaterial has been well known to be very stable in term of fundamental and various applications such as microwave absorbers, memory devices, microwave devices, environmental sensor, gas sensor, supercapacitor, magnetic hyperthermia cancer treatment, agents in drug delivery, magnetic resonance imaging, ferrofluids and also magnetic refrigeration. Particle size, morphology, cation distribution, compositions, core shell structure and structural characteristic effect has known to greatly influence the magnetic properties of the nanomaterial. Recently, the magnetic properties have been improved via synthetic techniques which have opened a wide range of applications[1–19]. As for in electronic application, devices based on polycrystalline $Ni_{0.5}Zn_{0.5}Fe_2O_4$ have been comprehensively applied due to their remarkable high resistivity, chemical stability, mechanical hardness and its high permeability value[20]. Microstructure elements such as grain size, grain boundary and pores were known to be highly impacted on the magnetic and electrical properties in $Ni_{0.5}Zn_{0.5}Fe_2O_4$ through the chosen synthesis process[21]. Conventional ceramic techniques based on oxide materials followed by sintering temperature at 1000 °C were normally used to synthesize ferrite with superior properties[22]. The extensive use of $Ni_{0.5}Zn_{0.5}Fe_2O_4$ and the general knowledge of their physical properties mainly contributed by their preparation condition have inspired us to investigate the heat treatment effect on complex permeability and permittivity along with hysteresis behavior in nickel zinc ferrite. The stoichiometric composition of $Ni_{0.5}Zn_{0.5}Fe_2O_4$ also has been known to have an effect on the electrical and magnetic properties of ferrites[23]. The nickel–zinc ferrite with the composition of $Ni_{0.5}Zn_{0.5}Fe_2O_4$ has been chosen in this study due to its chemical stability, high resistivity, noble soft magnetic property and low dielectric loss. As for recovery process, it is known as the behavior of a material's property whereas the initial values have been changed by cold-working or quenching tend to be recovered or restored after undergone a heat treatment process such as annealing through using the same annealing time during the recovery process[24–26]. In metals, the recovery behavior is usually attributed[27–29] to a huge increment in atomic vacancies by performing quenching, while the gradual decrease in the amount of the vacancies occurred with respect to the reheating process by annealing with slow cooling rate. The recovery behavior in $Ni_{0.5}Zn_{0.5}Fe_2O_4$ as a test material in this research work is based on the same idea referring to the recovery process which normally

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