Study the Absorption and Attenuation Coefficient to a model of Spinel Ferrite (CoFe2O4) to absorb a spectrum from (X-Band) of the Microwaves before and after irradiate it with fast neutrons

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Abstract: Four samples of the chemical-grade ferrite material were irradiated with fast neutrons (Am-Be) 241 and at an energy rate of 5 MeV and neutron flux ($\phi = 6 \times 10^7$ n.cm$^{-2}$.s$^{-1}$), knowing that these four models have been processed by four degrees of temperature (1250, 1200, 1150, 1100) ºC. The absorption and attenuation tests for these four models before and after irradiation were performed for microwaves (X-band) of the frequency band (8-12 GHz) in the Network Analyzer and found that the absorbance, attenuation coefficient and impedance increased by increasing the temperature of the sintering before and after irradiation, the best values were for absorption and the attenuation coefficient and resistance were at the sintering temperature of $T = 1250$ ºC and in state after irradiation. The results of irradiation showed that neutron irradiation significantly affected absorbance, as absorption and attenuation coefficient increased by increasing radiation dose.

1 Introduction
As the number of systems using high-frequency electromagnetic waves has increased, serious electromagnetic compatibility problems have become apparent, this has led to the search for electromagnetic wave absorption materials for the use in the GHz range [1]. The general composition of such ferrite is MeFe 2O4, where Me represents the divalent transition metals such as Co, Mn, Zn, Ni, Cu, Fe, Mg, the most popular being (CoFe 2O4) ferrite.
The gyromagnetic properties of ferrite make it the best electromagnetic wave absorber materials. Ferrite, having a resistivity of up to $10^8$ (Ω.cm) as compared to $10^7$ (Ω.cm) for iron, reduces the eddy current losses in them to negligible values even at microwave frequencies, Ferrite can be classified according to crystal structure into three types: Spinel Ferrite, Hexagonal Ferrite, The Garnet [2]. Microwaves region MW lies between radio frequency RF and infrared region IR, its wavelength are between (1-100) cm, and the nature of the spectrum of this region is a rotational spectrum. The microwaves frequency consist of many regions which are divided by two methods; IEEE method; and the other method is US military [3, 4]; every region has its own specific applications, like monitoring, detecting, and censoring for the far or the short range. The most important are X-band because it is widely used in radar systems

2 Fast Neutrons
This group includes nitrous which its energy more than 0.5 M eV. This type of neutrons is produced by some nuclear reactions, including fission. Within this range of energy, the predominant type of interaction between neutrons and matter is flexible scattering, which usually results in the atom's rebirth. The atom is exposed to
light matter. This occurs mostly in light materials, whenever there are more neutrons, the less likely it is to interact with matter. The neutrons, which exceed 20 M eV are very rare and are sometimes called relative neutrons because their speed is close to the speed of light. The access of neutrons to thermal energies depends on the absorbent medium, which should have a relatively low cross section compared with the scattering section. These substances (water, paraffin wax, heavy water, beryllium, graphite) [5].

3 Experiment section:

Spinel Ferrite (CoFe₂O₄) was prepared by solid-state reaction method using mixed (Fe₂O₃, CoO). We prepare four templates with dimensions (21 × 9× 9 mm³) to agree with the guide for grid analyzer instrument for the same dimensions above. Figure (1) explain the picture for sample template in this study [6].

![Figure 1: The sample template in this study.](image)

4 Neutron Source

A plane ²⁴¹²⁹⁰Am − Be manufactured by the USA, and of recent 38 mCi activity is provided and used in the present work. It is one of alpha initiated radioisotopic sealed neutron source and most widely used. The alpha particles from Americium have sufficient energy to react with beryllium, causes emission of neutrons according to the following reaction (Glenn F. Knoll 2000):

\[
^{241}_{95}\text{Am} \rightarrow ^{237}_{93}\text{Np} + ^{4}_{2}\text{Be}^\alpha
\]

\[
^{4}_{2}\text{Be} + ^{12}_{6}\text{C} + ^{1}_{0}\text{n} + Q = 5.71 \text{ MeV}
\]

Where: Q is the kinetic energy released in the reaction. Figure 2 explain the neutron source used to irradiation for sample templates, the dimension of the neutron source shielding from paraffin wax.

![Figure 2: the dimension of the neutron source shielding from paraffin wax.](image)

5 Irradiation of samples

Plane ²⁴¹²⁹⁰Am − Be neutron source is having a nominal output of 1.406x10⁹ ns⁻¹ at a mean energy of 5 MeV, \( \phi = 6x10^7 \text{ n.cm}^{-2}.\text{s}^{-1} \) provides the fast neutron for slowing down. Four samples of (CoFe₂O₄)
were placed into an irradiation port for 48 hr. The main advantages of using this kind of Source are physically small size, flux stability, and long useful lifetime (dies off with the half-life emitter).

6 The measurement

The following decibel (dB) law is very useful for calculations [7]:

$$dB = 10 \log R$$

(1)

Where, (R) The reflection coefficient, and the calculations for the attenuation coefficient or loss on reflection we use the following law in (dB) [7]:

$$\text{atten.Coeff} = 20 \log |R|$$

(2)

To calculate the reflectivity ($R^2$) by squares reflection coefficient and the evaluate transmission coefficient [7]:

$$dB = 10 \log T$$

(3)

and transmittance ($T^2$) by taking the second power, then we can find absorbability ($A^2$) use the following law [7].

$$R^2 + T^2 + A^2 = 1$$

(4)

7 Result and discussion

These tests include absorption and attenuation coefficient was performed using a network analyzer. The latter gives the absorbency tests and the thin wave attenuation factor within the X-ray range (8-12) GHz, the absorption curves, the attenuation coefficient, the impedance, and taken as a function of the frequency and the four temperatures. observed the absorption and attenuation coefficient increases as the sintering temperature increases. The best results are when ($T = 1250 ^\circ C$), in both cases before irradiation and after irradiation, but the best was after irradiation, we note the figures (3-14) of resistance, each form consists of two parts real part (RESISTANCE) and imaginary part (REACTANCE). In this study, RESISTANCE and its relation with absorptivity were observed. We observed from the resistance and absorptive curves that the resistance of the spinel ferrite with the following chemical formula (……) increases as the temperature of the sintering increases and the absorbance increases due to the increase of the resistance due to the relationship between them. With the results of previous research, we will conclude The following formula (……) is the best material to obtain high absorption after irradiation with fast neutrons. These results are better than the results obtained from previous research [9,8].

8 Conclusions

1- The temperature of the sintering is important for the formation of the ferrite, and increasing it works to eliminate all secondary phases.

2- The best value we obtained for absorption is at the temperature of sintering 1250 ºC because the spinel ferrite did not form at this temperature or less than of it then passes several stages, it has the ability to absorb. However, when the temperature of the frying is increased, the ferrite will be formed and its absorption will decrease because the resonance frequencies will be outside the range (X-band).
Figure 3: Show the absorbance curves as a function of frequency for samples at T=1150 °C.

Figure 4: Show the attenuation coefficients curves as a function of frequency for samples at T=1150 °C.

Figure 5: Show the impedance curves as a function of frequency for samples at T=1150 °C before Radiation.

Figure 6: Show the impedance curves as a function of frequency for samples at T=1150 °C after Radiation.
Figure 7: Show the absorbance curves as a function of frequency for samples at T=1200 °C.

Figure 8: Show the attenuation coefficient curves as a function of frequency for samples at T=1200 °C.
Figure 9: Show the impedance curves as a function of frequency for samples at T=1200 °C before Radiation.

Figure 10: Show the impedance curves as a function of frequency for samples at T=1200 °C after Radiation.

Figure 11: Show the absorbance curves as a function of frequency for samples at T=1250 °C.

Figure 12: Show the attenuation coefficient curves as a function of frequency for samples at T=1250 °C.
Figure 13: Show the impedance curves as a function of frequency for samples at T=1250 before Radiation.

Figure 14: Show the impedance curves as a function of frequency for samples at T=1250 °C after Radiation

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