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Study the Effect of MgO Addition on Some of Physical Properties of ZnO

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Abstract

Different percents(1.0,2.5,5.0 and 10)wt%of MgO powders were added to ZnO powder to study their effects on the physical properties of ZnO.Density, porpsity and water absorption of ZnO were decreased as MgO weigth percentage content increased. The values of vickers hardneess have double values especially at 1.0 wt % of MgO.

Introduction

Ceramics have been widely applied in engineering applications due to their excellent resistance to heat, corrosion, and wear .

Zinc oxide was the material of choice for this observation because it by far is the most common material used in the commercial manufacture and research due to its low cost and wide availability. It is valuable both for direct application or preparation of other compounds[1-3].

Zinc oxide (ZnO) has been produced commercially for considerably more than century, originally for use as a pigment in paints and also for rubber, glass, porcelain enamels and pharmaceuticals[4-6].More recently, Zinc oxide has found new application in semiconductors, luminescence and photoconductivity [1-3]

Zinc oxide varistors are ceramic semiconductor devices with highly non–linear electrical behavior and greater energy absorption capabilities.

This property allows their use in the protection of electric and electronic circuits, where as lightning rods remain the principal application .

Zinc oxide is also transparent to vissible light to a relatively high and uniform degree so that it exhibits a pure white of high brilliance [7] .

This research deals with the effect of magnesium oxide (MgO) addition on the physical properties of zinc oxide **.**

Some researchers studyied the addition of the materials on ZnO such as :

Lu et al [8] have studied the effect of porosity on the scaling of fracture strength who showd that the fracture strength of ZnO ceramics is more influenced by the ratio of pores and grain sizes.

Ramires et al [6] have studied the effect addition of SnO_2 on ZnO on the mechanical properties and found that the elastic modulus of ZnO –SnO_2 is doubled then ZnO only.

Abdullatif [9] has studied the effect of adding borax on the properties of ZnO such as linear shrinkage, density which shows that the increase of the weight percent of borax would lead to reduce the linear shrinkage and increasing the bulk density.

Experimental part

Materials

Zinc oxide powder (purity 99.5%) (Germany) with small parctical size less than 25µm has been used. Magnesium oxide has been prepared from magnesium salt (Boh) by heating the powders to 600 C° for 1hr . Four weight percentages of MgO (1.0% ,2.5% ,5.0% and 10%) have been used. Polyvinyl alcohol was used as a binder (at 1.5%).

5 samples for each percents have been prepared . All the samples sintered at (1300 C°) using 5 C°/min as a heating and cooling rate . The soaking time was 2 hrs.

Equipments

Many equipment have been used to prepare and test samples as follows:

- Digital balance (0.0001g) type (DNVER INSTRUMENT).
- Electrical oven type (COOPER HEAT).
- Hydraulic press (5 ton) type (BEGO) .
- Electrical furnace (up to 1350C°) type (RUHSTRAL)) .
- Microvickers harness type (TIME GROUP) .
- Gainding and polishing machine type (METASERV).

Preparation of disc samples

Each percent of MgO powder was mixed carefully with ZnO powders by ball mill for 1 hr. The homogenized powder compacted as a discs (10mm diameter and 10mm height) using 2 tons as a pressure force.

Characterization

Density measurement

Archemdise role has been used to calculate the apparent density according to ASTM (c373-71) and ASTM (c20-74) using the equation [10].

$\rho = w_d/(w_s - w_n)$ ……..(1)

where :

ρ= density (gm/cm^3)

w_d = dry weight (gm)

w_s= saturated weight in water

w_n= lmmersed weight in water

Porosity measurement

According to ASTM (c373-72) the porosity of the sintered sample was calculated by using the equation [10] .

P% =(ws-wd)/(ws-wn) *100……..…(2)

Water absorption measurement

According to the ASTM (c133 -81) the water absorption of the sintered sample was calculated by using equation [11].

$W.A\ \% = w_S - w_d/w_d * 100$ ……...…(3)

where :

W.A is water a absorption.

Linear shrinkage measurement

By using the below equation the linear shrinkage was calculated as follows [11] :

$L.sh\% = L_0 - L/L_0 * 100$……..…..(4)

where :

L.sh= linear shrinkage.

L_0 = hight of sample before firing.

L= hight of sample after firing.

Microvickers hardness measurement

Equation below was used to measure the microhardness of the sintered sample as follows [10]:

$H_V = 2p\sin(136/2)/D^2 = 1.854p/D^2$ ……..…(5)

Where :

H_V = Vickers hardeners (kg/mm^2)

P= Applied load .

D= diameter of the indent (mm)

Results and Discussion

Table (1) and all figures showed the behavior of zinc oxide doped by the different percentages of magnesium oxide for most physical properties. Fig.(1) shows the effect of MgO weight percentage on the bulk density of zinc oxide. This behavior has a good correlation with the mixture role which is[9]:

$\rho = \rho_1 v_1 + \rho_2 v_2$……(6)

where

ρ is the density of the doped sample

ρ_1 is the density of zinc oxide

v_1 is the volume fraction of zinc oxide

ρ is the density of magnesium oxide

v_2 is the volume fraction of MgO.

The density of ZnO is decreased as the MgO weight percentage is increased, that is clear because the density of zinc oxide is 5.606 g/cm^3 and the density of MgO is 3.58 g/cm^3.

Fig.(2) shows the effect of MgO weight percentage on the linear shrinkage of ZnO sample. The shrinkage is increased smoothly and then saturated at 1.0% and 2.5% then decreased at 10% and that may be due to the filling of the pores by MgO particals [9].

Fig.(3) shows the behavior of the zinc oxide porosity with MgO doped. It clearly showed that the porosity is decreased as the percent of MgO is increased. This behavior is proved by the increase of Vickers hardness Fig.(4) shows the effect of MgO percents on the water absorption property of ZnO, which shows the water absorption is decreased smoothly as this behavior is similar to the porosity behavior that is due to the pores found in the samples .All these values may be improved by increasing the sintering temperature [12].

Fig.(5) shows that the Vickers hardness has nearly double value of the native ZnO, and also it is well known that the porosity is inversely proportional to the mechanical properties. This increase in hardness may be due to the addition of MgO which may increased the crystal growth which caused the interconnecting of the grains [13].

Conclusions

The physical properties of ZnO was affected by the addition of MgO additive where density, porosity and water absorption have decreased as the percent of MgO increased.

Linear shrinkage has nearly a small variation but hardness is increased very obviously. Where the value of hardness is doubled than of pure ZnO (120HV).

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Table: (1) The physical propeties of doped ZnO

MgO Percent	Bulk density (gm/cm^3)	Linear shrinkage	Appernt porosty	Microhardness (Kg/mm^2)	Water absorption
0.0	4.97	0.52	19.23	59.7	4.13
1.O	4.80	0.54	18.00	126	3.29
2.5	4.67	0.54	15.75	93	3.50
5.0	4.70	0.55	15.75	86.8	3.60
10	4.47	0.53	15.71	78.9	3.30

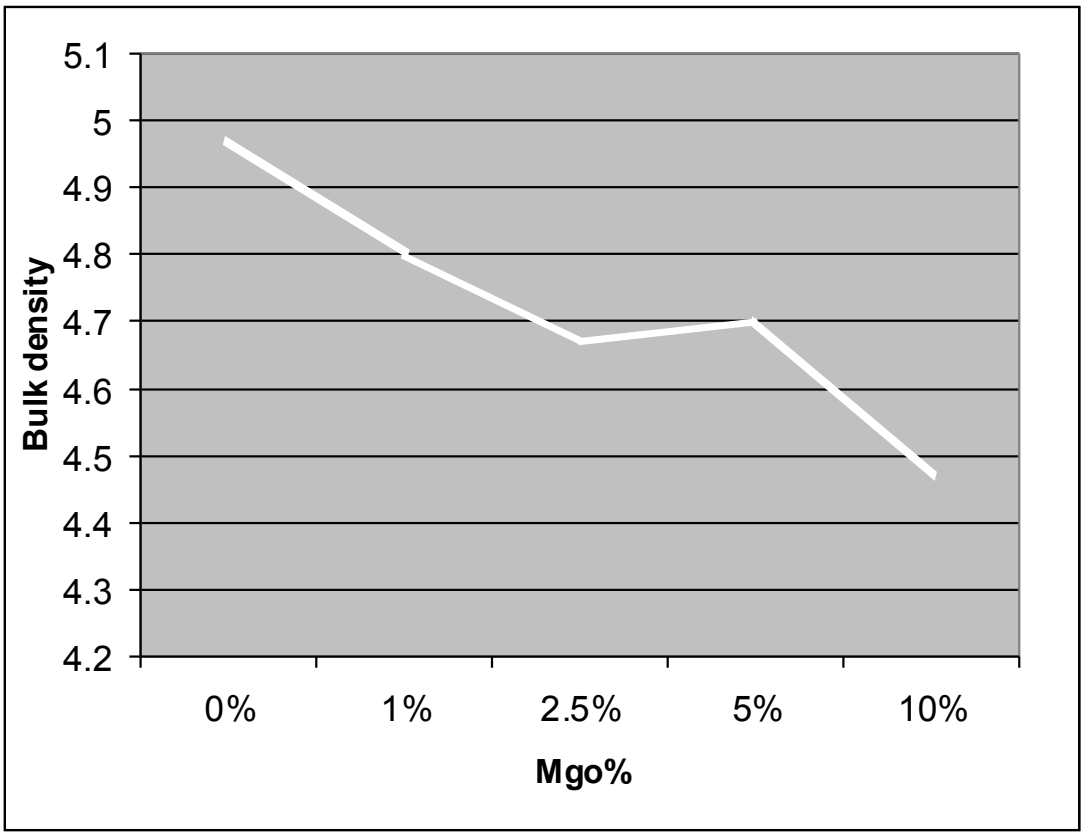

Fig. (1) Variation of bulk density of ZnO with MgO percentage

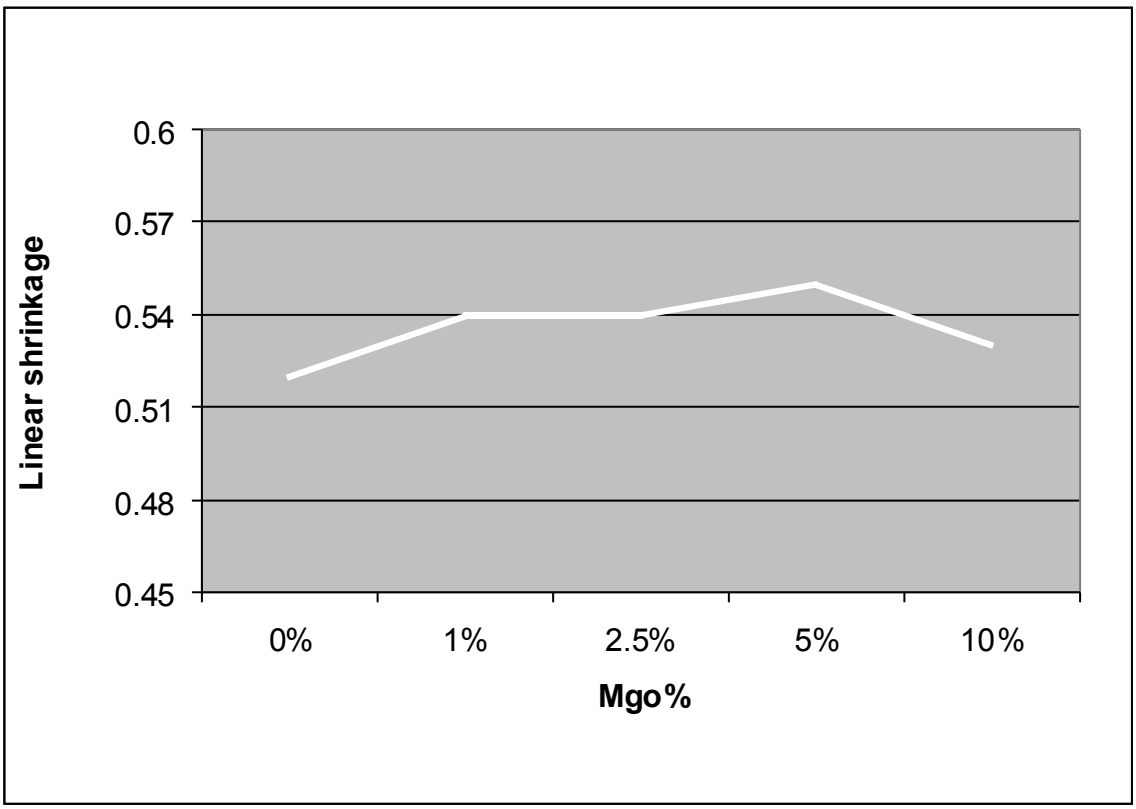

Fig. (2) Variation of linear shrinkage of ZnO with MgO percentage

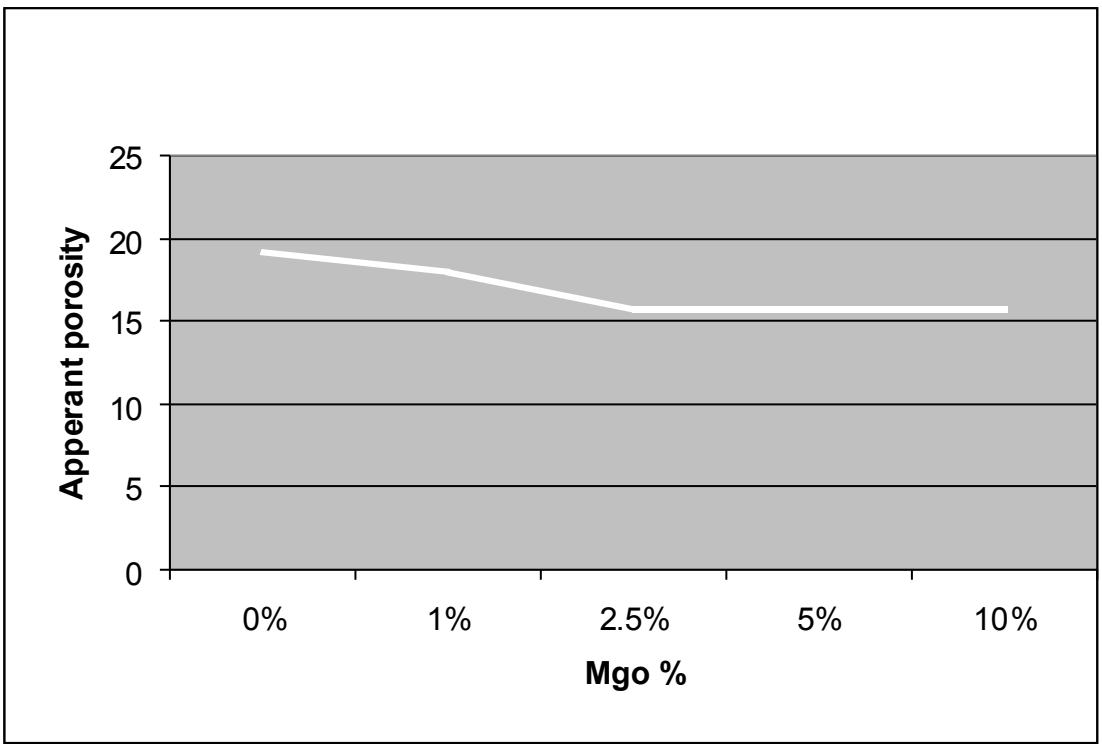

Fig .(3) Variation of apperant porosity of ZnO with MgO percentage

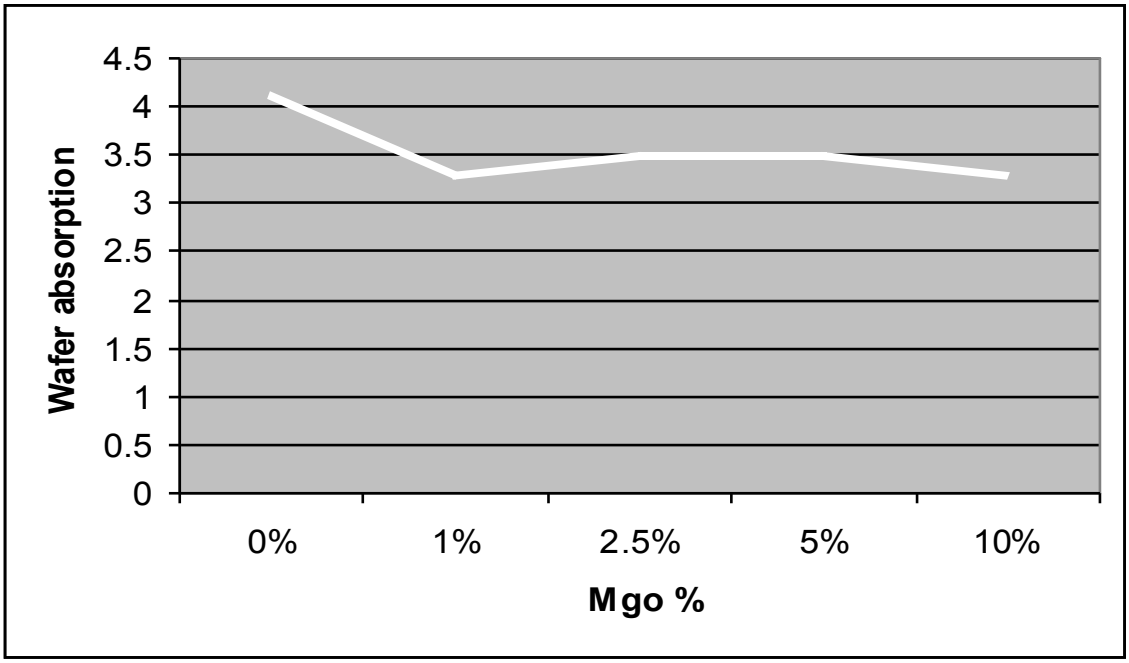

Fig .(4)Variation of water absorption of ZnO withMgO percentage

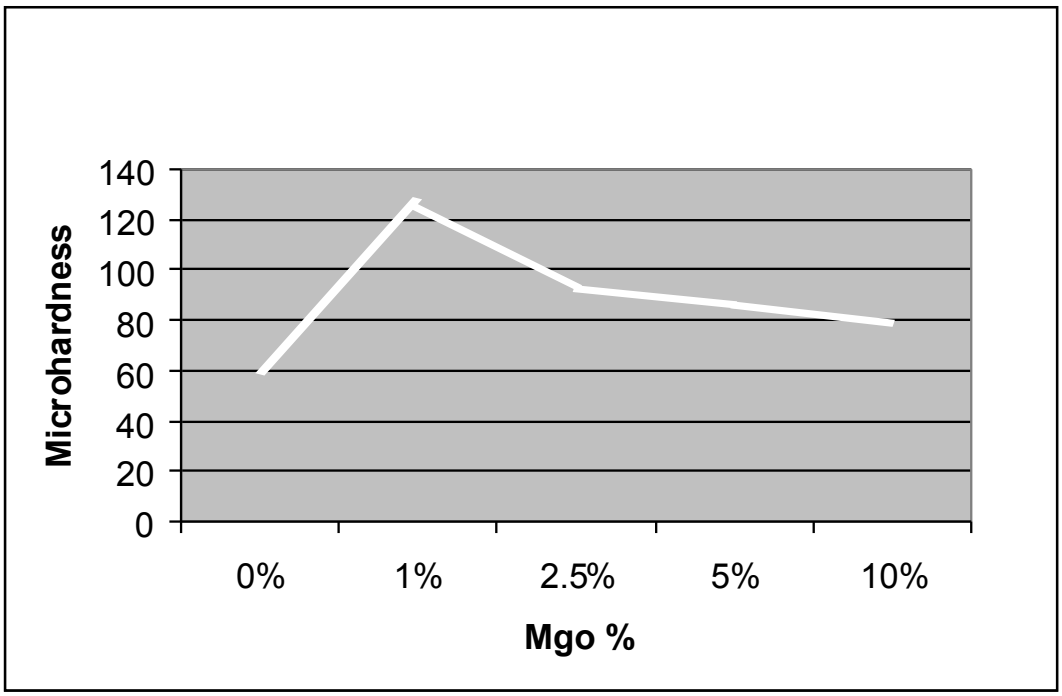

Fig .(5) Variation of microhardness of ZnO with MgO percentage

مجلة ابن الهيثم للعلوم الصرفة والتطبيقية المجلد23 (2) 2010

دراسة تاثير اضافة اوكسيد المغنسيوم فى بعض الخواص الفيزيائية لأوكسيـد الزنـك

شيماء قاسم عبد الحسن

قسم الفيزياء ،كليه التربيه ابن الهيثم ، جامعه بغداد

الخلاصة

أضيف نسب وزنية % (1.0,2.5,5.0and10) من اوكسيد المغنسيوم الى مسحوق اوكسيد الزنك لدراسة تاثيرها فى الخواص الفيزيائية لـه .ولقد وجد ان الكثافة والمسامة والامتصاصية للماء تقل لاوكسيد الزنك كلما ازدادت نسبة الاضافة لاوكسيد المغنسيوم . الا انه قد لوحظ ان قيمة صلادة فيكرز تضاعفت عند النسبة الوزنية % 1.0من اوكسيد المغنسيوم.