التمثيل العددي لبعض خصائص سيليكات الالمنيوم المغنيسيوم للسيراميك الزجاجي

ايسر جمعة ابراهيم

قسم الفيزياء ، كلية التربية – ابن الهيثم، جامعة بغداد

الخلاصة

يحتوي الزجاج سيليكات الالمنيوم المغنيسوم على كميات مختلفة من فلوريد المغنيسيوم تتراوح بين(0-13.2)%.

يلاحظ ان معامل التمدد الحراري والصلابة الدقيقة للزجاج الاساسي ونماذج الزجاج السيراميكي معتمد بشكل تداخلي على بعضهما لكون هناك مركبات عديدة تدخل في التركيب، ويلاحظ ان السلوك معقد نوعا ما مع زيادة محتوى فلوريد المغنيسيوم.

ان معامل التمدد الحراري يزداد مع نقصان الصلابة، والتمثيل في هذه الدراسة استخدمت طريقة L^2-regress للتمثيل العددي لهذين المتغيرين للمقارنة بين الكمية المقاسة عمليا والمحسوبة بالطريقة الرياضية.

Numerical Estimation of Some Properties of Magnesium Aluminum Silicate Glass Ceramic

A. J. Ibrahiem
Department of Physics., College of Education – Ibn Al-Haitham , University of Baghdad

Abstract

Magnesium aluminum silicate of glass ceramic having different amounts of magnesium fluoride in the range (0-13.2)%.

Thermal expansion coefficient and micro hardness of the base glass and glass ceramic samples are seen to be interdependent but due to the multi – component system, the behaviour is seen to be somewhat complex, with an increase in MgF_2 content.

The thermal expansion coefficient increase and micro harness decrease, numerical simulation of thermal expansion and hardness is useful in this study, L^2 – regression is used to calculate the two parameters associated with each glass component, by comparing the measured parameters and the calculated parameters ,it is useful to use such a method to calculate the quantity of the component used in manufacturing the glass & class ceramic.

Introduction

The glass ceramics based on the magnesium aluminum silicate (MAS) system belong to an important class of advanced technological material, having a wide range of applications[1] .Some of their interesting features are mach inability, stability, high electrical insulation, vacuum compatibility, etc. Coeff, conductivity… etc depend on the composition and microstructure, [2] in some papers carried out some studies on thermal properties of Li_2O-MgO – Al_2O_3 – SiO_2 glass and glass ceramic, [3] in the preparation and study of thermal expansion and micro hardness of (MAS) glass and glass ceramic having different composition prepared under different conditions [4], the concentration of MgF_2 was varied from 0-13.2% mole. Due to the multi component nature of material the behavior was found to be some what complex.

The knowledge of thermal and mechanical properties of glass ceramic needed for the application in the field of glass ceramic to metal, generally the glass ceramic exhibits a wide range of thermal expansion depending upon the composition the consolidated study of thermal expansion coefficient, and micro hardness of MAS glass ceramic of a function of processing temperature which seems not to be reported.

The average thermal expansion (30-300)°C of base glass samples decreases from ($8.38 \rightarrow 7.936\times10^6$), with the increase of MgF_2,the content of the micro hardness of base glass without MgF_2 is higher than (6.822 Gpa) as compared to 13.2% mole of MgF_2 (6.32 Gpa).

In all cases, thermal expansion coefficient (TEC) increases & micro hardness decreases when glass is transformed to glass ceramic by controlled crystallization at different processing temperature.

Numerical simulation

In some research[4], simple model is used to interpret the contribution. of glass component to the thermal expansion of certain temperature, the model assumes linear contribution of glass component to glass property i.e. thermal expansion and hardness chemical

The simulation model at hand (L^2- regression) related linearity the glass property to weight percentage or mole fraction of each chemical component of glass, to fundamental of linear algebra are essential presenting matrices model.

Reliance on such model comes from that, this study aims to assist in solving problems in glass industry which is mainly originated from minor change in composition of Iraqi ores.

Let a_i be the ith component (e.g Wt%) of the chemical composition that contributes to the glass property P as follows

$$P = \sum_{i}^{n} a_i x_i > \ldots\ldots(1)$$

where x_i are numerical coefficients and n is the number of composition components.

If there are m measures for the property, each for different composition for the glass tehn

$$P_j = \sum_{i,j}^{n,m} a_{i,j}, x_i \ldots\ldots(2)$$

Where j = runs on the composition numbers

a_{ij} is the value of the ith component of the jth composition and P_j is the value of the glass property fo jth composition

in matrix notation, the system of linear equation can be expressed in term of matrix C.

$$Cx = p \ldots\ldots(3)$$

C is the matrix of numerical values a_{ij}

X is a column factor containing the coefficient x_i and p is also a column vector containing the measurement value p_i

So in order to obtain the values of the coefficients x_i the above equation can be written as [5].

$$X= C^{-1}P \ldots\ldots(4)$$

The solution of the linear system linear system equ (4) utilizing L^2 – regression is as follows:

$$X= (C^T.C)^{-1} C^TP \ldots\ldots(5)$$

Where C^T = the transpose of matrix C

$(C-^TC)^{-1}$ is the inverse of matrix resulting form the dot – product C^T C.

The experimental data is used to compose the materials, a computer program for mathematical operation Matlab installed on Pc computer has been used to handle matrix operation and obtaining the coefficient table and plots are done by using Microsoft excel, the measured coefficient of TEC & hardness, and the calculated are plotted for different batches at different temp.

Results

The thermal expansion and micro hardness for different batches samples after processing at different temperatures are summarized in tables from (1- 10) and the measuring data of such kind of base glass and ceramic [4]– glass have been used for calculating thermal expansion & the micro hardness by using L^2- regression.

Table (1) represents the batches used to calculate the two parameters and tables (2-5) represent each batch with different temperatures, and we can see the measure parameters and the calculated parameters.

While the tables (6-10) show the two parameters both measured and calculated at constant temperature with different batches.

Conclusion

From the tables (2-9) result for both of the measurements of the calculated data, it can be seen that the differences are too small which were excepted due to the measurement occurring for chemical composition, therefore, it is always better to have alarge amount of data and optimizing the solution by using an advance technique such as L^2 –regression used in this study.

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Table (1):Nominal composition of different batch samples

Batch	SiO_2/M-Oxide	MgO (mol%)	MgF_2 (mol %)
Batch I	1.137	12.85	0.00
Batch II	1.127	12.85	6.6
Batch III	1.129	12.82	13.2
Batch IV	0.764	25.7	6.6

M= Al+B+K+Mg.

Table (2-5): Shows the difference between the measure and calculation of the two parameters (TEC & micro hardness)

Table (2)

Batch1 T^OC	Micro Hardness Meas	(Gpa) Har	TEC Meas	TEC (30-300) ($10^{-6}/^OC$) (Calcu)
600	5.84	5.81	7.936	7.84
725	5.74	5.67	8.211	8.101
850	5.67	5.56	8.266	8.230
950	5.57	5.51	8.413	8.391
1050	5.43	5.20	8.6	8.621

Table (3)

Batch2 T°C	(Opa) Micro Hardness Meas	(Gpa) Hard (Calc)	TEC Meas	TEC (30-300) (10^{-6}/°C) (Calc)
600	6.03	5.98	8.53	8.56
725	5.82	5.79	9.255	9.311
850	5.74	5.71	9.553	9.492
950	4.59	5.10	9.591	9.583
1050	4.25	4.42	9.618	9.611

Table (4)

Batch3 T °C	(Opa) Micro Hardness Meas	(Gpa) Hard (Calc)	TEC Meas	TEC (30-300) (10^{-6}/°C) (Calc)
600	6.32	6.24	9.285	9.311
725	6.25	6.134	9.56	9.461
850	5.02	5.131	9.821	9.793
950	4.67	4.63	9.873	9.821
1050	4.22	4.31	10.159	10.063

Table (5)

Batch4 T °C	(Opa) Micro Hardness Meas	(Gpa) Hard (Calc)	TEC Meas	TEC (30-300) (10^{-6}/°C) (Calc)
600	6.82	6.752	7.463	7.352
725	6.38	6.27	7.583	7.471
850	5.22	5.20	9.376	9.151
950	5.37	5.29	9.587	9.643
1050	5.36	5.34	9.643	9.512

Table from (6-10) shows the difference of the two parameters (TEC) and hard ness at constant temperature with different batches

Table (6)

At 600°C	(Opa) Micro Hardness Meas	(Gpa) Hard (Calc)	TEC Meas	TEC (30-300) (10^{-6}/°C) (Calc)
B_1	5.84	5.81	7.963	7.84
B_2	6.03	5.98	8.53	8.56
B_3	6.32	6.24	9.285	9.311
B_4	6.82	6.752	7.463	7.352

Table (7)

T= 725°C	(Opa) Micro Hardness Meas	(Gpa) Hard (Calc)	TEC Meas	TEC (30-300) (10^{-6}/°C) (Calc)
B_1	5.74	5.67	8.211	8.101
B_2	5.82	5.79	9.255	9.311
B_3	6.25	6.13	9.56	9.461
B_4	6.38	6.27	7.583	7.471

Table (8)

T=850°C	(Opa) Micro Hardness Meas	(Gpa) Hard (Calc)	TEC Meas	TEC (30-300) (10^{-6}/°C) (Calc)
B_1	5.67	5.56	8.266	8.230
B_2	5.74	5.7	9.553	9.492
B_3	5.02	5.131	9.84	9..793
B_4	5.22	5.202	9.376	9.151

Table (9)

T= 950°C	(Opa) Micro Hardness Meas	(Gpa) Hard (Calc)	TEC Meas	TEC (30-300) (10^{-6}/°C) (Calc)
B_1	5.57	5.51	8.413	8.56
B_2	4.59	5.10	9.591	9.583
B_3	4.67	4.36	9.873	9.82
B_4	5.37	5.29	9.587	9.643

Table (10)

T=1050°C	(Opa) Micro Hardness Meas	(Gpa) Hard (Calc)	TEC Meas	TEC (30-300) (10^{-6}/°C) (Calc)
B_1	5.43	5.20	8.6	8.621
B_2	4.25	4.42	9.618	9.611
B_3	4.22	4.31	10.159	10.063
B_4	5.36	5.34	9.643	9.512