MICROWAVE PROCESSING OF SILICA FROM RICE HUSK

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Abstrak

Penelitian ini untuk membuat silica keramik dengan menggunakan energi mikrowave. Silika diproduksi dari sekam padi yang diperoleh di persawahan di Sulawesi Tenggara. Silika yang diperoleh memiliki kemurnian rata-rata 93.8 %. Silika ini di buat pellet lalu disinterring sampai suhu 1100 ^oC untuk mendapatkan keramik dengan kualitas tinggi. Mikrowave yang digunakan dari hasil modifikasi oven microwave komersial. Hasilnya dibandingkan dengan pemanasan biasa (dengan tanur listrik). Hasil ekperimen menunjukkan perbedaan yang signifikan dibandingkan keramik hasil pemanasan biasaterhadap sifat-sifat keramik. Ini menunjukkan bahwa ada 'microwave effect' terhadap silika selama sintering.

***Kata Kunci**: Silika, mikrowave, keramik, microwave effect.*

I. INTRODUCTION

Microwave used for material processing becomes populer recently because of its peculiar effect on materials [1]. For ceramic sintering, they have been widely studied. For example for alumina, zirconia, barium titanate, mullite, phosphates, and borides [2-5]. In addition, many other processes have been applied microwave energy and showed a different behavior than that of conventionally processing [6-11]. Some advantages were reported and tried to explained theoritically [12-14]. The researchers interest on the use microwaves to reduce the time necessary to achieve esterifications, hydrolyses, ether preparations, Diels-Alder reactions, oxidations, ene reactions, and halide exchange reactions [13]. In this research, we applied microwave energy for processing silica extracted from rice husk ash. Effect of microwaves to properties of silica ceramic then studied.

II. MICROWAVE ABSOPTION MECHANISM

In a microwave furnace, the material will absorb microwave energy and will convert it into heat by various dissipation mechanisms [1]. On the basis existing theories, the total absorption of microwave energy in materials is hypothesized to result from the simultaneous contributions of ionic conduction, ion jump relaxation, and multi phonon processes.

In conventional heating, the heating elements supply heat to the sample, the majority of heat is concentrated along the surface. Because energy absorbed only at surface and must be transferred into the bulk of part by conduction which taking a finite amount of time. Then the surface must hotter than interior until the part achieves thermal equilibrium [2].

In general, the time-averaged power dissipated per unit volume in a material can be expressed as [1]

$P_v = 1/2\omega\varepsilon_0\varepsilon^{``}|E|^2$……………………(1)

Where ε is the imaginary of the complex dielectric constant of the materials, ω is the angular frequency of the electric field E, and ε_0 is the permittivity of free space. The complex and frequency-dependent dielectric constant is determined by the structural properties and thermodynamic state of the material. The charges present in the material would respond to the electric field by two processes, i.e. polarization and conduction [2,3]. The formation and displacement of dipoles is dominant at the microwave frequencies (2.45 GHz) as shown in Figure 1.

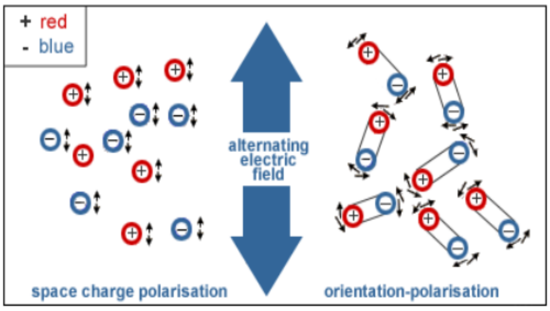

Fig. 1 Polarization of dipoles because of microwaves

Another observation that is important to microwave processing is the shift in the losses due to dipolar rotation towards microwave frequencies with temperatureas shown in Figure 2. The absorption of microwave energy and conduction would result in a rise in temperature, $\frac{\Delta T}{\Delta t}$, and this given by the following equation [1]:

$$\frac{\Delta T}{\Delta t} = \frac{2\pi f\varepsilon_0\varepsilon_{eff}^{``}E_{rms}^2}{\rho c_p} \quad \ldots\ldots\ldots\ldots\ldots\ldots(2)$$

where, $\varepsilon_0^{``}$ is the permittivity of free space ($8.85\times10^{-12}$ $V/m^3$), $\varepsilon_{eff}^{``}$ is the relative effective dielectric loss due to ionic conduction and dipolar reorientation, f is the frequency (Hz), E_{rms} is the root mean square of the electric field within the material (V/m), ρ is the bulk density of dielectric material (kg/m^3) and C_p is the heat capacity of the material at constant pressure(J/kg^oC).

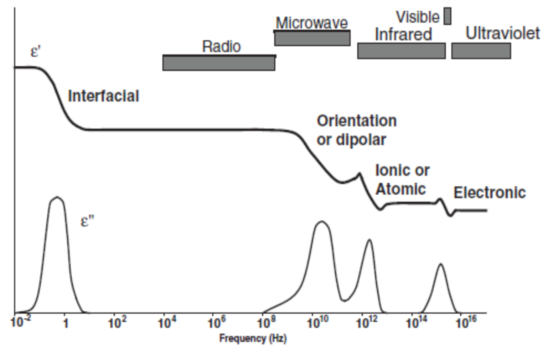

Fig. 2 Frequency dependence of microwave absorption

III. EXPERIMETAL

a. Material

Silica powder was produced from rice husk ash. The procedure of extracting silica from rice husk ash has been published elsewhere [5]. The silica powder found in this experiment has 93.8 % purity.

b. Sintering

The microwave sintering experiments were performed in a 2.45 GHz microwave oven (Panasonic NE-C236, Japan). The maximum automatic output microwave power is 800 W. The power consumption is 1.43 kW. The schematic picture of the sintering system is shown in Figure 3.

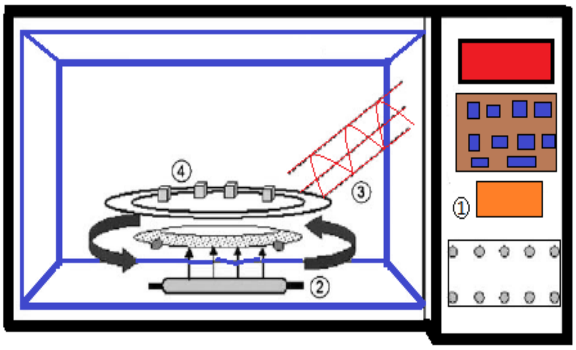

Fig. 3. Schematic picture of a microwave oven : (1) control; (2) lamp; (3) microwave radiation; (4) samples on turntable table

Sintering was continuously performed until the desired temperature of the samples reached. And the samples were cooled in air. During the experiments, ambient temperature was recorded.

Silica sintering experiments were performed by using three power levels: high power was calculated as 600 W, medium power as 300 W and low power as 150 W from temperature 600 to 1100 ^{o}C. The samples were placed in the oven and temperature every 30 seconds was recorded by a digital balance.

The densities of sintered samples were measured by using Archimedes Method [3].

III. EXPERIMENTAL RESULTS

Experiments of sintering silica by using microwave energies were succesfully performed by using microwave devices with frequency 2.45 GHz. The temperatures were recorded by infrared thermometer. Some experiment results are presented in this section. Figure 4 shows the densification behavior of silica after sintered by using microwave 2.45 GHz and electric furnace (conventional). The difference in density at same sintering temperature was showed.

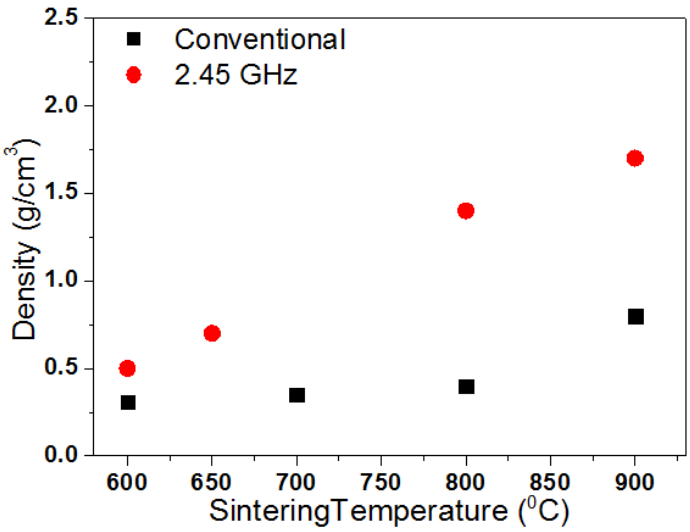

Fig. 4 Densification of microwave 2.45 GHz and conventionally sintered silica .

The graph shows a faster densification on microwave sintering. The result indicates a microwave effect occurred during sintering of silica. Next experiment will be prepared for more details characterization of sintered samples such as by using Scanning Electron Microscophy for microstructure, X-Ray Diffraction for phase change, etc. Moreover, experiment by using higher microwave frequencies such as 28 GHz and 300 GHz should be performed to more understanding microwave interaction mechanism with silica.

IV. CONCLUSION

Experiment to investigate microwave-silica interaction effect was performed by using a domestic microwave oven (2.45 GHz). Densification of sintered samples was then evaluated. Conventional sintering was also performed and used as a comparison. The microwave showed a faster densification than conventional ones at all sintering temperatures.

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