MICROWAVE-INDUCED MASS TRANSPORT ENHANCEMENT IN NANO-POROUS ALUMINUM OXIDE MEMBRANES

C.J.Bonifas[1], A.Marconett[1], J.Perry[1], J.H.Booske*[1], R.F.Cooper[2]
1. University of Wisconsin. Madison, Wisconsin
2. Brown University. Providence, Rhode Island

The affect of electromagnetic forces on the diffusion of charged species has been observed by Freeman et. al to increase the diffusion of a charged species in an ionic crystal [1]. Additionally, previous work by Bykov et. al demonstrated that the presence of an electro-magnetic field during the thermal treatment of an aluminum oxide membrane affected the amount of diffusion occurring in the membrane [2]. It was shown that a significant increase in diffusion was seen when the pores were heated to 1100 ^{o}C with a 100 GHz gyrotron versus a conventional furnace. Experimentally, this increase in diffusion manifested itself as an increased amount of pore aperture shrinkage on the surface of the sample. These basic studies increase our understanding of nonthermal reactions due to the high frequency electric field forces present during microwave heating of materials.

However, it was unknown whether this increase in mass transport is unique to the 100 GHz regime, as there had yet to be a study that analyzed the affects of lower electro-magnetic frequencies on diffusion. This paper illustrates the difference in the amount of diffusion occurring in aluminum oxide membranes heated in a 2.45 GHz microwave furnace versus those heated in a conventional furnace. Aluminum oxide membranes with an average pore diameter of 200 nm were heated in a resonant cavity microwave system operating at 2.45 GHz and compared to specimens heated in a conventional radiative tube furnace. The total thermal budget for the two techniques was kept the same. The net diffusion in the samples was calculated by analyzing the relative difference in pore size before and after the anneals via scanning electron microscopy. Though an enhanced mass transport effect was seen in the microwave heated samples, the manifestation of this increased diffusion was different than that seen by Bykov et. al. As opposed to a reduction in pore aperture diameter, the pores on the surface of aluminum oxide samples heated with 2.45 GHz microwave radiation experienced increased coalescence compared to samples heated in a conventional furnace. This difference between the two studies is likely due to the difference in the initial surface pore density of the samples.

[1] S.A.Freeman, J.H.Booske, R.F.Cooper, "Nonthermal Affects of Microwave Radiation on Ionic Diffusion in Ionic Crystalline Ceramics," in Proceedings of IEEE International Conference on Plasma Science. (5-8 June 1995).
[2] Y.V.Bykov, et. al, "Evidence for Microwave Enhanced Mass Transport in the Annealing of Nanoporous Alumina Membranes," Journal of Materials Science, 36 (1), 131-136, January 1, 2001.