

## Errata

Str.	Wiersz		Jest	Powinno być
	góra	dół		
4		18	$n_\gamma - n_\alpha = 0.080 - 0.079$	$n_\gamma - n_\alpha = 0.080 - 0.079$
9	13		(Ch) transformed	(Ch) partially transformed
15	9		16.4	16.4%
19	11		Fig. 1 12	Fig. 1, 12
19	12		MgCO <sub>3</sub>	MgCO <sub>3</sub>
22		7	burned	burned
46	2		by activation	activation by
47		13	CZENKO N. S.	CHENKO N. S.
plansze kredowe po str. 100			WOŁOSIŃSKI	WŁOSIŃSKI

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## THE TRANSFORMATION OF THE PHASE COMPOSITION OF POLYCRYSTALLINE CERAMIC MATERIALS DURING METASOMATIC RE-SINTERING

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**Abstract.** Taking as an illustrative case a ceramic material made up of polycrystalline  $\alpha$ - $\text{Al}_2\text{O}_3$  which was subjected to *metasomatic sintering* at 2000 K in the presence of sodium aluminate  $\text{NaAlO}_2$ , the authors demonstrate the possibility of complete transformation by diffusion of compact polycrystalline ceramic  $\alpha$ - $\text{Al}_2\text{O}_3$  into  $\beta$ - $\text{Al}_2\text{O}_3$  ( $\text{Na}_2\text{O} \cdot 11\text{Al}_2\text{O}_3$ ). The resultant material has an ionic conductivity of  $2.7 \cdot 10^{-1} \Omega^{-1} \text{cm}^{-1}$  at 570 K. The preservation of compact, non-porous structure of the material despite a 20% increase in volume was possible due to the fact that  $\beta$ - $\text{Al}_2\text{O}_3$  retains the tabular habit of corundum crystals. Sodium aluminate ( $\text{Na}_2\text{O} \cdot 11\text{Al}_2\text{O}_3$ ) is pseudomorphous after corundum. The material obtained meets all the requirements as a solid electrolyte used in Na-S cells.

### INTRODUCTION

Ceramic materials are obtained by partial or complete vitrification of a set of mineral components, or by inhibiting of the sintering process at a specified moment. It follows, therefore, that the whole process rests on a series of solid-state reactions and, if appropriately programmed, yields a ceramic material of the desired phase composition and structure. It is also interesting to note that a large number of microstructures with different properties may be obtained from batches of similar composition. Due to this, it is generally held that ceramics is the chemistry of inhibited processes.

Due to considerable divergence in opinions concerning the nomenclature of ceramic materials (Szymański 1976), certain option is allowed in this respect. Assuming that the name of a material is to define briefly its kind and composition, the present authors will use furtheron the name *ceram* suggested by E. Görlich, which has the same connotation in ceramography as *rock* in petrography or *metal* in metallography. The word *ceram* denotes that the inorganic non-metallic material is obtained by synthesis, whereas

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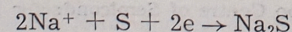
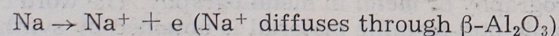


the preceding word or words define its composition and approximate structure, e.g. corundum ceram. The terms *alundum ceramic material* or *alundum ceramic*, which are generally used, afford no information on the material.

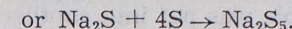
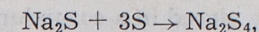
If ceramics is defined as the chemistry of inhibited processes, it is obvious that a process may be prolonged and, consequently, the properties of the resultant ceram changes as desired. The first materials subjected to secondary heat or photochemical treatment were glass cerams (Stooky 1959, McMillan 1964). Depending on the intensity of the process, re-heating or irradiation of glass cerams containing the nuclei of crystals results in controlled devitrification, yielding ultimately a wide spectrum of new glass-ceramic cerams with a cryptocrystalline structure and properties modified by the amount and kind of mineral components, such as cristobalite, pyroxenes, and others, crystallizing in the ceram. These materials have been given different names (devitrificates, *sittals*, glass-ceramic materials) which are to render their intermediate position between glass cerams and the porcelain-type polycrystalline cerams. The cryptocrystalline structure of devitrified glass cerams increases their hardness by two Mohs degrees relative to the initial glass ceram (Szymański 1973). This widens considerably the range of application of these materials (Mc Millan 1964; Szymański, Włosiński 1976).

As demonstrated hereafter, polycrystalline cerams can be heat-treated again with simultaneous introduction by diffusion of specific cations into the structure of minerals making up the initial ceram. In the process of *metasomatic re-sintering* the phase composition and the structure of the ceram can be changed in such a way that the product would possess the desired functional properties. A monophase corundum ceram made up of polycrystalline  $\alpha$ - $\text{Al}_2\text{O}_3$  with a small amount of intercrystalline aluminium-high glassy phase was selected for the present investigations. The material in question is formed from aluminium oxide obtained in Bayer process as aluminium hydroxide which is transformed by calcination into  $\alpha$ - $\text{Al}_2\text{O}_3$ . After grinding to a grain-size  $< 3 \mu\text{m}$  and compressing at a pressure of about  $3000 \text{ kg/cm}^2$ , the material is heated in a gas furnace at  $2070 \text{ K}$ , yielding a typical corundum ceram of a hardness between 9.1—9.2 in Mohs scale and a porosity  $< 0.01$ . It is used as dielectric in electronic industry or as a construction and tool material in machine building industry.

The purpose of this paper was to investigate the possibility of transformation of  $\alpha$ - $\text{Al}_2\text{O}_3$  into  $\beta$ - $\text{Al}_2\text{O}_3$ , being actually sodium aluminate  $\text{Na}_2\text{O} \cdot 11\text{Al}_2\text{O}_3$ , in the process of re-sintering.  $\beta$ - $\text{Al}_2\text{O}_3$  is a prospective material which can find application in one-fluid sodium-sulphur cells (Miles, Wynn-Jons 1971; Kawalcami *et al.* 1975; Demot 1971; Seltzer, Jaffee 1974) as a solid electrolyte of high unipolar ionic conductivity induced by migration of  $\text{Na}^+$  ion. The cell consists of liquid sodium as the cathode, the solid electrolyte  $\beta$ - $\text{Al}_2\text{O}_3$  as interlayer and sulphur-saturated graphite adhering to aluminium or steel which acts as the anode carrying away the current. At about  $570 \text{ K}$ , when a complete circuit is made, liquid sodium migrates through the electrolyte to sulphur according to the reaction:



and then



After the electromotive force of the cell drops down to  $< 1.8$ , the cell is recharged (sodium returns). It is claimed that up to 600 cycles the structure of the solid electrolyte  $\beta$ - $\text{Al}_2\text{O}_3$  is not subject to changes (this is true of a monocrystalline material). Being impermeable to liquids and gases and heat-resistant up to high temperatures,  $\beta$ - $\text{Al}_2\text{O}_3$  is a material specifically useful for cells operating at elevated temperatures. The conductivity of  $\beta$ - $\text{Al}_2\text{O}_3$  increases with a rise in temperature and, according to the data published by other authors, at  $570 \text{ K}$  it attains a value of  $3 \cdot 10^{-1} \Omega^{-1} \text{cm}^{-1}$  for a monocrystal (Miles, Wynn-Jons 1971),  $0.35 \cdot 10^{-1} \Omega^{-1} \text{cm}^{-1}$  for pure polycrystalline cerams (Demot 1971), or  $1.88$  and  $2.61 \cdot 10^{-1} \Omega^{-1} \text{cm}^{-1}$ , respectively, for polycrystalline cerams with admixtures of  $\text{MgO}$  and  $\text{Y}_2\text{O}_3$  ( $0.3$ — $3.0\%$ ) (Kawalcami *et al.* 1975). It is interesting to note that, in contrast to monocrystals, the cerams show substantial variations in conductivity in the temperature range of  $570$ — $670 \text{ K}$ . This is due to unequal internal porosity of cerams which were formed from aluminium oxide transformed into  $\beta$ - $\text{Al}_2\text{O}_3$  prior to formation, or from a mixture of  $\alpha$ - $\text{Al}_2\text{O}_3$  with sodium aluminate  $\text{NaAlO}_2$ . The transformation by diffusion of the compact corundum ceram obtained by firing at  $2070 \text{ K}$  into  $\beta$ - $\text{Al}_2\text{O}_3$  should guarantee the preservation of the compact structure, whereby the conductivity of a polycrystalline ceram will be close to that of a monocrystal.

## EXPERIMENTAL

Two batches of ceramic materials were prepared: pure aluminium oxide  $\alpha$ - $\text{Al}_2\text{O}_3$  ( $99.5 \text{ Al}_2\text{O}_3$ ) of grain size  $< 3 \mu\text{m}$  and the specific surface area  $5080 \text{ cm}^2/\text{g}$  (A), and the same oxide with a 2 mole % addition of  $\text{CaO}$  to facilitate sintering (B). The batches disks of a size  $\phi 30 \times 4 \text{ mm}$  were for-

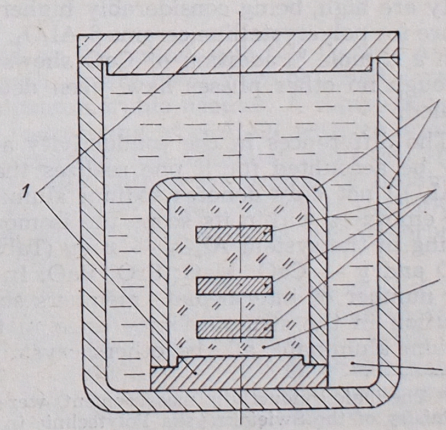


Fig. 1. The position of plates of  $\alpha$ - $\text{Al}_2\text{O}_3$  ceram subjected to metasomatic re-sintering in the furnace  
1 —  $\alpha$ - $\text{Al}_2\text{O}_3$  ceram lids, 2 —  $\alpha$ - $\text{Al}_2\text{O}_3$  ceram crucibles, 3 —  $\alpha$ - $\text{Al}_2\text{O}_3$  ceram plates, 4 —  $\alpha$ - $\text{Al}_2\text{O}_3 + \text{NaAlO}_2$  powder, 5 —  $\alpha$ - $\text{Al}_2\text{O}_3$  powder



med at a pressure of 3000 kG/cm<sup>2</sup> and fired at 2070 K to give corundum ceram. The fired disks were placed in a corundum ceram crucible together with  $\alpha$ -Al<sub>2</sub>O<sub>3</sub> powder mixed with NaAlO<sub>2</sub> powder in the ratio of 1:2 (Fig. 1). The sealed crucible was put into another crucible and the inter-space filled with pure  $\alpha$ -Al<sub>2</sub>O<sub>3</sub> powder. The batch thus prepared was re-sintered in a gas furnace in an atmosphere of air at 1900–2000 K for 24 h and held for 1 h at maximum temperature. Sodium from NaAlO<sub>2</sub> diffused into  $\alpha$ -Al<sub>2</sub>O<sub>3</sub>, transforming it into sodium aluminate Na<sub>2</sub>O·11Al<sub>2</sub>O<sub>3</sub>.

## RESULTS

The cerams obtained upon metasomatic re-sintering were subjected to X-ray examinations in a Rigaku-Denki apparatus and ceramographic analyses in a scanning microscope (Jeol 4A). Moreover, their ionic conductivity was investigated\*. After re-sintering the samples showed an increase in diameter of 20%, corresponding approximately to the difference in the crystal structure density between  $\alpha$  and  $\beta$ -Al<sub>2</sub>O<sub>3</sub>.

Table 1 presents the results of X-ray examinations of sample A, along with the ASTM data and those reported by some other authors (Dyson, Johnson 1973). The above results substantiate the inferences emerging from the increase in volume, viz. that the corundum ceram underwent complete structural transformation into sodium aluminate  $\beta$ -Al<sub>2</sub>O<sub>3</sub>. The latter ceram has been found to contain no  $\alpha$ -Al<sub>2</sub>O<sub>3</sub> which made up the initial material.

Ceramographic investigations have revealed that samples A and B have a compact but different structure (Phot. 1a–d). The photographs show the samples at magnifications of 1000 and 3000 $\times$ .

Conductivity measurements were performed on 3 mm thick plates placed in a specially designed measuring device made of brass. A plate was sealed between two flanged tubes containing liquid sodium. Direct current was passed through the plate and sodium, and the current intensity and voltage were measured. Knowing the dimensions of the working part of the plate, the conductivity of the material was calculated, neglecting the resistance of sodium and wires (Table 2). The obtained values for conductivity are high, being considerably higher than those reported in the literature for polycrystalline cerams  $\beta$ -Al<sub>2</sub>O<sub>3</sub>. It is worth noting that the ceram with a 2 mole % addition of CaO shows a markedly lower conductivity although no other phases have been detected in either of the materials studied.

The differences in the conductivity and structure of the two cerams may be accounted for if one realizes that the name  $\beta$ -aluminium oxide ( $\beta$ -Al<sub>2</sub>O<sub>3</sub>) not only denotes sodium aluminate Na<sub>2</sub>O·11Al<sub>2</sub>O<sub>3</sub> but actually also embraces within its scope the isomorphic series of alkali aluminates arising in the system Al<sub>2</sub>O<sub>3</sub> —  $x$  —  $y$  (Table 3), in which  $x$  — Na<sub>2</sub>O; K<sub>2</sub>O; Li<sub>2</sub>O and  $y$  — CaO; MgO; SrO; BaO. In view of the similar ionic radii, any number of intermediate members showing a various degree of substitution in the structure may arise in this system because, except for lithium aluminate, all the others crystallize in the same class C6/mmc.

\* The ionic conductivity measurements were made in the Department of Physical Chemistry of the Świętokrzyska Polytechnic in Radom.

X-ray diffraction data for  $\beta$ -Al<sub>2</sub>O<sub>3</sub>

Sample A		After ASTM		After Dyson and Johnson (1973)	
<i>d</i> (Å)	<i>I</i>	<i>d</i> (Å)	<i>I</i>	<i>d</i> (Å)	<i>I</i>
5.63	9.1	5.7	30	—	—
4.83		—	—	4.732	2
4.46		4.45	10	—	—
4.36		—	—	—	—
4.07	6.2	4.07	10	—	—
2.768		—	—	2.797	46
2.676	28.3	2.68	70	—	—
2.501		2.501	30	—	—
2.41		2.41	30	—	—
2.373		—	—	2.368	18
2.245		2.24	30	—	—
2.135		2.14	30	—	—
2.037	15.6	2.03	30	—	—
2.006		—	—	—	—
1.936		1.936	30	—	—
1.837		1.848	30	—	—
—		1.743	30	—	—
1.649		1.651	10	—	—
1.615		—	—	1.615	10
1.594		1.591	70	—	—
1.564	8.0	1.563	30	—	—
—		1.483	30	—	—
1.409		—	—	1.412	24
1.402	30.5	1.402	100	—	—
1.392		—	—	—	—
1.360		1.369	50	—	—
1.340		—	—	—	—

When pure  $\alpha$ -Al<sub>2</sub>O<sub>3</sub> was used as the initial material (ceram A) un-oriented Na<sub>2</sub>O·11Al<sub>2</sub>O<sub>3</sub> crystals with a platy habit were obtained, forming a subtle network of auto- and hipautomorphic needles. A completely different structure resulted from re-sintering of  $\alpha$ -Al<sub>2</sub>O<sub>3</sub> with an addition of CaO. The resultant  $\beta$ -aluminium oxide has a tabular habit and shows a xeno- and hipautomorphic form. Both habits are typical of aluminium oxide, the platy habit being characteristic of 3CaO·16Al<sub>2</sub>O<sub>3</sub> or CaO·6Al<sub>2</sub>O<sub>3</sub> and the tabular habit of corundum.  $\beta$ -Al<sub>2</sub>O<sub>3</sub> is presumably pseudomorphous after corundum  $\alpha$ -Al<sub>2</sub>O<sub>3</sub>.

The results for ionic conduction are much better in the case of pure sodium aluminate, the values obtained being much higher than those reported for polycrystalline cerams. This fact indicates that the batch with CaO yielding  $\beta$ -Al<sub>2</sub>O<sub>3</sub> with a tabular habit and greater molecular density (cf. Table 3, items 2 and 5) in the unit cell has a markedly lower conductivity. It seems, therefore, that MgO or K<sub>2</sub>O have no negative effect on



Table 2

Ionic conductivity of  $\beta$ - $\text{Al}_2\text{O}_3$  cerams obtained by metasomatic re-sintering

Temperature K	Ionic conductivity ( $10^{-1} \Omega^{-1} \text{cm}^{-1}$ )					
	Ceram A	Ceram B	Pure ceram (after Miles, Wynn- Jones 1971)	Ceram containing MgO (after Seltzer, Jaffee 1974)	Ceram containing $\text{Y}_2\text{O}_3$ (after Seltzer, Jaffee 1974)	$\beta$ - $\text{Al}_2\text{O}_3$ mono- crystal (after Demot 1971)
540	—	1.0				
550	—	1.2				
560	2.7	1.7				
570	2.7	1.0	0.35	up to 1.88	up to 2.61	3.0

Table 3

Structural data for  $\alpha$ - $\text{Al}_2\text{O}_3$  and its alkaline variety  $\beta$ - $\text{Al}_2\text{O}_3$ 

No	Phase	Formula	Crystal system	Space group	Molecules per unit cell (Z)
1	Alpha	$\text{Al}_2\text{O}_3$	hexagonal	R3c	2
2	Sodium beta	$\text{Na}_2\text{O} \cdot 11\text{Al}_2\text{O}_3$	hexagonal	C6/mmc	1
3	Potassium beta	$\text{K}_2\text{O} \cdot 11\text{Al}_2\text{O}_3$	hexagonal	C6/mmc	1
4	Magnesium beta	$\text{MgO} \cdot 11\text{Al}_2\text{O}_3$	hexagonal	C6/mmc	1
5	Calcium beta	$\text{CaO} \cdot 6\text{Al}_2\text{O}_3$	hexagonal	C6/mmc	2
6	Strontium beta	$\text{SrO} \cdot 6\text{Al}_2\text{O}_3$	hexagonal	C6/mmc	2
7	Barium beta	$\text{BaO} \cdot 6\text{Al}_2\text{O}_3$	hexagonal	C6/mmc	2
8	Lithium zeta	$\text{Li}_2\text{O} \cdot 5\text{Al}_2\text{O}_3$	cubic	Fd3m	2

ionic conductivity (Table 3, items 3 and 4), whereas  $\text{CaO}$ ,  $\text{BaO}$ ,  $\text{SrO}$  and  $\text{Li}_2\text{O}$  admixtures are highly undesirable. A decrease in the density of the lattice by about 20%, resulting from incorporation of  $\text{Na}^+$  ions in the structure of corundum  $\alpha$ - $\text{Al}_2\text{O}_3$ , is limited by the amount of admixtures. This problem, however, requires thorough experimental studies combined with X-ray analysis (to determine the lattice parameters), as well as measurements of ionic conductivity of various modifications of the polymorphic  $\beta$ - $\text{Al}_2\text{O}_3$ . Table 3 does not give the data for silver ceram  $\beta$ - $\text{Al}_2\text{O}_3$  discussed elsewhere (Seltzer, Jaffee 1974), the conductivity of which is similar to that of sodium ceram.

After measuring its ionic conductivity, ceram A was subjected to ceramographic analyses which failed to show any changes in its structure

(Phot. 2a—b). This is a substantial argument for the application of  $\beta$ - $\text{Al}_2\text{O}_3$  ceram obtained by metasomatic re-sintering of corundum ceram in reversible sodium-sulphur cells.

## CONCLUSIONS

1. It has been demonstrated that polycrystalline cerams can be transformed by metasomatic re-sintering in the presence of powdered material which is a carrier of the diffusing cation.

2. The resultant ceram retains high strength and the compact structure, due to which its ionic conduction ( $2.7 \cdot 10^{-1} \Omega^{-1} \text{cm}^{-1}$  at 570 K) is close to that of a  $\beta$ - $\text{Al}_2\text{O}_3$  monocrystal, exceeding the values reported by other authors. Not only the compact structure but also complete transformation of  $\alpha$ - $\text{Al}_2\text{O}_3$  into  $\beta$ - $\text{Al}_2\text{O}_3$  is responsible for this high ionic conductivity. The materials discussed in other publications contained only 80—85%  $\beta$ - $\text{Al}_2\text{O}_3$  (Seltzer, Jaffee 1974).

3. It also seems possible to transform the polycrystalline corundum ceram  $\alpha$ - $\text{Al}_2\text{O}_3$  by diffusion using other than aluminate sources of diffusion of sodium ions.

4. The above method of metasomatic re-sintering seems to be applicable to the transformation of other cerams of high ionic conductivity, such as ferrites of the magnetoplumbite type ( $\text{BaO} \cdot 6\text{Fe}_2\text{O}_3$ ) and hollandite ( $\text{Ba}_2\text{Mn}_8\text{O}_{16}$ ), or to control the properties of cerams formed from garnet ferrites or cordierite.

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## О МОЖЛИВОСТИ ПРЕТВАРЗАНИЯ СКЛАДУ МИНЕРАЛЬНОГО CERAMIKI POLIKRYSTALICZNEJ W PROCESIE WTÓRNEGO SPIEKANIA METASOMATYCZNEGO

### Streszczenie

Na przykładzie spiekania *metasomatycznego* w 2000 K tworzywa ceramicznego zbudowanego z polikrystalicznego  $\alpha$ - $\text{Al}_2\text{O}_3$  w obecności glinianu sodowego  $\text{NaAlO}_2$  autorzy udowadniają możliwość pełnego dyfuzyjnego przetworzenia litej ceramiki polikrystalicznej  $\alpha$ - $\text{Al}_2\text{O}_3$  w  $\beta$ - $\text{Al}_2\text{O}_3$  ( $\text{Na}_2\text{O} \cdot 11\text{Al}_2\text{O}_3$ ). Pełna przebudowa struktury korundu w strukturę jedena-stoglinianu sodu pozwoliła na otrzymanie tworzywa o przewodnictwie jonowym do  $2,7 \cdot 10^{-1} \Omega^{-1} \text{cm}^{-1}$  w 570 K. Utrzymanie, mimo wzrostu objętości tworzywa o 20%, litej, nieporowatej struktury było możliwe dzięki zachowaniu przez  $\beta$ - $\text{Al}_2\text{O}_3$  tabliczkowatego pokroju kryształów  $\alpha$ - $\text{Al}_2\text{O}_3$ . Jedena-stoglinian sodowy powstał tu jako pseudomorfoza po korundzie.

Otrzymane tworzywo spełnia wymagania stawiane stałym elektrolitom stosowanym w ogniwach sodowo-siarkowych.

### OBJAŚNIENIA FIGUR

Fig. 1. Sposób umieszczania płytek ceramu  $\alpha$ - $\text{Al}_2\text{O}_3$  do wtórnego spiekania metasomatycznego

1 — przykrywki z ceramu  $\alpha$ - $\text{Al}_2\text{O}_3$ , 2 — tygle z ceramu  $\alpha$ - $\text{Al}_2\text{O}_3$ , 3 — płytki z ceramu  $\alpha$ - $\text{Al}_2\text{O}_3$ , 4 — zasypka  $\alpha$ - $\text{Al}_2\text{O}_3$  +  $\text{NaAlO}_2$ , 5 — zasypka  $\alpha$ - $\text{Al}_2\text{O}_3$

### OBJAŚNIENIE FOTOGRAFII

Fot. 1. Struktury przełamów (SEM) ceramów  $\beta$ - $\text{Al}_2\text{O}_3$  otrzymanych w procesie wtórnego metasomatycznego spiekania  $\alpha$ - $\text{Al}_2\text{O}_3$

a — próbka A,  $\times 1000$ , b — próbka B,  $\times 1000$ ,  
c — próbka A,  $\times 3000$ , d — próbka B,  $\times 3000$

Fot. 2. Struktura przełamu (SEM) ceramu  $\beta$ - $\text{Al}_2\text{O}_3$  po badaniu przewodnictwa jonowego

a —  $\times 600$ , b —  $\times 1800$

ного преобразования компактной поликристаллической керамики  $\alpha$ - $\text{Al}_2\text{O}_3$  в  $\beta$ - $\text{Al}_2\text{O}_3$  ( $\text{Na}_2\text{O} \cdot 11\text{Al}_2\text{O}_3$ ). Полная перестройка структуры корунда в ( $\text{Na}_2\text{O} \cdot 11\text{Al}_2\text{O}_3$ ) позволила получить вещество с ионной проводимостью до  $2,7 \cdot 10^{-1} \Omega^{-1} \text{cm}^{-1}$  при температуре 570 K. Сохранение, помимо повышения объёма вещества на 20%, компактной, непористой структуры было возможно благодаря сохранению  $\beta$ - $\text{Al}_2\text{O}_3$  плиточной формы кристаллов  $\alpha$ - $\text{Al}_2\text{O}_3$  ( $\text{Na}_2\text{O} \cdot 11\text{Al}_2\text{O}_3$ ) образовался как псевдоморфоз после корунда. Полученное вещество отвечает всем требованиям, которые ставятся постоянным электролитам в серно-натриевых батареях.

### ОБЪЯСНЕНИЕ К ФИГУРЕ

Fig. 1. Способ помещения плиток керамики  $\alpha$ - $\text{Al}_2\text{O}_3$  при вторичном metasomatическом спекании

1 — крышка из керамики  $\alpha$ - $\text{Al}_2\text{O}_3$ , 2 — тигель из керамики  $\alpha$ - $\text{Al}_2\text{O}_3$ , 3 — пластинки из керамики  $\alpha$ - $\text{Al}_2\text{O}_3$ , 4 — присыпка  $\alpha$ - $\text{Al}_2\text{O}_3$  +  $\text{NaAlO}_2$ , 5 — присыпка  $\alpha$ - $\text{Al}_2\text{O}_3$

### ОБЪЯСНЕНИЯ К ФОТОГРАФИЯМ

Фот. 1. Структуры переломов (SEM) керам  $\beta$ - $\text{Al}_2\text{O}_3$  полученных в процессе вторичного metasomatического спекания  $\alpha$ - $\text{Al}_2\text{O}_3$

a — образец A,  $\times 1000$ , b — образец B,  $\times 1000$ ,  
c — образец A,  $\times 3000$ , d — образец B,  $\times 3000$

Фот. 2. Структура перелома (SEM) керамики  $\beta$ - $\text{Al}_2\text{O}_3$  после исследований ионной проводимости

a —  $\times 600$ , b —  $\times 1800$

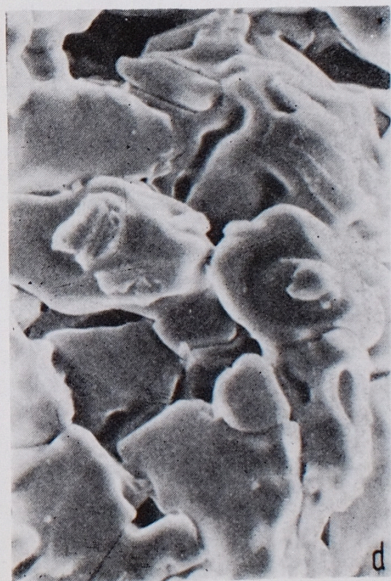
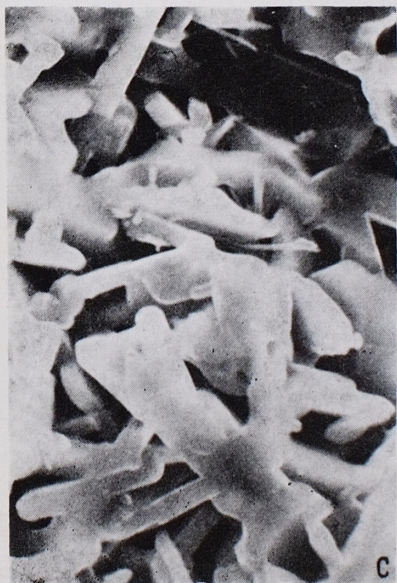
Андрей ШЫМАНЬСКИ, Владислав ВЛОСИНЬСКИ

## О ВОЗМОЖНОСТИ ВИДОИЗМЕНЕНИЯ МИНЕРАЛЬНОГО СОСТАВА ПОЛИКРИСТАЛЛИЧЕСКОЙ КЕРАМИКИ ВО ВРЕМЯ ПРОЦЕССА ВТОРИЧНОГО METASOMATического СПЕКАНИЯ

### Резюме

На примере metasomatического спекания при температуре 2000 K керамического вещества построенного из поликристаллического  $\alpha$ - $\text{Al}_2\text{O}_3$  в присутствии  $\text{NaAlO}_2$  авторы доказывают возможность полного диффиз-

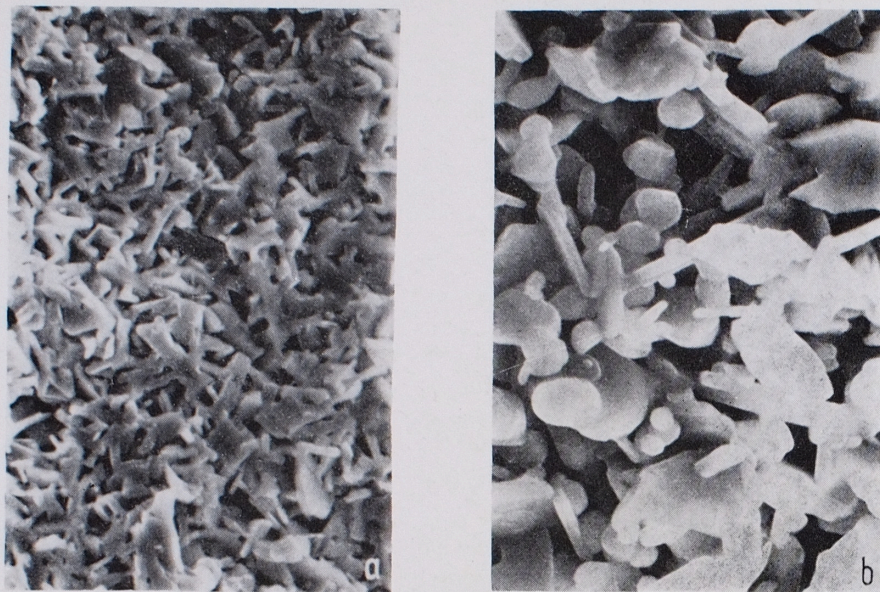




Phot. Fractures of  $\beta$ - $\text{Al}_2\text{O}_3$  cerams (SEM) obtained by metasomatic re-sintering of  $\alpha$ - $\text{Al}_2\text{O}_3$   
 a — sample A,  $\times 1000$ , b — sample B,  $\times 1000$ , c — sample A,  $\times 3000$ , d — sample B,  $\times 3000$

Andrzej SZYMAŃSKI, Władysław WOŁOSIŃSKI — The transformation of the phase composition of polycrystalline ceramic materials during metasomatic re-sintering





Phot. 2. Fracture of  $\beta$ - $\text{Al}_2\text{O}_3$  ceram after measurements of ionic conductivity  
*a* —  $\times 600$ , *b* —  $\times 1800$