sublimation of uranyl fluoride by assuming that the slope of a plot of log k_v vs. $1/T$ was equal to the heat of sublimation. However, the scatter in the values of k_v precluded any such estimation.

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Any discussion of this paper will appear in a Discussion Section to be published in the December 1960 JOURNAL.

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Some Properties of Aluminum Nitride

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ABSTRACT

Aluminum nitride crystals in the form of six-sided prismatic needles, up to 0.5 mm in diameter by 30 mm long, and thin plates, 2-3 mm in diameter, have been prepared by vaporization of aluminum in a nitrogen atmosphere at temperatures ranging from about 1800° to 2000°C, and the properties of the crystals determined. Also, an aluminum nitride body, having a density of 98% of theoretical, has been prepared by hot pressing the fine powder, and a study made of its properties.

Aluminum nitride, AlN, consists of 65.81% aluminum and 34.19% nitrogen. Although aluminum nitride was prepared many years ago, its properties have not been well known. Early investigators considered it too unstable, especially with respect to moisture and oxidizing conditions, to be useful as a refractory. More recent work, however, has indicated that aluminum nitride, prepared at high temperature, is relatively inert and, therefore, may have applications as a refractory.

Reconsideration of the potentialities of aluminum nitride as a refractory appears to have started with a publication (1) in 1956 by Kohn and associates of the U. S. Bureau of Mines. These investigators incidentally obtained small crystals of aluminum nitride while working at high temperatures on another project and reported that the crystals were inert to hot and cold mineral acids and alkali solutions. Other recent workers who found aluminum nitride a relatively stable material include Rey (2), Renner (3), and Long and Foster (4). Notwithstanding the considerable recent work on aluminum nitride prepared at high temperature, there is still disagreement on many of its properties such as melting point, hardness, color, and oxidation resistance.

Refractories based on aluminum nitride are not now commercially available, although Rey (2) has prepared aluminum nitride brick by a sintering process and Long and Foster (4) have made laboratory-size crucibles, also by a sintering method. In addition, Johnson (5) has prepared a composite aluminum nitride-cryolite body, and Taylor (6) has used aluminum nitride as a bond for other refractory materials. High density, impervious, essentially pure aluminum nitride ware, however, has not previously been made.

The objects of the present work were to study crystalline aluminum nitride further, especially those properties which are still in dispute, and to prepare and determine the properties of a high-density aluminum nitride body. In the latter instance, hot pressing was chosen as a method of fabrication because preliminary experiments indicated that it would yield ware of maximum density, and, therefore, of optimum physical properties.

Crystalline Aluminum Nitride

Formation of Crystals.—Two methods of forming the crystals were tried: (*a*) heating aluminum nitride powder in a nitrogen atmosphere at high temperatures to induce crystal growth by recrystallization, and (*b*) heating aluminum metal powder in a nitrogen atmosphere to sufficiently high temperatures to vaporize the aluminum and thus form crystals by a vapor phase reaction. The second method was more effective and was used to prepare most of the crystals described in this report.

Sintered aluminum nitride boats and crucibles were used as containers in vaporizing the metal. The reaction was carried out in a horizontal graphite tube resistance furnace or in a vertical induction furnace having a graphite susceptor. In the horizontal resistance furnace, it was possible, using an optical pyrometer with telescope, to follow the origin, growth, and development of the crystals and to measure the corresponding temperatures at the same time.

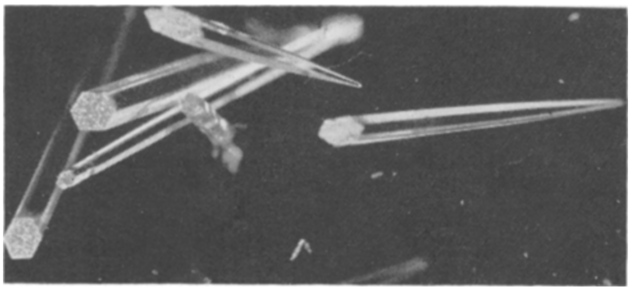

Fig. 1. Aluminum nitride crystals in the form of six-sided prismatic needles, obtained by nitriding aluminum vapors at 1850°C.

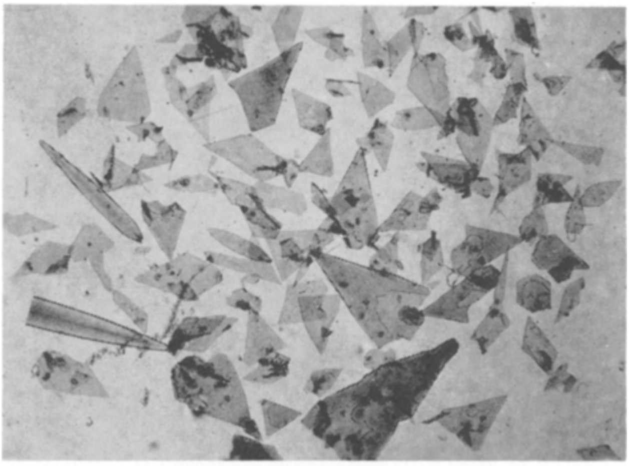

Fig. 2. Plate-like crystals of aluminum nitride formed by heating aluminum nitride powder in nitrogen at temperatures in excess of 1900°C.

It was observed that short, extremely fine filaments of aluminum nitride formed in the range of 1450°-1750°C, while at 1800°-1900°C the crystals were predominantly well-defined six-sided prismatic needles, some of which were about 0.5 mm in diameter and 30 mm long (Fig. 1). Some elongated plates also formed in this temperature range. At 1900°-2050°C, new growth appeared mainly as plates (Fig. 2), while above about 2050°C, previously formed crystals began decreasing in size very slowly due to vaporization. In the case of the prismatic needles shown in Fig. 1, the tapered end was the free end.

Color.—The color of the crystals varied from white to various shades of blue. Rey (2) states that pure aluminum nitride forms blue hexagonal crystals. Long and Foster (4) claim that pure aluminum nitride is water white and that the blue coloration results from the presence of about 7% aluminum oxycarbide (Al_2OC) in the crystals. They report that aluminum oxycarbide is isomorphous with aluminum nitride and that formation of solid solution between the two compounds is very likely. They suggest that Al_2OC results from a reaction between carbon monoxide, incidentally formed in the graphite lined furnace, and aluminum in the sample. In order to test these theories, aluminum nitride crystals were formed in carefully controlled atmospheres of (*a*) nitrogen only, (*b*) in nitrogen containing 0.5-2% of carbon monoxide, and (*c*) in nitrogen containing 1% of methane. Blue crystals formed only when carbon monoxide was present, the shade of blue becoming deeper with increasing amount of carbon monoxide in the nitriding atmosphere; 0.5% carbon monoxide resulted in light blue crystals, while 2% carbon monoxide produced dark blue crystals. Chemical analysis of the crystals showed the presence of carbon and oxygen in an approximately equimolecular ratio. The percentage of carbon varied from a few tenths of a per cent in the light blue crystals to about 2% in the deeper colored crystals. If carbon and oxygen are combined as aluminum oxycarbide, Al_2OC, as stated by Long and Foster (4), then the amount of this compound in the crystals prepared in the present study ranged up to about 14%.

Crystal structure and density.—Both the white and blue crystals have the hexagonal wurtzite structure. Other investigators have reported cell dimensions as follows:

Investigator	Type of material	Cell dimensions a_0	c_0
Ott (7)	Powder	3.113	4.981
Stackelberg and Spiess (8)	Light gray powder	3.104±0.005	4.96±0.008
Kohn, Cotter, and Potter (1)	Blue crystals	3.10±0.01	4.965±0.01
Paretzkin (9)	Powder	3.114	4.986

In the present investigation, unit cell dimensions were determined by x-ray diffractometer back reflection techniques. Each sample was standardized independently with a spectrographically pure silicon sample. The National Bureau of Standards value of $a = 5.4301$Å for silicon was used.

The following values were obtained for light colored aluminum nitride: $a = 3.111$Å; $c = 4.980$Å.

A sample of the dark blue crystals containing approximately 2% carbon and 2.7% oxygen produced an x-ray diffraction pattern with broader reflections, some of which showed three distinct peaks. Most of these were shifted from the peaks of the light material. Values of 3.11-3.13Å for the a dimension and 4.93-4.98Å for the c dimension were obtained, depending on which peak was evaluated. Differences in reflections of the white and blue crystals were not detected when the usual film techniques were used. Possibly the blue samples contained enough pure AlN to overshadow the less prominent shifted reflections. Also, the general broadening would tend to produce the same geometrical center for the reflections of both the white and blue crystals.

The density of aluminum nitride, calculated from the cell dimensions $a = 3.111$Å and $c = 4.980$Å, is 3.26 g/cc.

Melting point.—The literature reports melting points in the range of 2000°-2400°C. Renner (3) observed strong vaporization of aluminum nitride at 2450°C, but no melting. The present investigation confirms Renner's conclusions. The experiments were carried out in a microfurnace (10) at atmospheric pressure in argon. Well-formed prismatic crystals, about 0.2-0.5 mm thick by about 2-5 mm long, were heated in a V-shaped tungsten crucible, making observations with an optical pyrometer. The crystals were heated to 1800°C in 2-3 min, after which the temperature was increased at the rate of about 200°C/min. Some vaporization could be observed at 2300°C; at 2450°C vaporization was rapid, and after 1 min at 2500°C the crystals had completely disappeared without evidence of melting. In some experiments, crystals were heated to 2450°-2500°C in about 3 min and then immediately allowed to cool. The crystals had partially vaporized, but no evidence of melting was observed.

Hardness.—Hardness values on the Mohs scale ranging from 5 to between 9 and 10 are found in the literature. No accurate microhardness indentations have been reported. However, crystals obtained in the present research were sufficiently large that Knoop indentations could be made readily. All indentations were made with a load of 100 g, the force being applied perpendicular to the c or long axis of the crystal. Some indentations were made with the long diagonal of the indenter parallel to, and some perpendicular to the c axis of the crystal. Results varied somewhat with the direction, probably because of the anisotropic nature of the crystals. The over-all hardness of aluminum nitride appears to be approximately 1200. This is equivalent to a hardness of slightly higher than 7 on the Mohs scale. Detailed hardness data are seen in Table I.

Oxidation resistance.—Aluminum nitride crystals appear to begin to oxidize in air at about 700°C. This was investigated by heating colorless and blue crystals on a platinum lid in flowing air to various temperatures for 24 hr, and then carefully examining the crystals microscopically after each test. At between 700° and 800°C, the surface of clear transparent crystals became slightly foggy, indicating the beginning of oxidation. The oxidation rate of well-formed crystals, however, was slow even at much higher temperature, because of the formation of a dense adherent aluminum oxide film. Thus, after 24 hr at 1400°C, the cross section of crystals of about 1 mm diameter and 7 mm long showed an oxide surface film estimated to be 40 μ thick. The inside core of the crystal, however, was still clear and transparent.

Table I. Hardness of aluminum nitride crystals

Indentation* No.	Knoop hardness, K_{100}	
	White crystals	Blue crystals
1	1010	920
2	1075	970
3	1010	980
4	1115	1030
5	1000	1050
* Average	1042	990
6	1453	1415
7	1426	1510
8	1454	1450
9	1356	1445
10	1348	1530
* Average	1407	1470
Over-all average	1225	1230

* Indentations 1 through 5 were made with the long diagonal of the indenter parallel to the c axis of the crystal, 6 through 10 were made with the long diagonal of the indenter perpendicular to the c axis.

Tendency to oxidize also was determined by heating 2-3 g samples of the finely milled powder, having an average particle size of about 5 μ, in a flowing stream of air. The weight gain, after 24 hr at 700°C, was 3.2%, corresponding to a conversion of 13% of the compound to aluminum oxide. When a new sample of the same powder was heated 24 hr in air at 800°C, the increase in weight was 9%, corresponding to a conversion of about 36% of the compound to aluminum oxide. In the latter case, x-ray diffraction clearly showed the presence of gamma alumina.

Corrosion resistance.—Crystals of aluminum nitride have been immersed in water at room temperature for several months with no apparent effect on the crystals. Some recent investigators (1, 3, 4) state that aluminum nitride is essentially unaffected by mineral acids. In the present research, it was observed that aluminum nitride crystals were dissolved slowly in a boiling mixture of one part concentrated hydrochloric and one part water. Thus, prismatic needles having a diameter of about 80 μ were dissolved completely in 80 hr. The corrosion rate, based on these experiments, is approximately 170 mils per year.

Hot Pressed Aluminum Nitride

Preparation of hot pressed aluminum nitride.—Aluminum nitride powder was prepared by direct combination of aluminum and nitrogen. Alcoa's No. 101 atomized aluminum powder was mixed with 1% sodium fluoride, which catalyzes the nitriding at low temperatures (11), and heated in purified nitrogen in a refractory crucible. The temperature was raised rapidly to 650°C and then increased slowly over a period of 40 hr to a maximum of 1800°C. In this way a porous sintered agglomerate was obtained. It was reduced readily by dry ball milling in a stainless steel mill with stainless steel balls to a light gray powder with an average particle size of about 5 μ. Chemical analysis of the milled aluminum nitride powder and also the calculated composition, based on this analysis, are shown in Table II. It will be noted that the aluminum nitride content is approximately 96%, and that the chief impurity is alumina. The density of the powder was 3.23 g/cc, compared with a density of 3.26 g/cc as calculated from the cell dimensions of the crystals.

Table II. Aluminum nitride powder
(Pure AlN: 65.81% Al; 34.19% N)

Chemical analysis		Calculated composition	
Al	64.8%	AlN	96.0%
N	32.8%	Al_2O_3	2.1%
C	0.2%	Other compounds	1.9%
Si	0.4%		
Fe	0.1%		
O	1.0%		

Particle size: 0.5 to 25μ
Density: 3.23 g/cc

Table III. Strength and elasticity properties of hot pressed aluminum nitride

Temp, °C	Modulus of rupture, psi	Modulus of elasticity, psi
25	38,500	50×10^6
1000	27,000	46×10^6
1400	18,100	40×10^6

Test specimens, 3 in. in diameter and 3 in. long, were fabricated by hot pressing the milled powder at 2000°C in graphite dies, applying pressures of about 5000 psi. Test bars, 3 x 0.5 x 0.25 in., were cut from the hot pressed pieces with a diamond wheel and then ground to produce smooth parallel surfaces. The test specimens were light gray in color and had a bulk density of 3.20 g/cc or about 98% of the theoretical for pure aluminum nitride. Using a load of 100 g, 10 Knoop hardness indentations gave values ranging from 1005 to 1240, with an average of 1130.

Strength and elasticity.—Data for modulus of rupture and modulus of elasticity at room temperature, 1000° and 1400°C, are presented in Table III. Four specimens, 3 x 0.5 x 0.25 in. were tested at each temperature, pressure being applied perpendicular to the direction in which the bars were hot pressed. These values compare favorably with those for other high-density ceramic materials, especially at high temperatures. For instance, hot pressed alumina is stronger at room temperature, but weaker at 1400°C. The modulus of elasticity of hot pressed aluminum nitride is about the same as that of hot pressed alumina at room temperature, but is higher than that of hot pressed alumina at 1400°C.

Long and Foster (4) reported a modulus of rupture of sintered aluminum nitride at room temperature of 11,500 psi. The exact density of the test specimens was not given but presumably was appreciably lower than that of the hot pressed material reported herein. Rey (2) reported the compressive strength of sintered aluminum nitride brick to be about 3000-4000 psi. Preliminary tests on the hot pressed material indicate a compressive strength of about 300,000 psi.

Thermal conductivity.—The thermal conductivity was measured by a linear flow comparative method, parallel to the direction of pressing, in an atmosphere of stagnant nitrogen, using Inconel as a standard. Values obtained over a temperature range of 200°-800°C are shown in Table IV. These results indicate that aluminum nitride is a good conductor of heat, being intermediate between dense silicon carbide, which is an excellent conductor, and alumina, which is a fair conductor. This is illustrated by the following comparative values for thermal conductivity expressed in cal/cm²/cm/sec/°C obtained by the same method:

Material	At 200°C	At 800°C
Dense SiC	0.24	0.10
Hot pressed AlN	0.072	0.048
Dense Al_2O_3	0.054	0.017

Table IV. Thermal conductivity of hot pressed aluminum nitride

Temp, °C	Cal/cm²/cm/sec/°C	Btu/ft²/in./hr/°F
200	0.072	209
400	0.060	173
600	0.053	153
800	0.048	139

The present data are in sharp contrast to those of Long and Foster (4), who recently reported the thermal conductivity of sintered aluminum nitride at 25°C as 0.0042 cal/cm²/cm/sec/°C. The density of the specimens used by Long and Foster was not disclosed, but the density of some of their test specimens used for determination of electrical resistivity was as high as 2.66 g/cc. It seems probable, therefore, that the difference in density alone is not responsible for the great dissimilarity of the thermal conductivity values, but rather the difference in methods is mainly responsible. According to Kingery and co-workers (12) thermal conductivity at zero porosity can be calculated employing the following simplified relationship of Loeb:

$$k_s = \frac{km}{(1 - P_v)}$$

where k_s is the solid thermal conductivity (zero porosity); k_m, measured thermal conductivity; P_v, volume pore fraction.

Even if it is assumed that the thermal conductivity, $k_m = 0.0042$ cal/cm²/cm/sec/°C, measured at 25°C by Long and Foster, is for a specimen with 40% porosity, the thermal conductivity at zero porosity calculated according to above equation, will be only 0.007 cal/cm²/cm/sec/°C.

The accuracy of the present method has been checked by comparing the results obtained on some standard materials with data from other laboratories as illustrated in the following examples:

Laboratory	Material	Thermal conductivity, cal/cm²/cm/sec/°C 400°C	600°C
Carborundum	Inconel	0.049	0.057
National Bureau of Standards (13)	Inconel	0.049	0.058
Carborundum	Nickel	0.119	0.130
International Nickel Company (14)	Nickel	0.112	0.136

Thermal expansion.—The determination of thermal expansion was made by the dilatometer method, using a silicon carbide dilatometer assembly (15). Thermal expansion was measured parallel to the direction of pressing, on a bar 3 in. long and 0.5 in. in diameter. Values are given in Table V. These

Table V. Thermal expansion of hot pressed aluminum nitride

Temperature interval, °C	Linear expansion, cm/cm/°C
25-200	4.03×10^{-6}
25-600	4.84×10^{-6}
25-1000	5.64×10^{-6}
25-1350	6.09×10^{-6}

check closely the results reported by Long and Foster (4) (4.8×10^{-6} cm/cm/°C in the range 20°-500°C) for the sintered aluminum nitride. The thermal expansion of hot pressed aluminum nitride is in the moderate range for a ceramic, being only slightly higher than that of silicon carbide.

Thermal shock resistance.—The high thermal conductivity and low thermal expansion of hot pressed aluminum nitride are conducive to good thermal shock resistance. Bars, 3 x 0.5 x 0.25 in., heated rapidly to 2200°C in an oxygen-acetylene torch and cooled rapidly, did not crack or spall when the test was repeated consecutively several times. The thermal shock resistance was evaluated also by measuring the loss in strength of hot pressed aluminum nitride bars after 30 cycles of heating in 2.5 min to 1400°C and rapidly cooling to room temperature in an air blast. The modulus of rupture before thermal cycling was 38,500 psi and after thermal cycling, 33,700 psi, or a loss of 12% of the original strength.

Stability in various atmospheres at elevated temperatures.—Test specimens, 0.25 x 0.5 x 0.5 in., were exposed to flowing air, oxygen, dry steam, chlorine, and hydrogen at elevated temperatures. Results are reported in Table VI. The last column shows the percentage of aluminum nitride converted to aluminum oxide or aluminum chloride according to the different conditions of the experiments. As can be seen from these data, the effect of air or oxygen at temperatures up to 1400°C or of steam at 1000°C after 30 hr is slight. At 1700°C in air, however, the rate of oxidation becomes rather rapid. It will be recalled from the discussion of the crystalline material that it was found that oxidation of aluminum nitride in air starts at about 700°C, but that the rate of oxidation is slow even at temperatures as high as 1400°C, because of the formation of a protective oxide coating. This coating also accounts for the slow rate of oxidation of the dense hot pressed material. Figure 3 shows a 0.25 x 0.5 in. cross section of a bar after exposure to air at 1400°C for 24 hr. The oxide layer is approximately 60 μ or 2-3 mils thick. At 1700°C, however, it was noted that the oxide coating tended to crack and no longer protected effectively the aluminum nitride against oxidation. The cracking of the coating at this temperature may be due to the appreciable difference in the thermal expansion of aluminum oxide and aluminum nitride.

Table VI. Stability of hot pressed aluminum nitride in various atmospheres of elevated temperatures
(Test specimens, 0.25x0.5x0.5 in.)

Atmosphere	Temp, °C	Time, hr	Conversion to other compounds, %
Air	1000	30	0.3 Al_2O_3
Air	1400	30	1.3 Al_2O_3
Air	1700	4	10.6 Al_2O_3
Oxygen	1400	30	0.9 Al_2O_3
Dry steam	1000	30	0.3 Al_2O_3
Chlorine	500	30	<0.1 $AlCl_3$
Chlorine	700	30	19.2 $AlCl_3$
Hydrogen	1700	4	nil

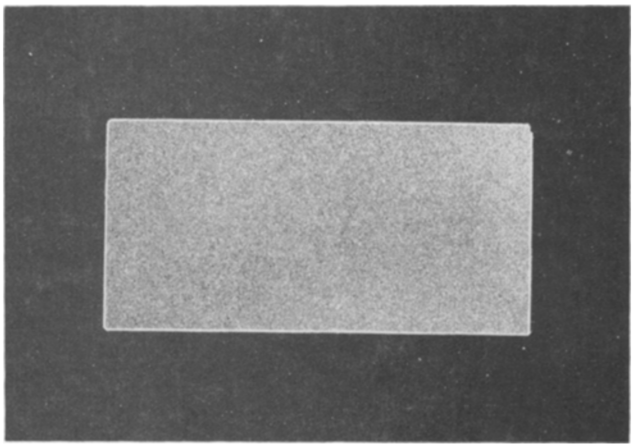

Fig. 3. Cross section of a hot-pressed aluminum nitride specimen showing the protective oxide coating after heating in air 24 hr at 1400°C.

It is of interest to note the difference in the oxidation rate of hot pressed aluminum nitride and the sintered material as reported by Long and Foster (4). Exposure to air for 1 hr at 1200°C of 1-cm cubes of sintered material resulted in a conversion of about 11% of the sample to aluminum oxide, whereas exposure to air for 30 hr at 1400°C of dense hot pressed aluminum nitride specimens of comparable size resulted in a conversion of only about 1% to aluminum oxide.

Table VI also shows that hot pressed aluminum nitride is not appreciably attacked by chlorine at 500°C, but that the reaction rate at 700°C is rapid. Furthermore, hot pressed aluminum nitride is practically unaffected by hydrogen at 1700°C for 4 hr.

Corrosion in water and mineral acids.—As in the case of the crystalline material, hot pressed aluminum nitride is slowly dissolved by hot mineral acids. The results of the corrosion tests are shown in Table VII. Specimens 0.25 x 0.5 x 0.5 in. were heated in a 600 ml volume of water and in the several mineral acids for 72 hr. With the exception of hydrofluoric acid, the tests were made at the boiling temperatures of the liquids. The corrosion rate in boiling water can be considered as low. Although dissolution in the mineral acids is slow, the rate is too great to classify hot pressed aluminum nitride as a corrosion resistant material in these acids. It will be recalled that

Table VII. Corrosion of hot pressed aluminum nitride in water and mineral acids
(0.25x0.5x0.5 in. specimens in 600 ml liquid, 72 hr)

Corrosive liquid	Temp, °C	Corrosion rate, mils/year
Water	100	14
Conc. HCl acid	72	320
1 Conc. HCl acid: 1 H_2O	110	570
Conc. H_2SO_4 acid	305	180
1 Conc. H_2SO_4 acid: 1 H_2O	145	550
Conc. HNO_3 acid	120	150
1 Conc. HNO_3 acid: 1 water	111	200
1 HF: 1 HNO_3 conc. acids	57	160
1 Conc. HF acid: 1 water	57	215

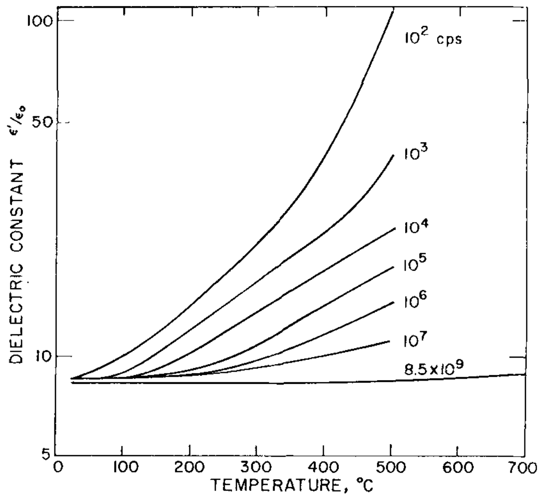

Fig. 4. Effect of temperature on dielectric constant of hot pressed aluminum nitride at several frequencies.

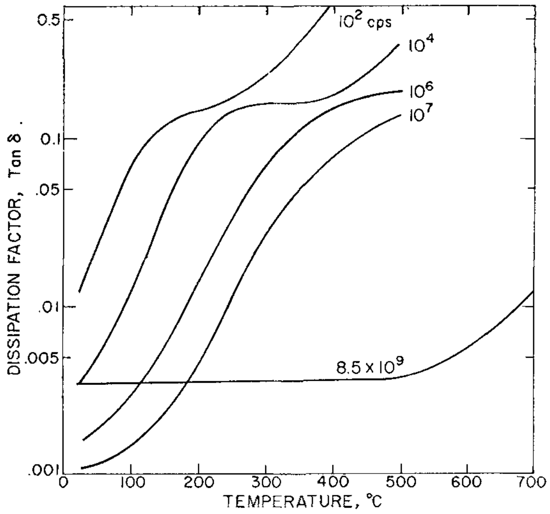

Fig. 5. Effect of temperature on dissipation factor of hot pressed aluminum nitride at several frequencies.

the corrosion rate of single crystals in a boiling mixture of 1 part concentrated hydrochloric and 1 part water was estimated to be about 170 mils per year.

Corrosion in cryolite and aluminum and in boric oxide.—Hot pressed aluminum nitride was heated in an inert atmosphere in a bath consisting of a mixture of molten cryolite and aluminum for 66 hr at 1200°C without visual evidence of corrosion. A piece of hot pressed aluminum nitride, 0.25 x 0.5 x 0.5 in., immersed in molten boric oxide for 4 hr at 1000°C, showed only very slight evidence of attack in the form of faint surface marking and a weight loss of 0.02%. This is equivalent to a corrosion rate of about 25 to 30 mils per year.

Electrical properties.—The electrical properties of hot pressed aluminum nitride appear to be similar to those of alumina, and especially to some of the high density hot pressed aluminas. Dielectric constant and dissipation factor were determined by the Laboratory for Insulation Research at Massachusetts Institute of Technology and also by our own laboratories, the results agreeing fairly closely. Data on dielectric constant are shown in Fig. 4. At room temperature the dielectric constant, over a wide range of frequencies, is about 8.5 compared with between 9 and 10 for many aluminas. The dielectric constant increases rapidly with temperature at low frequencies, less rapidly at high frequencies. At a frequency of 8.5 x 10^9 cps, the change with temperature is only slight. This behavior is also typical of the aluminas.

The dissipation factor at various frequencies and temperatures is shown in Fig. 5. At low frequencies, the dissipation factor increases rapidly with temperature. However, at the frequency of 8.5 x 10^9 cps, the change with temperature up to 500°C is slow. At room temperature the dissipation factor at the various frequencies is between about 0.01 and 0.001, while for the aluminas, the dissipation factor at this temperature is about 0.001 to 0.0001. At high temperatures (400°-500°C) and low frequencies (10^2-10^3 cps) the dissipation factor of hot pressed aluminum nitride and alumina are comparable, while at high temperatures and high frequencies the dissipation factor of the aluminas is appreciably lower.

The volume resistivity of hot pressed aluminum nitride as calculated from the dielectric constant and dissipation factor is shown in Fig. 6. Data for a hot pressed alumina at two frequencies are also shown in Fig. 6 for comparison. At a frequency of 100 cps, the resistivity of hot pressed aluminum nitride is about 2 x 10^{11} ohm-cm at room temperature and 7 x 10^7 ohm-cm at 500°C. Resistivity decreases with frequency; this is also typical for the aluminas and other ceramic insulators.

Summary

Pure aluminum nitride is white. Blue crystals are formed when the metal is heated above 1750°C in nitrogen containing small amounts of carbon monoxide.

Aluminum nitride does not melt under atmospheric pressure in argon, but vaporizes rapidly at about 2400°C. Its Knoop hardness, with a load of

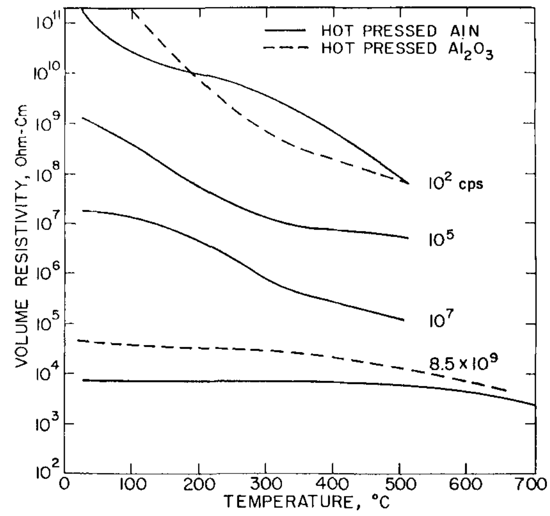

Fig. 6. Effect of temperature on volume resistivity of hot pressed aluminum nitride at several frequencies. Data for a hot pressed alumina at two frequencies are shown for comparison. (Data obtained from Tables of Dielectric Materials Volume V- Laboratory for Insulation Research, Massachusetts Institute of Technology.)

100 g, is approximately 1200, which is equivalent to seven plus on the Mohs scale.

Aluminum nitride starts to oxidize in air at between 700° and 800°C, but in the case of large crystals and the dense hot pressed material, oxidation is slow up to 1400°C because of the protective oxide surface layer formed. It is inert to hydrogen at 1700°C but is attacked by chlorine between 500° and 700°C.

Although aluminum nitride in the crystalline or hot pressed form does not dissolve readily in boiling mineral acids, it is not highly corrosion resistant to these acids. However, it has relatively good corrosion resistance to molten boric oxide and to a mixture of molten aluminum and cryolite in inert atmospheres.

Strength of hot pressed aluminum nitride is lower than that of high-density aluminum oxide at room temperature, but is higher at 1400°C. Compared with most ceramics, it has high thermal conductivity, low thermal expansion, and good thermal shock resistance. Its electrical properties, in many respects, are similar to those of aluminum oxide.

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Any discussion of this paper will appear in a Discussion Section to be published in the December 1960 JOURNAL.

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Manuscripts and Abstracts for Fall 1960 Meeting

Papers are now being solicited for the Fall Meeting of the Society, to be held at the Shamrock Hotel in Houston, Texas, October 9, 10, 11, 12, and 13, 1960. Technical sessions probably will be scheduled on Batteries, Corrosion, Electrodeposition, Electronics (Semiconductors), and Electrothermics and Metallurgy.

To be considered for this meeting, triplicate copies of abstracts (*not exceeding 75 words in length*) must be received at Society Headquarters, 1860 Broadway, New York 23, N. Y., *not later than June 1, 1960. Please indicate on abstract for which Division's symposium the paper is to be scheduled, and underline the name of the author who will present the paper.* Complete manuscripts should be sent in triplicate to the Managing Editor of the JOURNAL at the same address.

Papers submitted for presentation at the meeting become the property of The Electrochemical Society and may not be published elsewhere, in whole or in part, unless permission is requested and granted by the Society. Papers already published elsewhere, or submitted for publication elsewhere, are not acceptable for oral presentation except on invitation by a Divisional program Chairman.

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The Spring 1961 Meeting will be held in Indianapolis, Ind., April 30, May 1, 2, 3, and 4, 1961, at the Claypool Hotel. Sessions will be announced in a later issue.