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A study on Aluminum Nitradation process: Literature Survey and development of frame work for processing AlN

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***Abstract:*-- Aluminum Nitridation (AlN) has lot many applications in the automobile industry, aerospace, electronics where a high temperature application is required and other areas. There are various techniques, methods and approaches are used by various researchers in this area. Hence, this article presents a brief review of the research progress achieved on Preparation and feasibility formation mechanism in the field of Aluminum Nitride (AlN) and proposes the research objective and frame work developed for Aluminum Nitride formation for electronic industry applications.**

Key Words- Aluminum Nitridation, Synthesis, Thermal conductivity, Direct Nitridation, Oxygen Pressure.

1. INTRODUCTION

Aluminum nitride may be used in composite structure with aluminum for its application in structural and electronic applications because it has attractive thermal, electronic and mechanical properties which are termed as unique in most of ceramics. Aluminum nitride has the highest thermal conductivity among ceramic materials. Aluminum nitride synthesis technologies have been developed since the end of the 20th century owing to the progress in LED and computer production. The publication and inventive activities in this field have been showing a stable positive dynamics since 1991 [1].AlN in different forms, such as dispersed powder, single crystals and thin films, has found numerous applications in various industries. The high inventive activity with respect to AlN application in electronic industry can be explained by the tendency to reduce the weight and size of electronic devices improving simultaneously their performance, for example, the expansive growth in the compact and high-performance tablets market [2–5]

2. LITERATURE:

Aluminium nitride has continued to attract researchers' attention in the last two decades. This is not unconnected with its desirable properties such as:
Wide band gap, which makes it useful in optoelectronic devices [6, 7]; good electrical and thermal properties which, makes it applicable as thermal interface for flexible electronics for quick dissipation of heat, in UV structure and photovoltaic devices [8-9]. It's good chemical stability makes it applicable in high temperature applications, while its good wear resistance makes it applicable as a thin layer coating to impart hardness and wear resistance on aluminium. In this connection, it is essential study the various techniques, methods and approaches are used by various researchers in this area. Hence this article presents a brief review of the research progress achieved on Preparation and feasibility formation mechanism in the field of Aluminium Nitride (AlN) and proposes the research objective and frame work simple Aluminium Nitride formation for electronic industry applications

2.1 AL/ALN LAYERED COMPOSITES BY DIRECT NITRIDATION OF ALUMINUM [10]

Okada et.al [10] had led the experiments on aluminum compacts with the density up to 65% comprising of atomized powder and analyzed it from 500 to 700 degrees that is close melting point of aluminum. Furthermore, proposed that nitration was better with the oxygen weight and furthermore vacuum gives great outcome upon nitrdation proportion. It is clarified that nitration was finished below 600 degrees, and it was propose that nitration was better with the oxygen pressure as up to 0.5 Mpa was utilized. Nitradation was finished over 620 degrees. It was recommended that low nitridation temperature and pre heat in vacuum had better affected the entire nitridation of aluminum compacts through which avoiding the excessive growth of the surface nitride and furthermore oxide layer, and the distinction of thermal expansion between liquid state and solid state of aluminum

2.2 FEASIBILITY OF ALUMINUM NITRIDE FORMATION IN ALUMINUM ALLOYS [11]

The achievability of formation of aluminum nitride by in situ reaction of nitrogen gas which is infused on the aluminum alloys has been explored both logically and experimentally at

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the temperatures from 700 to 1500 degrees by Qinghuahou et.al [11]. It is guaranteed that aluminum is softened within the sight of combinations like Mg and Si, where receptive gases are ammonia and nitrogen over the temperature 1100 degrees Celsius. In this procedure initially formed was magnesium nitride into liquid aluminum. In the substitution reaction aluminum nitride which was formed before formed is magnesium nitride and aluminum. The aluminum nitride formed with the normal and average reinforcement size of 3 µm . This structures aluminum nitride composite which is useful in thermal and wear protection applications. Magnesium which is in the form of alloy acts as a catalyst for reaction, and this s one of the suitable method for nitride in aluminum alloys Products. It is asserted that demonstrate the large aluminum particles develop into comprising of numerous little AlN particles with round shape and stable size. Small particles can be processed utilizing ball processing can be thickly sintered at 1830 C for 2 hours. In the mechanism that the Al fluid structures at the high temperature continuously flows and responds with the coming nitrogen gas was proposed to clarify the development from the large aluminum particle into the total with little particles. Some further examinations were additionally done to exhibit this mechanism which is better in nitride formations.

2.3 PREPARATION AND FORMATION MECHANISM OF ALUMINUM NITRIDE CERAMIC PARTICLES FROM LARGE ALUMINUM POWDER BY SELF-PROPAGATING HIGH TEMPERATURE SYNTHESIS [12]

Liang Qiao et.al [12] Aluminum nitride ceramic powders are formed by high temperature self-propagating preparation utilizing the aluminum powders as reactants. The sintering conduct of the as-got powder was formed utilizing the traditional liquid sintering technique. X-beam diffraction and scanning electron microscope tests were conveyed to distinguish the phase compositions and study the morphologies.

2.4 THE SYNTHESIS OF HIERARCHICALLY MESO-MACROPORUS ALUMINUM NITRIDES MICRO PARTICLES VIA ALUMINUM ALLOY NITRIDIZATION [13]

The preparation of aluminum nitrides miniaturized scale particles with a hierarchically meso-macroporus structure by an aluminum-magnesium compound nitridization was claimed by Guojun Yana et.al [13]. The hierarchically with meso-macroporous aluminum nitrogen with a particular surface area of 97.7 m2/g and a particular volume of 0.10 cm3/g was set up by nitraidizing an aluminum-magnesium alloy with diameters in between of 75 µm and 150 µm at the temperature 500 °C for 8 h first and afterward took after by 800 °C for 6 h. Initially AlN hierarchically micro scale particles were integrated through nitraidizng an Al-Mg alloy at various temperatures. ALN particles were studied by SEM, STEM and nitrogen adsorption at - 195.7 °C.

2.5 AL/ALN LAYERED COMPOSITES BY DIRECT NITRADATION OF ALUMINUM [14]

PatamaVisuttipitukul et.al [14] has proved Aluminum nitride can be utilized as a part of composite structure with aluminum for its application in basic and electronic applications since it has excellent thermal, electronic and mechanical properties which is named as remarkable in the vast majority of ceramic production. There are commercial ways to AlN are by either direct nitradation of liquid aluminum metal powder or carbothermal reduction reaction of Al2O3, however both are costly because that they require temperatures more than 1200◦C.The beginning material aluminum cooking foil with a thickness of 10 µm. This was cut into 1 cm2 pieces, which were set over each other and softly compacted in a Carver hand worked press at a pressure of 25– 65 MPa. Where each sample comprised first low temperature hold was at either 510 or 540 ◦C for 60– 180 min took after by a moment hold of 30 min at either 620 or 630 ◦C. The subsequent microstructures were analyzed utilizing X-beam diffraction and so on tests were carried out for researching the layered composite of aluminum nitride.

2.6 NITRIDATION OF ALUMINUM UNDER FLOWING NITROGEN GAS: THE EFFECT OF OXYGEN PRESSURE [15]

Evarastics Polycarp et al [15] has conducted the experiment of nitridation of aluminum under flowing nitrogen gas and studied the effect of oxygen pressure. AlN has lots of applications in the automobile industry, aerospace, electronics where high temperature applications are required and other areas. Experiment is carried out under continuous flowing nitrogen gas at temperatures below the melting point of aluminum that is in between 550◦C and 630◦C. The results showed that use hydrogen gas reduced oxygen pressure, which promoted nitridation process. XRD results gave aluminum nitride peaks with higher values and intensity at 630 ◦C after 4 hours of holding time of nitrogen when hydrogen was flowed together with nitrogen gas into steel tubular furnace, the aluminum nitride formation was increased further with temperature and holding time of gases.

2.7 PRODUCTION OF ALUMINUM NITRIDE FROM ALUMINUM METAL USING MOLTEN FLUORIDE [16]

The preparation of aluminum nitride (AlN) from aluminum metal was tested by Osamu Takeda et al [16]. The nitridation of Al as rod powder, and thin-plate forms was facilitated by

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dissolving the Al2O3 thin films formation was on the Al samples with a liquid fluoride mixture, AlN was formed when NH3 gas was flowed to the Al test samples in solid and fluid forms wetted by liquid fluoride mixture. The most minimal temperature at which AlN was effectively formed was 773 K. No AlN was formed when N2 or H2– 25% N2 gas was supplied to the Aluminum sample, when a liquid fluoride mixture was utilized. The reaction rate for the nitridation of Al powder increased with the temperature and achieved 99% after 3 hour at 1173 K. AlN thin films of 2– 5 µm thickness were formed on Al thin plates of 0.075– 1.0 mm thick at 873 K.

2.8 PREPARATION AND FORMATION MECHANISM OF ALUMINUM NITRIDE CERAMIC PARTICLES FROM LARGE ALUMINUM POWDER BY SELF-PROPAGATING HIGH TEMPERATURE SYNTHESIS [17]

Liang Qiao et.al [17] has studied the Preparation and formation mechanism of aluminum nitride ceramic particles Aluminum nitride ceramic powders were prepared by self propagating high temperature synthesis utilizing the large spherical aluminum powders as reactants. The sintering behavior of the powder as got powder was characterized by utilizing the conventional fluid sintering method. X-ray diffraction and scanning electron microscope were used to identify the phase compositions and observe the morphologies of the products. The outcomes demonstrate that the large aluminum particles form into the aggregates comprising of numerous little AlN particles with spherical shape and stable size. The small spherical particles after de-agglomeration by ball milling can be densely sintered at 1830 C for 2 hours. The system that the Al fluid formed at the high temperature repeatedly and responds with the coming nitrogen gas was proposed to clarify the evolution from the vast aluminum particle into the total with little particles. Some further examinations were likewise done to exhibit this mechanism

2.9 FORMATION OF ALUMINUM NITRIDE WHISKERS BY DIRECT NITRIDATION [18]

This work depicts outcomes on the growth of aluminum nitride (AlN) whiskers direct nitridation of Al– NH4Cl beginning blends. The nitridation tests were completed in a flat tube heater at 1000°C for 1hour out of 1l/min N2 gas flow It is discovered that the development of AlN whiskers was primarily advanced by NH4Cl which gave an alternate response pathway relies upon vapor-stage reaction mechanism rather than ordinary liquid– gas system. The thermodynamic investigation of possible reasctions in the working temperatures range that the AlN whiskers could be developed through vapor-stage chlorination– nitridation processes. The SEM perception proved that relying upon NH4Cl fixation homogeneous AlN Nano whiskers formation.

3. RESEARCH OBJECTIVES AND RESEARCH FRAME WORK FOR FUTURE STUDY:

3.1 RESEARCH PROBLEM:

Global electronics industry, dissipation of heat is the most crucial part. And these electronics would not exist without ceramics. Ceramics' wide range of electrical properties including insulating, semi-conducting, piezoelectric and magnetic are critical to products such as cell phones, computers, television, and other consumer electronic products. In some areas there is a need of heat dissipation or electronics cooling and sometimes insulating property altogether, but this cannot be achieved with metals. So, there is a need of ceramics with some special properties which can be used in many applications in the electronics

3.2 RESEARCH OBJECTIVES:

Based on the research problem, objectives are set for processing AIN in thin sheets, where it is a suitable material in electronics with unique properties of semiconducting and high thermal conductivity (k).

1. Synthesis of aluminum nitride using aluminum 6063 by direct nitridation process
2. Evaluation of optimum process parameters like temperature, gas holding time, gas flow rate for conversion of aluminum to aluminum nitride
3. To determine the composition, microstructure, thermal and electrical properties of the Aluminum nitride

3.3 RESEARCH METHODOLOGY:

This research is proposed to conduct study on aluminium nitration process to arrive properties like high thermal conductivity (k) and electrical resistivity for electronic industry applications.

1. Nitridation of aluminium in the forms of thin sheets(thickness 0.6mm) to be carried out in a tube furnace under flowing nitrogen gas at temperatures below the melting point of aluminium (550 – 630°C.)
2. Tests are to be conducted for 2hr, 4hrs and 6 hours of nitrogen gas holding time in the tubular furnace
3. XRD and EDAX tests to be performed to reveal AlN peaks to identify percentage of nitride formation

4. Microstructure evaluation are done
5. Thermal conductivity is measured using heat spread test.
6. Electrical resistivity (ρ) is measured using four probe method.
7. To identify optimum process parameters for nitradation process to meet target values for electronic applications.

4. CONCLUSION:

The present paper is a review of state-of-the-art in aluminum nitride synthesis. Based on the literature review, research objectives were defined and also the future frame work for the development of aluminum nitride process have been developed and also identified equipment for mechanical thermal electrical property evaluation. However, the review of the synthesis methods shows that there is a scope to conduct direct nitridation is possible on Aluminium in the form of thin sheets below its melting point of Al (660 C) for electronic applications.

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