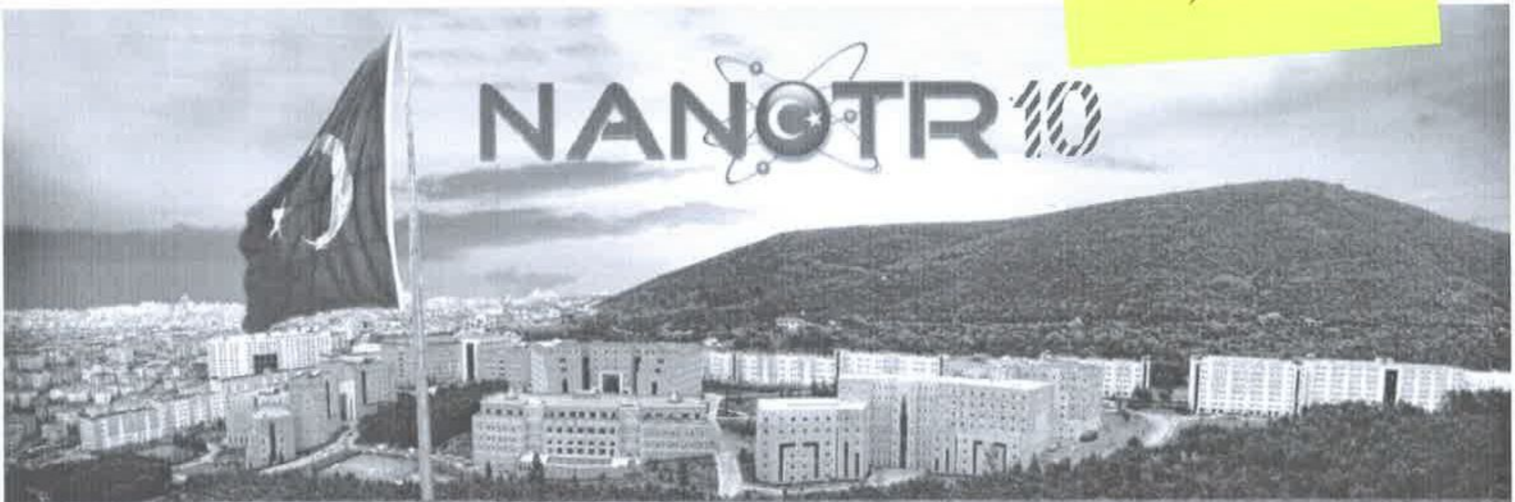

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YEDİTEPE ÜNİVERSİTESİ

The Influence of TiN Particle Size on Microstructure and Mechanical Properties of SiAlON-TiN Composites

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Abstract. TiN particle size and the TiN content are quite effective parameters on microstructure and mechanical properties of SiAlON ceramics. In this study, the effect of TiN particle size (nano and micron level) on sintering behavior, phase and microstructural evolution and mechanical properties were investigated. In order to observe the effects of TiN particle size on phase and microstructural evolution , SEM and the XRD characterization methods were used. Vickers hardness and fracture toughness of the samples were measured in order to evaluate the mechanical behavior. Correlation between TiN particle size, and hardness, fracture toughness, microstructure and phase evolution was discussed.

SiAlON ceramics are candidate materials for structural applications both at ambient and elevated temperatures due to its excellent combination of mechanical, thermal and chemical properties [1,2]. These materials require high wear and chemical resistance at high temperatures for a number of engineering applications. For example, SiAlON cutting tools are most extensively used in cast iron machining. However, their fracture toughness and chemical wear resistance is slightly inferior when compared to commercial Al_2O_3-SiCw cutting tools, which are used in super alloy machining. The addition of hard particles like TiN to silicon nitride based ceramic matrix is a plausible way to improve the toughness and chemical wear resistance [1,2]. Apart from toughness and chemical wear resistance improvement, TiN addition can enhance Si_3N_4 strength up to 1000 MPa [3]. Hence it is expected that TiN reinforced SiAlONs are the promising candidates for cutting tool applications.

In our previous studies, the effect of TiN (average particle size of 1-2 μm) addition on the densification, phase assemblage, microstructural evolution, z value and thermal shock resistance of SiAlON compositions was investigated [4,5]. It was revealed that TiN addition did not have any adverse effect on densification, phase assemblage, z value and mechanical properties. The microstructure of SiAlON-TiN composites consisted of elongated grains, and the addition of TiN positively affected the elongated grain morphology of β-SiAlON grains. The fracture toughness increased with the increasing TiN amount. The addition of TiN particles had little effect on the hardness values of SiAlON-TiN composites. SiAlON-TiN composites exhibited a superior thermal shock property when the amount of TiN was 25 wt%.

Nano-powders with high surface energy can offer considerable theoretical advantage contrast with micrometer powders. So in this study, α/β SiAlON- TiN composites were fabricated and effect of addition TiN particle size on mechanical properties was investigated. Submicrometer (0.5μm) and nanometer (40 nm) TiN powders were used as raw powders to synthesize α/β SiAlON-TiN composites. Starting coarse TiN powder (d50: 2.91 μm) was milled for 10 hours to reduce particle size to 0.5 μm. On the other hand commercial nano TiN powder (d50: 40 nm) were used. Nano sized powder was dispersed in pure water with dispersant and then exposed to ultrasonic treatment to prevent powders agglomeration. The SiAlON-TiN compositions were uniaxially pressed to a maximum pressure of 25MPa and subsequently cold isostatically pressed at 300MPa to increase the green density. The pellets were sintered using a two-step gas pressure sintering cycle with a maximum of 2.2MPa nitrogen gas pressure at 1890 °C for 90 min and then the furnace was allowed to cool at a rate of 5°C/min. The Archimedes principle was used to measure the density of samples after sintering. The types of crystalline phases and the α^{l}: β^{l}-SiAlON phase ratios were determined by means of X-ray diffraction analyses (XRD-Panalytical, Empyrean with Cu-Kα radiation).

Table-I Mechanical properties and phase evolution of SiAlON–TiN composites.

	M*	N*
β:α ratio	70β : 30α	77β : 23α
Z value	1.10	1.17
Intergranular phase(IGP)	Amorphous	Amorphous
Bulk density(g/cm³)	3.5591	3.5522
Open Porosite(%)	0.01	0.08
K_{Ic} *(MPam$^{1/2}$)*	7.20 ± 0.22	7.32 ± 0.34
HV10 (GPa)	15.64 ± 0.34	16.54 ± 0.16

M*: The samples that were prepared by addition of submicron sized TiN particles
N*: The samples that were prepared by addition of nanosized TiN particules

The results showed that TiN powder size had effect on hardness, fracture toughness and microstructural evolution. Decrease in particle size led to an increase in hardness and fracture toughness. However, despite the application of ultrasonic treatment nano sized powder did not well dispersed. Therefore nano TiN particle clusters were observed in microsture.

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NANOTR 10

YEDİTEPE ÜNİVERSİTESİ

F60	Fatma Özge Gökmen	Synthesis and Characterization of Polyacrylic Acid (PAA) and its SiO2 Nanocomposite Hydrogels
F61	Fatma Sarıipek	NO SHOW
F62	Burak Derkuş	Alginate and alginate-titanium dioxide nanocomposite scaffold as electrode materials
F63	Sara Fouladgar	NO SHOW
F64	Vajihe Nejadshafiee	NO SHOW
F65	Ümit Tayfun	Mechanical, Rheological and Electrical Properties of TPU/Fullerene Nano-composites: Effect of Surface Modification of Fullerene
F66	Fatma Sarıipek	Selectively Facilitated Transport of Cr (VI) through P(DEAEMA-co-GMA) Thin Film Membranes Prepared by Initiated Chemical Vapor Deposition
F67	Harun Bayrakdar	NO SHOW
F68	pınar özen	The Influence of TiN Particle Size on Microstructure and Mechanical Properties of SiAlON-TiN Composites
F69	Kuday Karaaslan	Coaxial electrospinning of hydrophilic polymer sheath surrounding oleophilic colloidal metal core
F70	Tugay Üstün	The Fabrication and Characterization of PAN/TiO2-ZnO Nanofiber their Photocatalytic Properties
F71	Seçil Kurtalan	Adsorption properties of ferrocene doped PEDOT: PSS conducting polymers
F72	Selcan Karakuş	Adsorption of Basic Red 46 onto Ternary Nanocomposite
F73	Mira ausama AL_Katib	NO SHOW
F74	Didem Mimiroğlu	Preparation of Lipase Encapsulated Liposomes for Cosmetic Applications