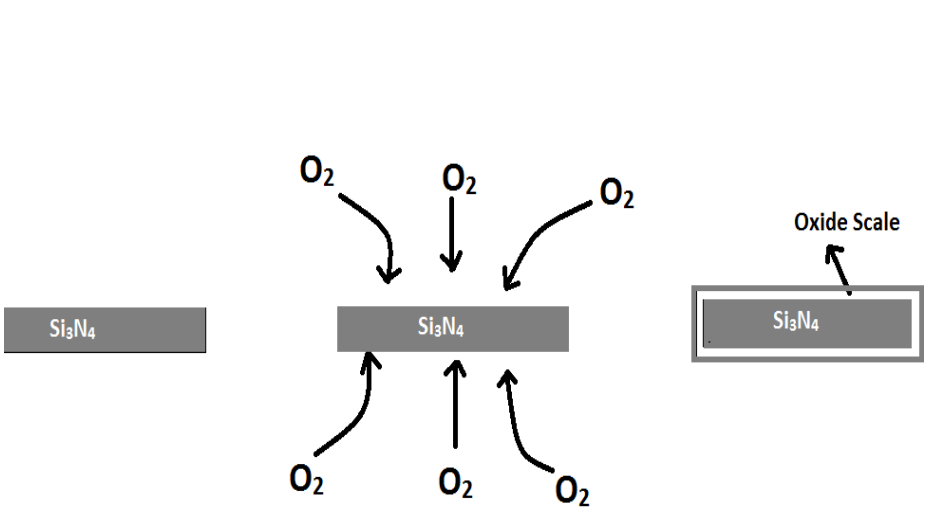
Effect of oxidized Si_3N_4 powder particles on mechanical properties of sintered Si_3N_4 material

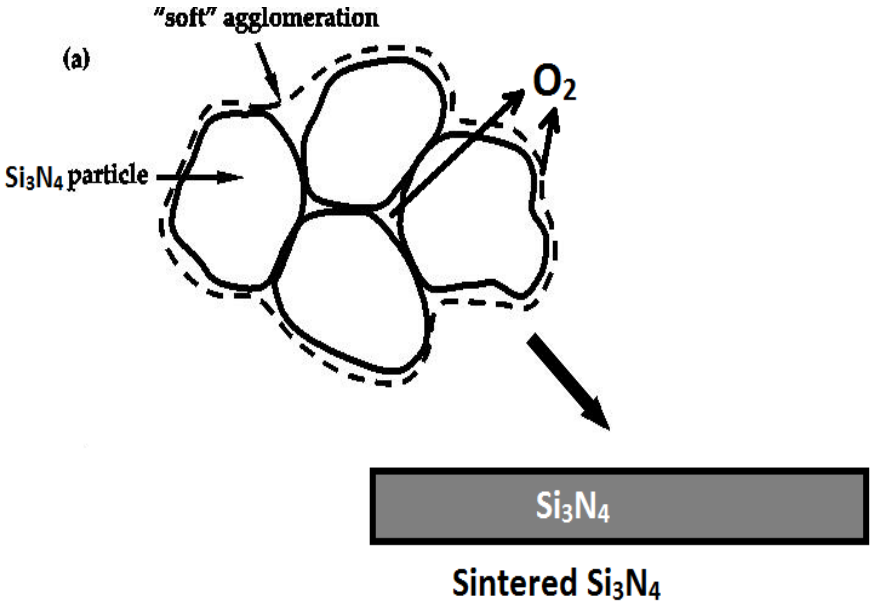
Awais QADIR

Supervisors: Dr. Katalin Balazsi
Dr. Csaba Balazsi

Aim of work

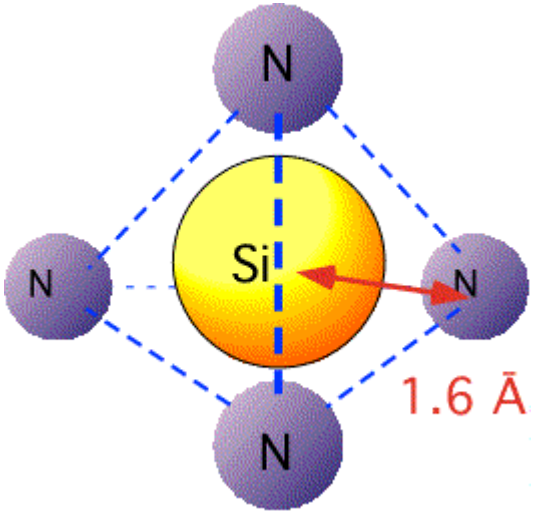
- To study the effect of oxidized Si_3N_4 powder particles on structural & mechanical properties of sintered Si_3N_4 material.





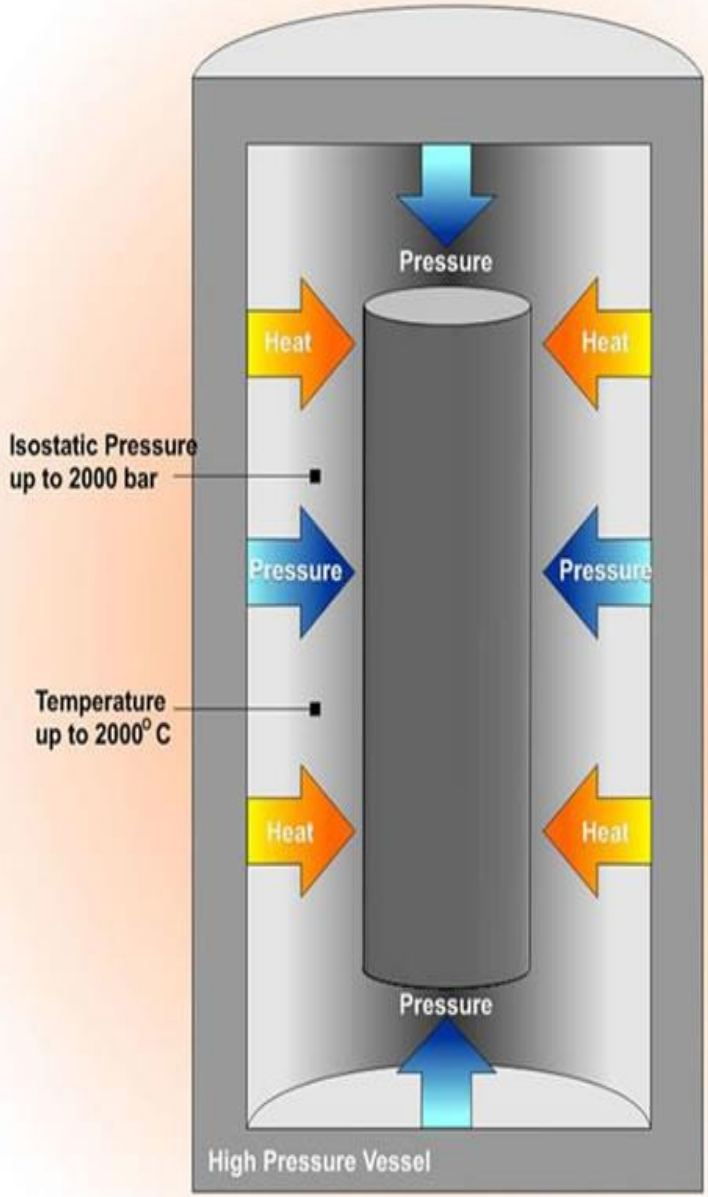
Silicon nitride

- Silicon nitride (Si_3N_4) based ceramics are gaining more attention due to their promising high-temperature thermal and mechanical properties.
- Three crystallographic structures of silicon nitride (Si_3N_4), α, β and γ phases.



Hot Iso-static Press (HIP)

- Process uses the combination of high temperatures and high pressures to densify engineering ceramics and hard metals
- Used to reduce the porosity & increase the density of many ceramic materials
- Improves the material's mechanical properties and workability
- Pressure up to 207 MPa & temperature as high as 2000°C.
- Typically, an inert gas (Argon or Nitrogen) is used.



Experimental Work

- Preparation of Powders
- Characterization of Powders
- Densification (Sintering) of Powders by HIP
- Characterization of Sintered Materials
- Mechanical Testing

Starting Powders

1

α-Si_3N_4 Powder

2

α-Si_3N_4 Powder

Oxidation at 1000 ˚ C for 10 hrs

3

α-Si_3N_4 Powder

Oxidation at 1000 ˚ C for 20 hrs

Characterization of Powders

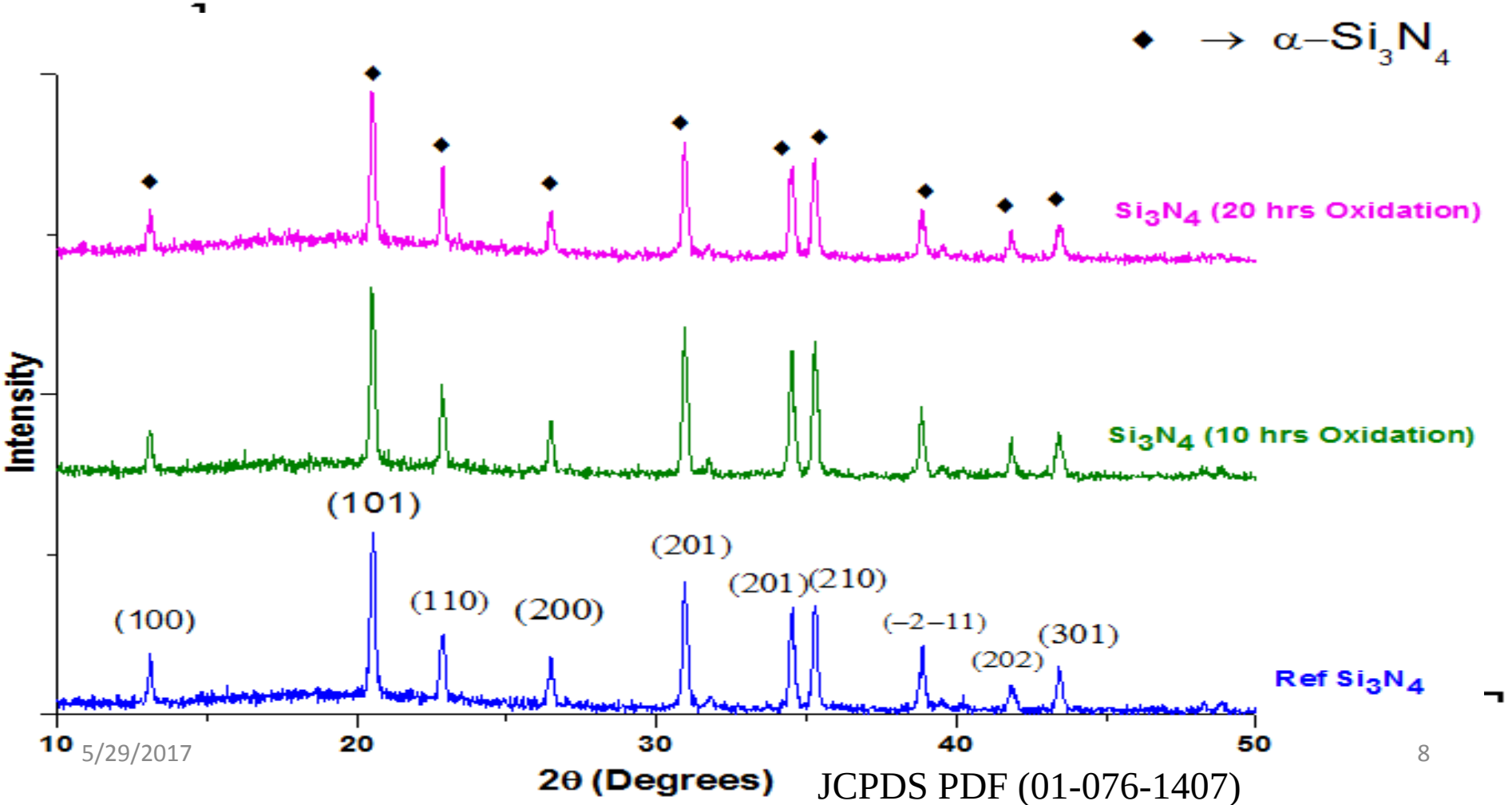
- XRD: Structural Analysis
- SEM: Morphologies of powders
- TEM: Analysis of Nano particles/grains
- EDX: Elemental composition in powders
- High Resolution Electron Microscopy (HTEM): Grains analysis

Characterization of Powder

α-Si_3N_4 Powder

10 hrs oxidized α-Si_3N_4

20 hrs oxidized α-Si_3N_4



JCPDS PDF (01-076-1407)

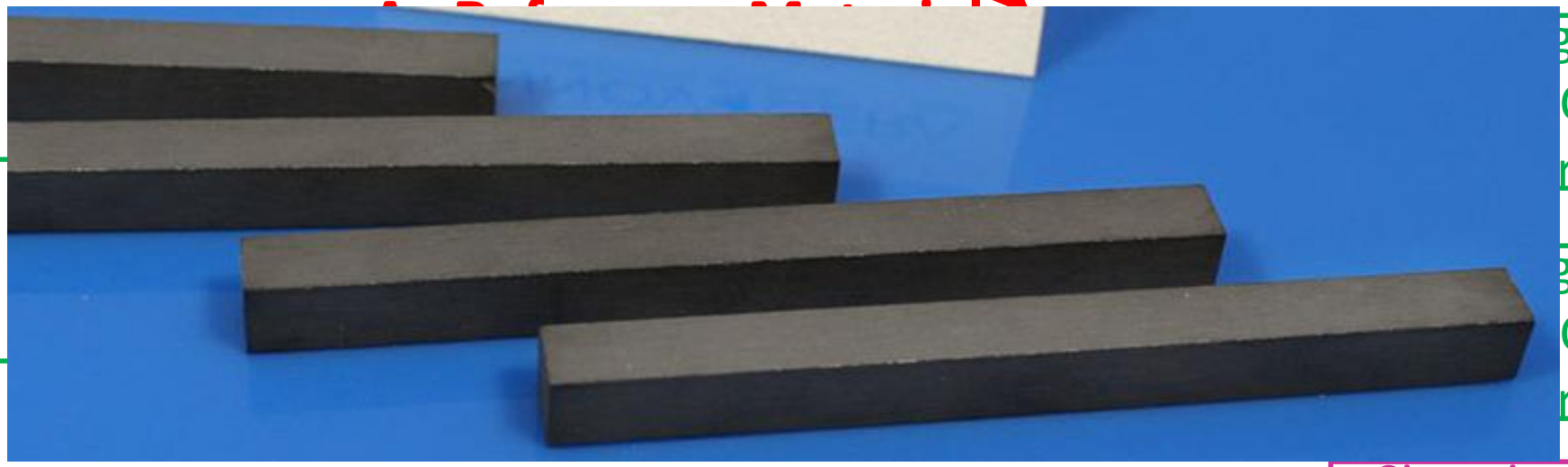
Materials Preparation

α-Si_3N_4 Powder

Mixing with Y_2O_3 & Al_2O_3

Sintering at 1500 ˚C for 3 hours

Sintering at 1700 ˚C for 3 hours



20 hrs oxidized α-Si_3N_4

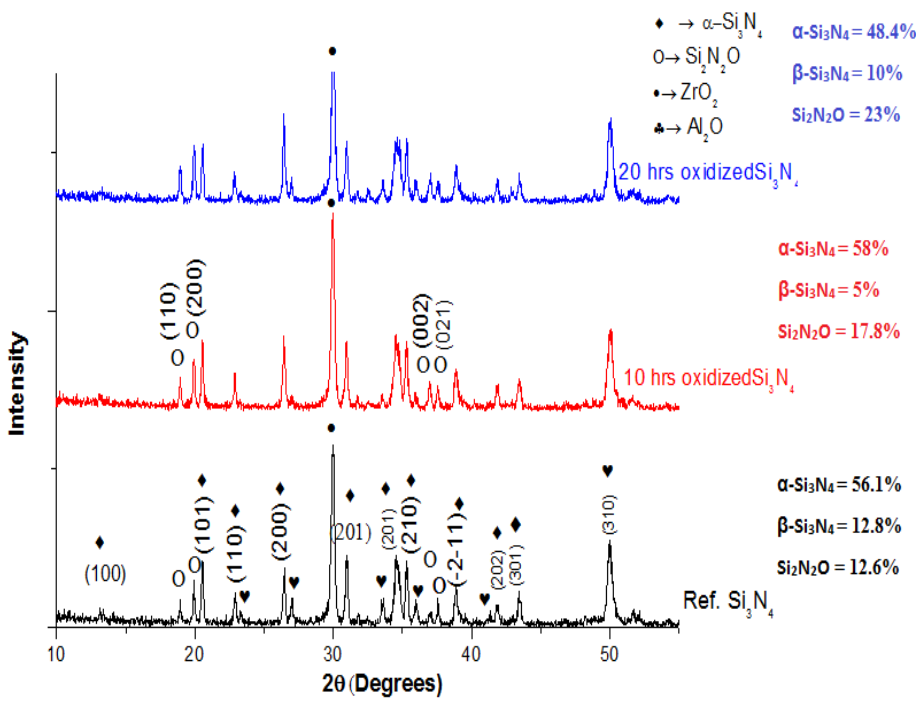
Mixing with Y_2O_3 & Al_2O_3

Sintering at 1500 ˚C for 3 hours

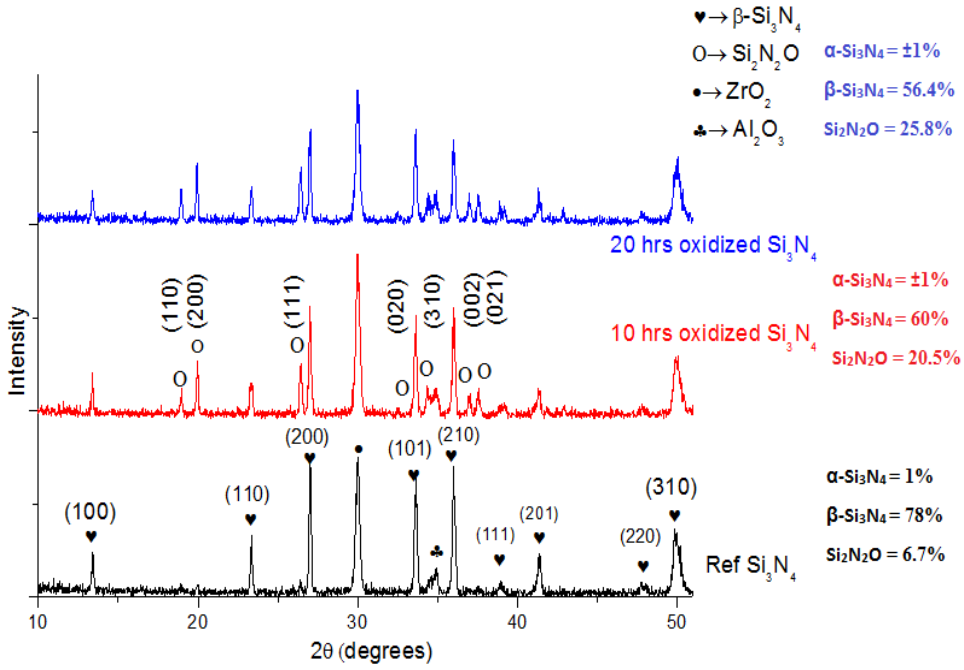
Sintering at 1700 ˚C for 3 hours

Characterization of sintered samples

Sintered at 1500 ˚C



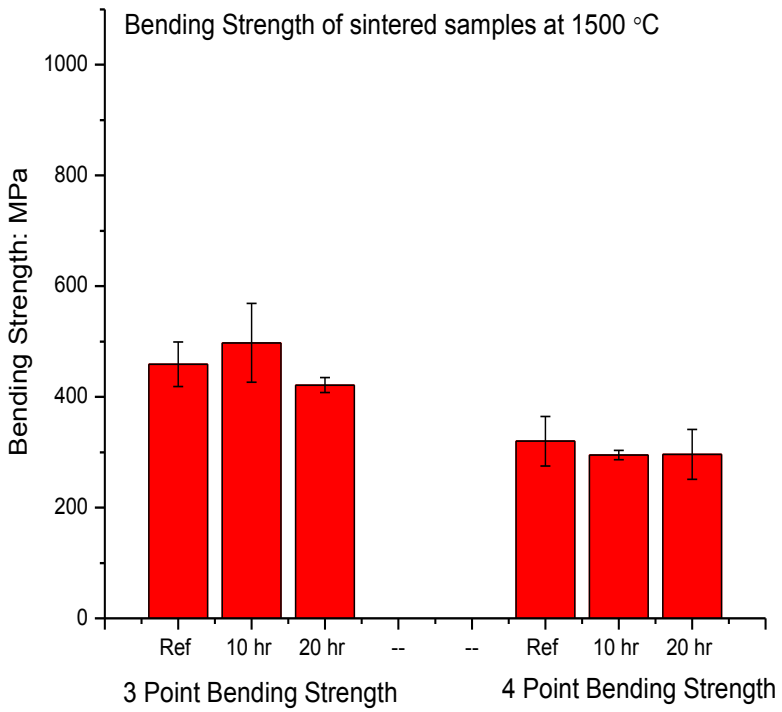
Sintered at 1700 ˚C



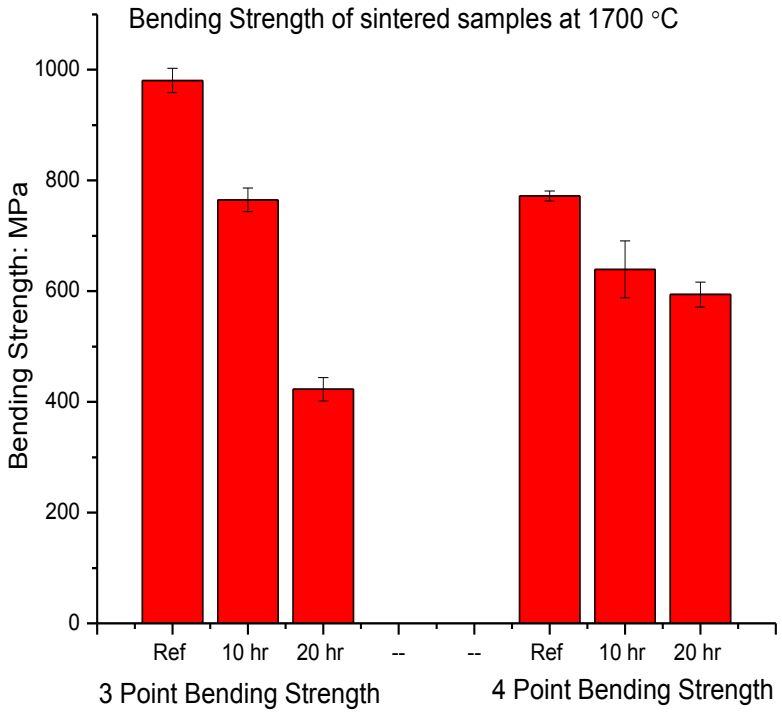
JCPDS PDF (01-076-1407), (00-33-1160), (00-47-1627) and (00-83-0944)

Bending strength of sintered samples

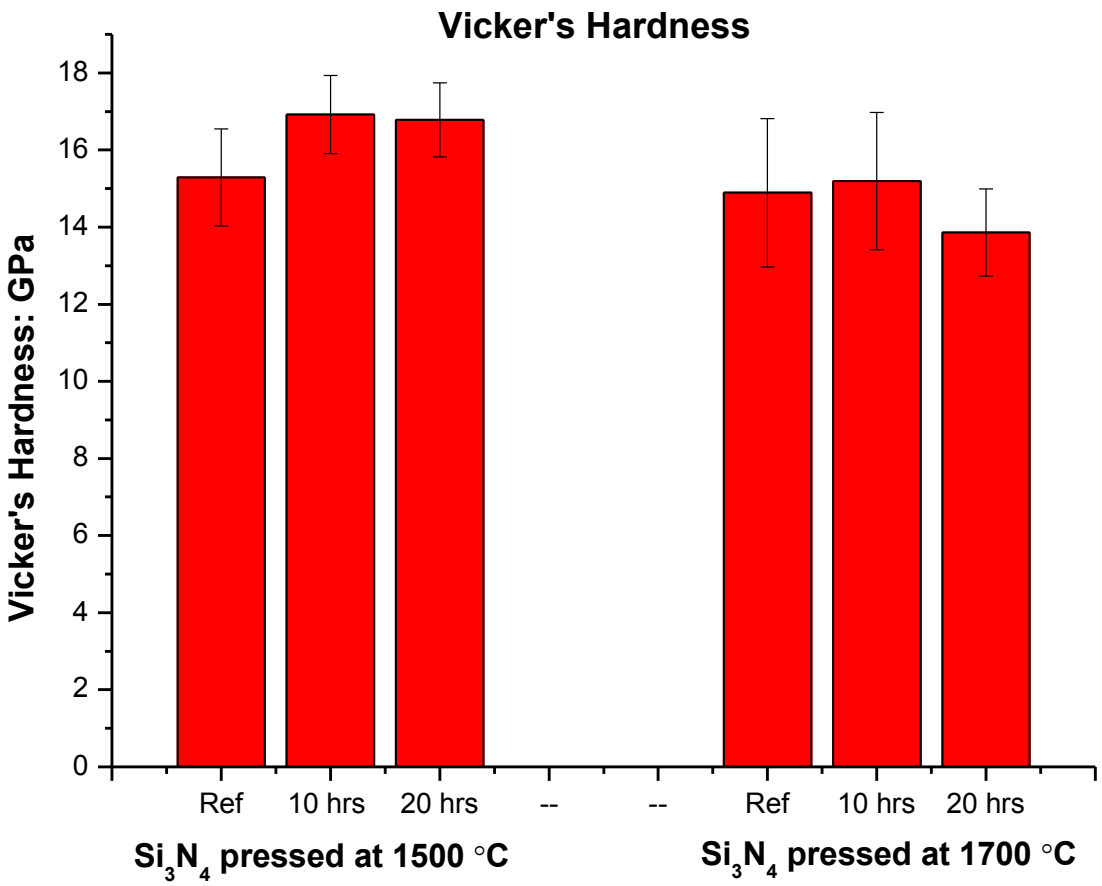
Sintered at 1500 ˚C



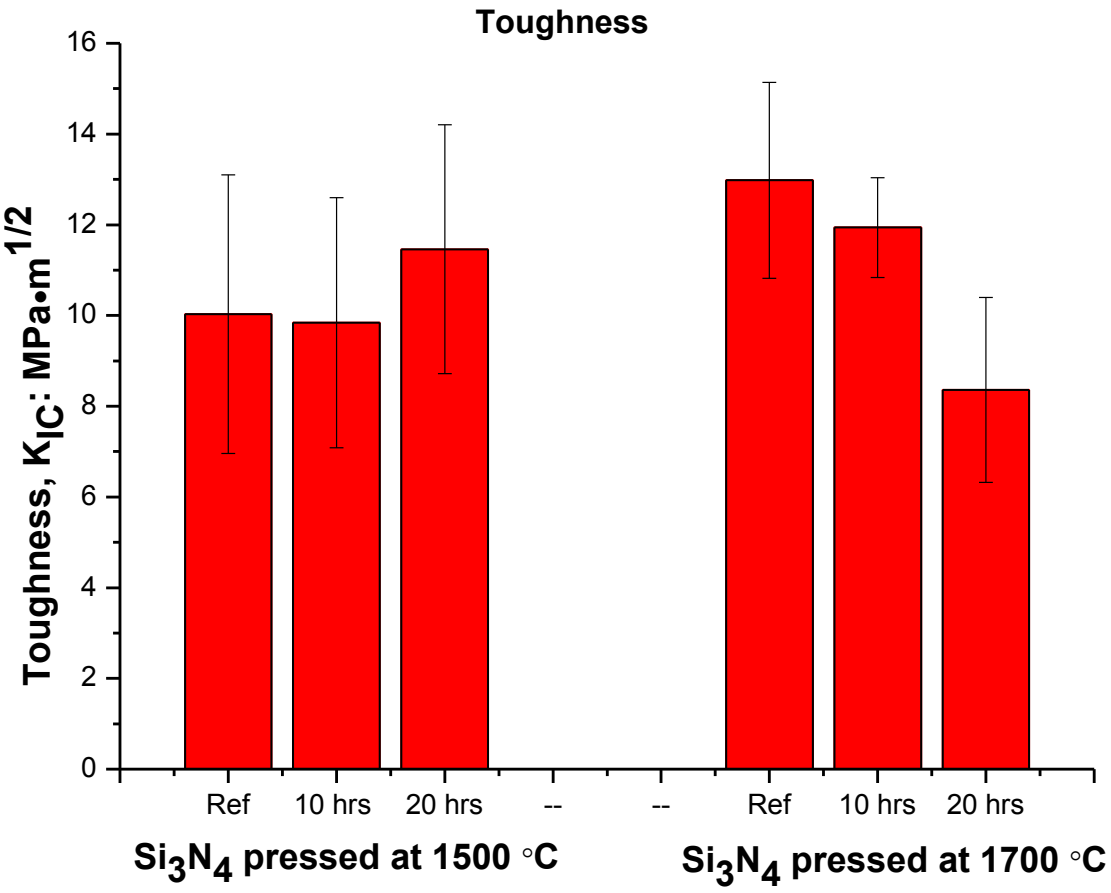
Sintered at 1700 ˚C



Vicker’s Hardness



Toughness

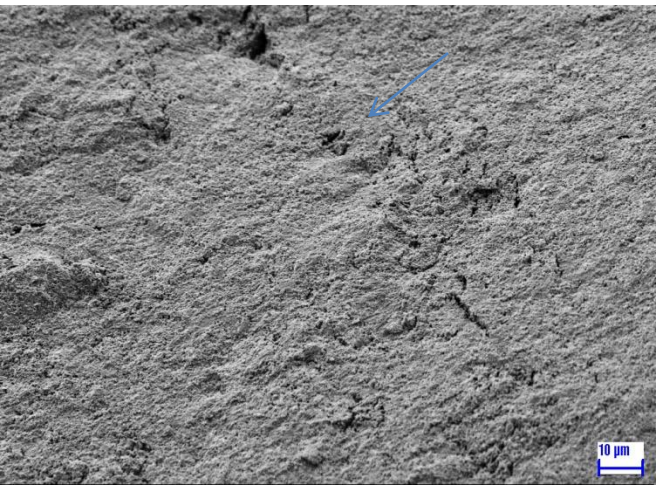

Toughness
Toughness, K_{IC}: MPa•m$^{1/2}$
0
2
4
6
8
10
12
14
16
Ref
10 hrs
20 hrs
--
--
Ref
10 hrs
20 hrs
Si_3N_4 pressed at 1500 °C
Si_3N_4 pressed at 1700 °C

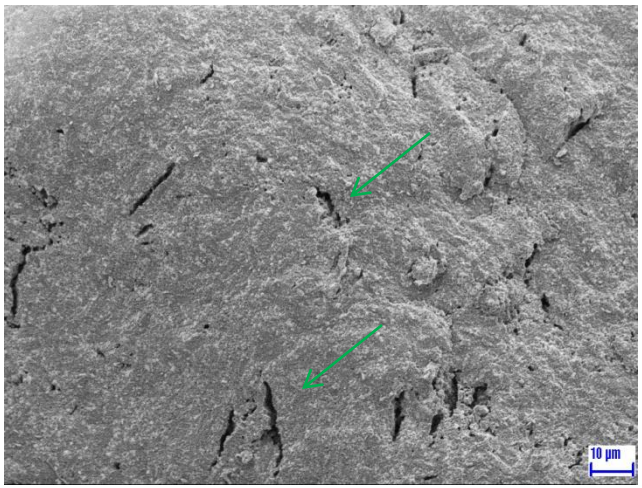
SEM of Fractured Samples of 1500 ˚C

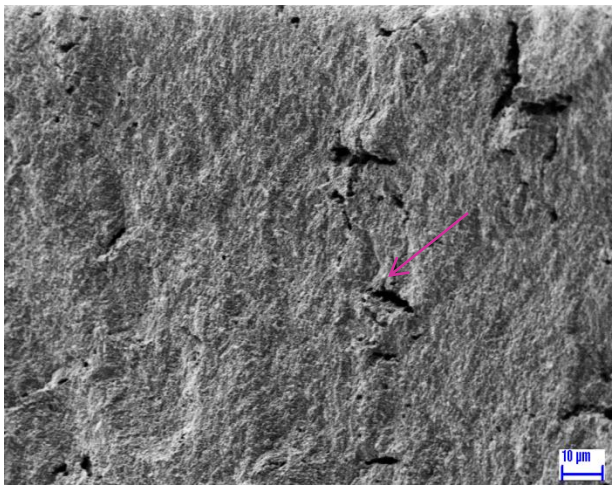
Ref. Si_3N_4

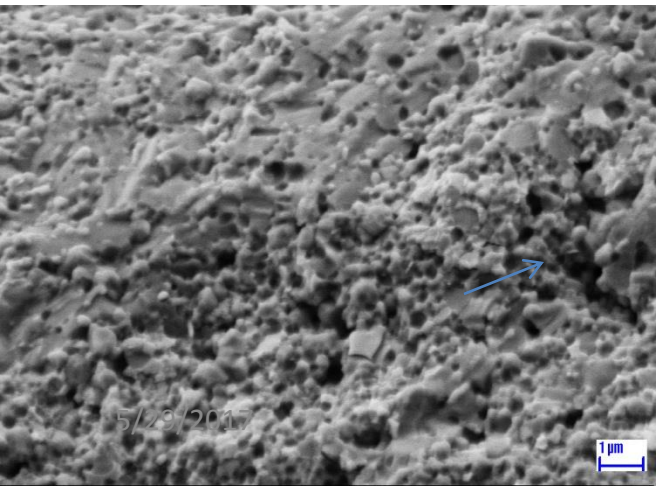
10 hrs oxidized α-Si_3N_4

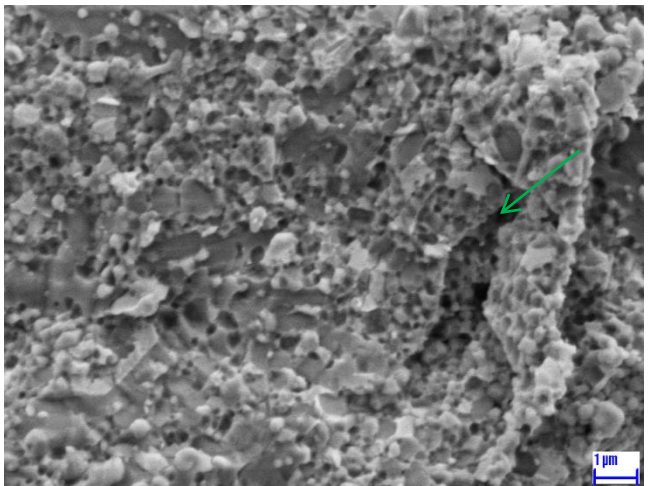
20 hrs oxidized α-Si_3N_4

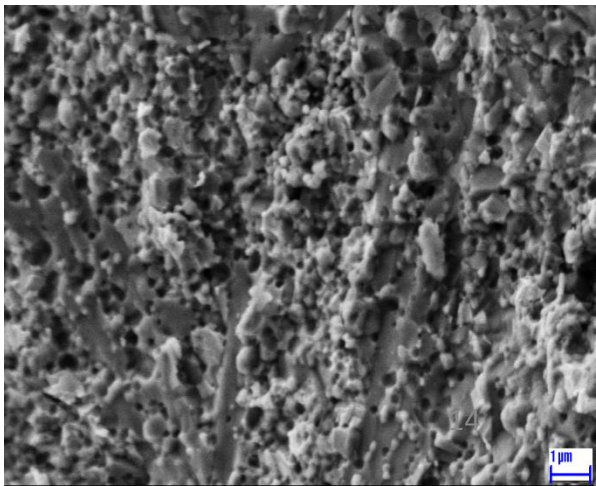










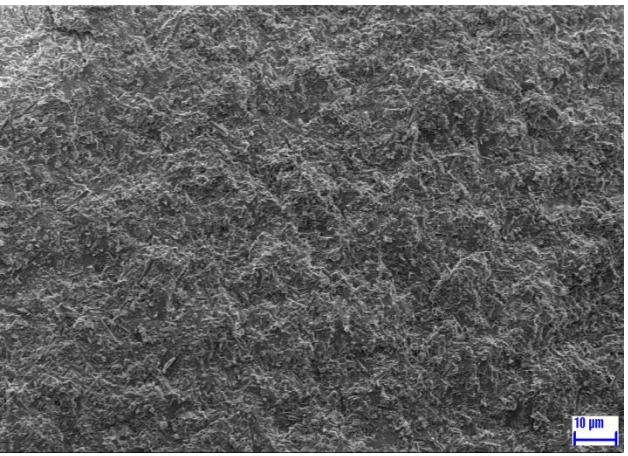


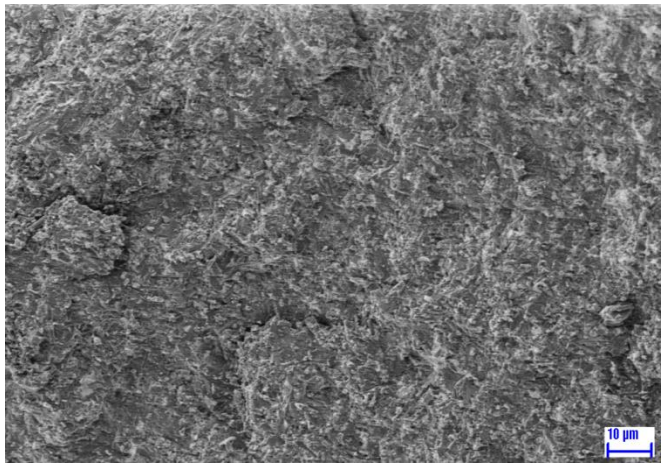
SEM of Fractured Samples of 1700 ˚C

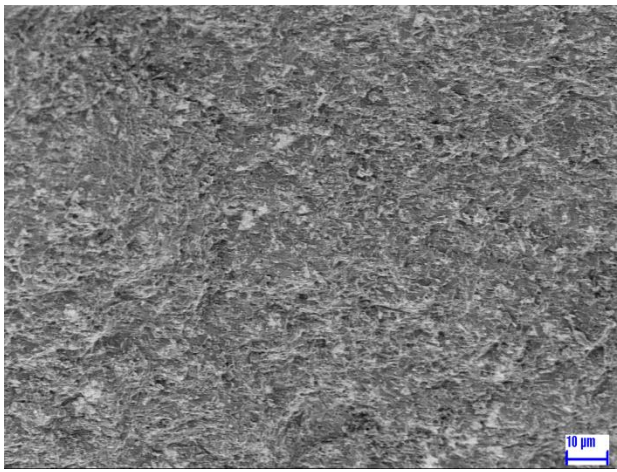
Ref. Si_3N_4

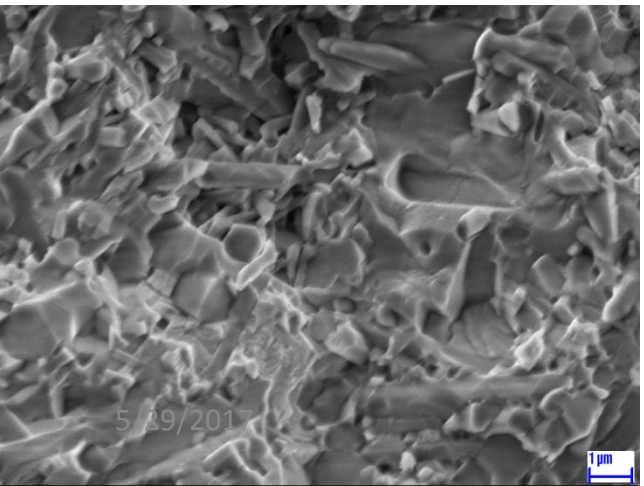
10 hrs oxidized α-Si_3N_4

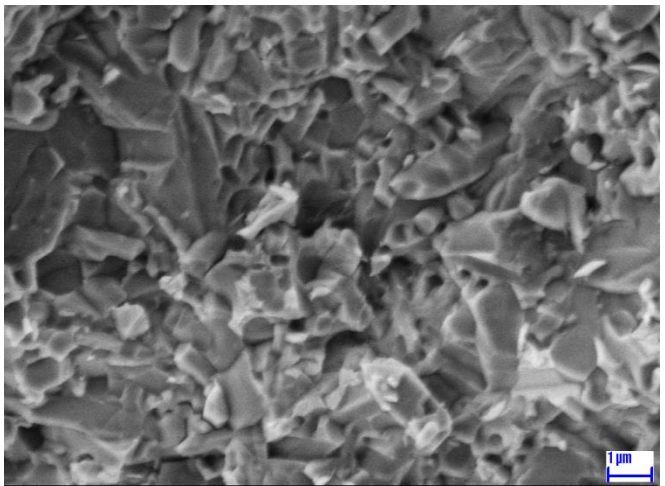
20 hrs oxidized α-Si_3N_4

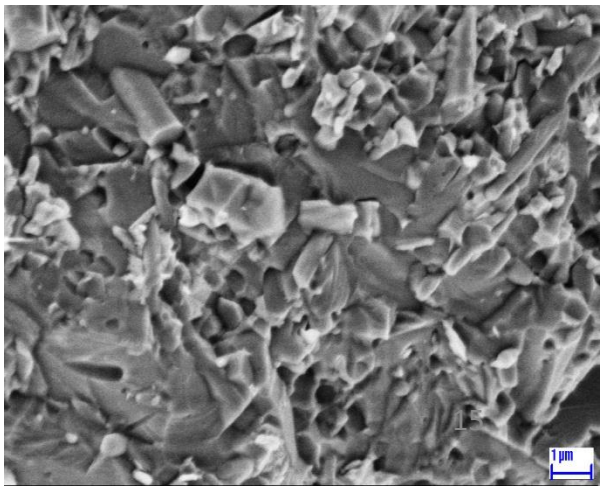












Conclusion

- Oxidation occurred in powder particles.
- Complete alpha to beta transformation at 1700 ˚C.
- The **flexural strength** is higher of those samples which were prepared at 1700 ˚C.
- Oxidation suppresses the beta phase.

Acknowledgement

- Dr. Zsolt Fogarassy for TEM & HRTEM and Dr. Zsolt E. Horvath for XRD.
- Special thanks to supervisors and other technical staff.

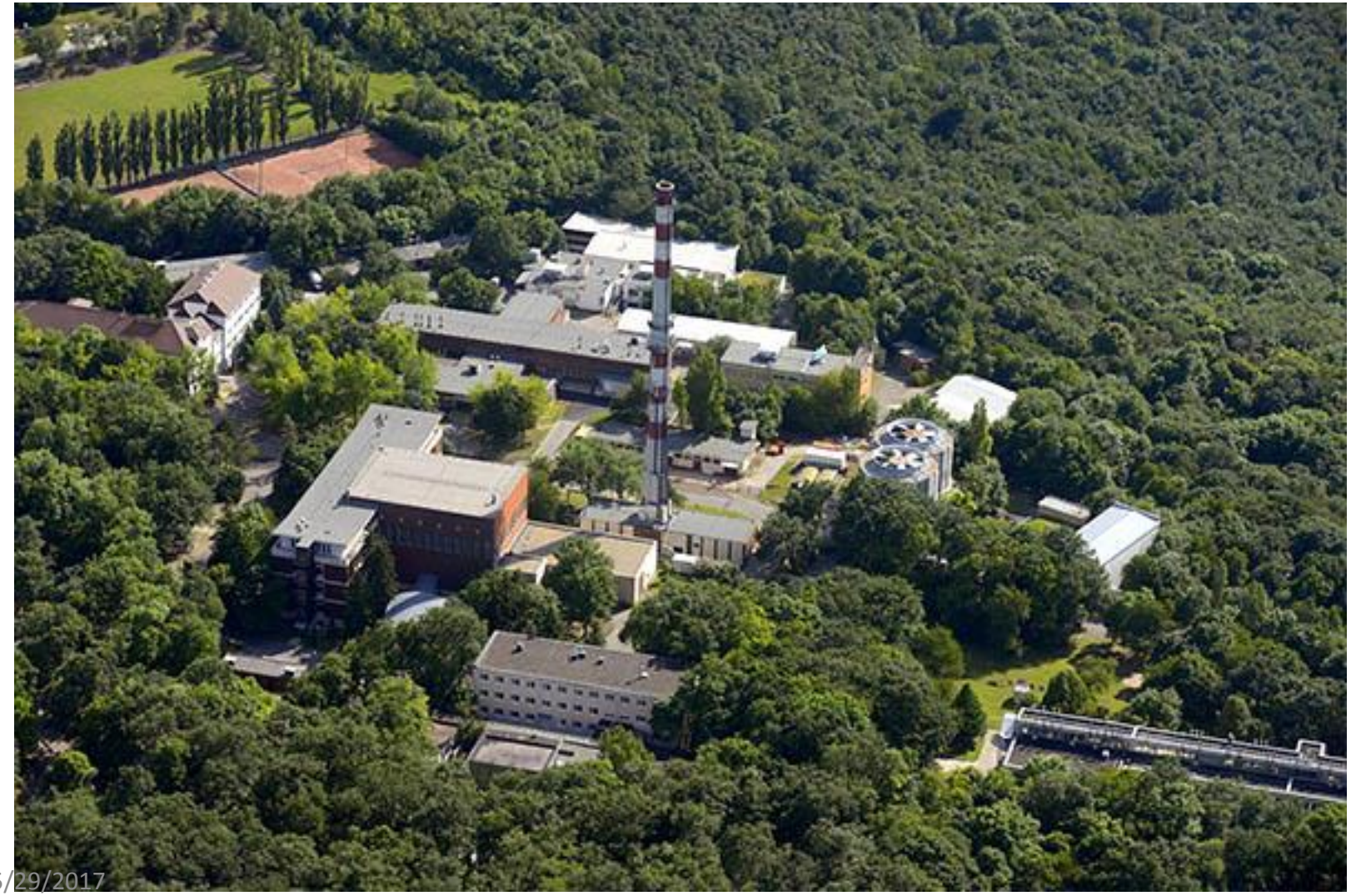
Progress Report of 1st Semester

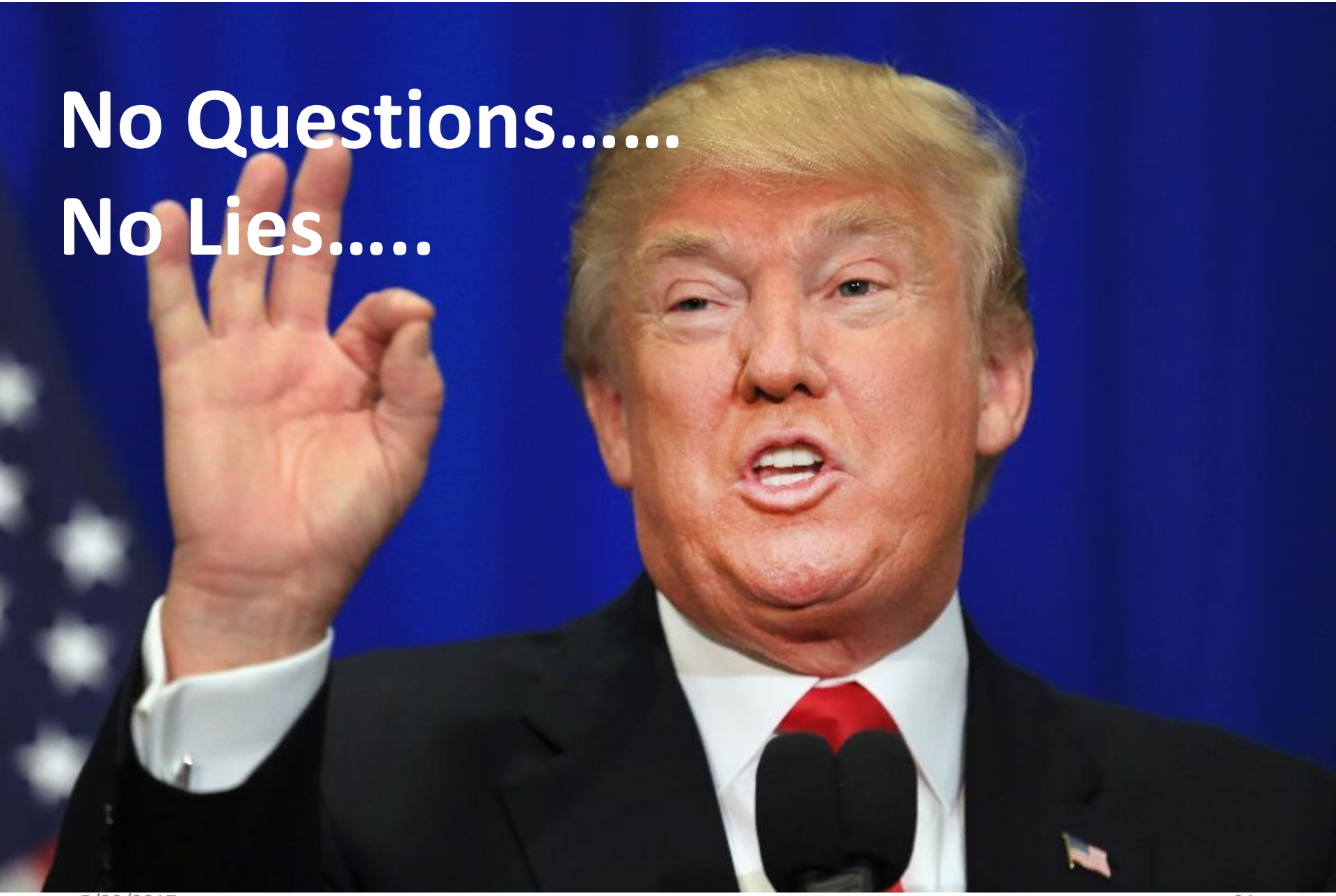
- Course Work "Selected Chapters on Material Methods Testing".
- Course Work "Ceramic Materials".
- Attended in Hungarian Microscopic Society Annual Conference & Meeting 2017.
- Webinar workshop on "Material By Design (MBD)".

Future Plans

- Tribological testing of sintered samples.
- CNTs and graphene as reinforcement in oxidized silicon nitride powders.
- Poster Presentation in ECerS 2017, Budapest.
- Paper publication in August, 2017.

Thank You! **Köszönöm**




No Questions……
No Lies…..