

References

1. Bongkoch Piempermpon. Improvement of thermal conductivity of alumina for Peltier Element. Faculty of Science, Chulalongkorn University.
2. Patrawan Kahawong. Effect of clay on preparation and forming of water-based alumina substrate by doctor blade process. Faculty of Science, Chulalongkorn University.
3. Ueyama, T.; and Wada, H. Alumina ceramic substrates. Advance ceramic. Shinroku Saito. Oxford University press, 1988.
4. Flock, W.M. Bayer Processed aluminas. Ceramic process before firing. New York : John Wiley&Sons, 1978.
5. Wada, S. Role of Al₂O₃ in ceramic industry. Faculty of Science, Chulalongkorn University.
6. Kingery, W.D.; Bowen, H.K.; and Uhlmann, D.R. Introduction to ceramics: 2nd edition. John Wiley&Sons. Singapore, 1991.
7. Richerson, D.W. Densification. Modern ceramic engineering. Marcel Pekher Inc. 1982
8. Berry, K.A.; and Harmer, M.P. Effect of MgO solute on microstructure development in Al₂O₃, J.Am.Ceram.Soc.69 (1986) : 143 – 149.
9. Chan Woo Park ;and Duk Yong Yoon. Effects of SiO₂ and MgO additions on the grain growth of alumina. J.Am.Ceram.Soc.83 [10] (2000) : 2605 – 2609.
10. Lange, F.F.; and Hirlinger M.M. Grain growth on two phases ceramics:Al₂O₃ inclusions in ZrO₂. J.Am.Ceram.Soc.70 [11](1987) : 827 – 830.
11. Reed, J.S. Principles of ceramic processing. John Wiley&Sons. Singapore, 1989.
12. White, J.F.; and Clavel, A.L. Extrusion properties of non-clay oxides. Cer.Bulletin 42 (1963) : 698 – 702.
13. Janney, M.A. Plastic forming of ceramics: extrusion and injection molding. Ceramic Processing. Chapman & Hall. London, 1995.
14. Schuetz, J.E. Methylcellulose polymers as binder for extrusion of ceramics. Cer.Bulletin 65 [12] (1986) : 1556 – 1559.

15. Robison, G.C. Extrusion defects. Ceramic process before firing. John Wiley&Sons, 1978
16. Mistler, R.E. ; and Twiname, E.R. Tape casting theory and practice: The American Ceramic Society, 2000.
17. Hyatt, T.P. Tape casting and roll compaction. The American ceramic society Bulletin 74 [10] (1995) : 56 - 59.



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Appendices

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Appendix 1

Average value of bulk density, relative density and water absorption of specimens sintered at 1500 - 1650 °C

1. Pure AKP-30			
Sintering temperature (°C)	Average bulk density (g/cm ³)	Average relative density (%)	Average water absorption (%)
1500	3.703	93.3	4.59
1550	3.765	94.8	3.39
1600	3.854	97.1	1.30
1650	3.823	96.3	0.14
2. AKP-30+0.5% MgO			
Sintering temperature (°C)	Average bulk density (g/cm ³)	Average relative density (%)	Average water absorption (%)
1500	3.766	94.9	1.94
1550	3.697	95.2	0.07
1600	3.815	96.1	0.06
1650	3.848	97.0	0.04
3. AKP-30+1.5% ZrO ₂			
Sintering temperature (°C)	Average bulk density (g/cm ³)	Average relative density (%)	Average water absorption (%)
1500	3.649	91.4	6.43
1550	3.879	97.2	0.17
1600	3.917	98.2	0.04
1650	3.942	98.8	0.16
4. AKP-30+3.0%ZrO ₂			
Sintering temperature (°C)	Average bulk density (g/cm ³)	Average relative density (%)	Average water absorption (%)
1500	3.659	91.2	5.80
1550	3.930	98.0	0.19
1600	3.931	98.0	0.57
1650	3.875	96.6	0.20

Appendix 2 A

Data of specimens for thermal conductivity measurement

Composition	Sintering temperature (°C)	Suspended weight (g)	Saturated weight (g)	Dry weight (g)	Bulk density (g/cm ³)	Relative density (%)	Water absorption (%)
1. AKP-30	1450	0.4414	0.5924	0.5923	3.901	98.3	0.07
	1500	0.4414	0.5900	0.5900	3.958	99.7	0.00
	1550	0.4427	0.5939	0.5938	3.915	98.7	0.07
2. AKP-30 +0.5% MgO	1500	0.4190	0.5720	0.5643	3.675	92.6	5.03
	1550	0.3851	0.5202	0.5200	3.836	96.7	0.15
	1600	0.3407	0.4598	0.4596	3.845	96.9	0.17
	1650	0.3966	0.5369	0.5368	3.813	96.1	0.07
3. AKP-30 +1.5 ZrO ₂	1550	0.4505	0.6098	0.6098	3.815	95.6	0.00
	1600	0.4567	0.6173	0.6173	3.830	96.0	0.00
	1650	0.2179	0.2921	0.2921	3.923	98.3	0.00
4. AKP-30 +3.0 ZrO ₂	1550	0.3453	0.4695	0.4695	3.767	93.9	0.00
	1600	0.2796	0.3783	0.3783	3.819	95.2	0.00
	1650	0.3191	0.4287	0.4287	3.898	97.2	0.00

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Appendix 2 B

Data of thermal conductivity measurement

Composition	Sintering temperature (°C)	Thermal diffusivity (cm ² /s)	Specific heat (J/K g)	Bulk density (g/cm ³)	Thermal conductivity (W/m K)
1. AKP-30	1450	0.1018	0.8231	3.901	32.8
	1500	0.1063	0.8339	3.958	35.6
	1550	0.1100	0.8673	3.915	37.4
2. AKP-30 + 0.5% MgO	1500	0.0830	0.7910	3.675	24.2
	1550	0.1070	0.8390	3.836	34.2
	1600	0.1160	0.7990	3.845	35.9
	1650	0.1100	0.8350	3.813	36.4
3. AKP-30 + 1.5% ZrO ₂	1550	0.1030	0.8530	3.815	34.1
	1600	0.1070	0.8760	3.830	36.2
	1650	0.1010	0.8500	3.923	33.8
4. AKP-30 + 3.0% ZrO ₂	1550	0.1100	0.8160	3.822	34.2
	1600	0.0980	0.7860	3.893	30.0
	1650	0.1130	0.7580	3.949	33.9

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Appendix 3

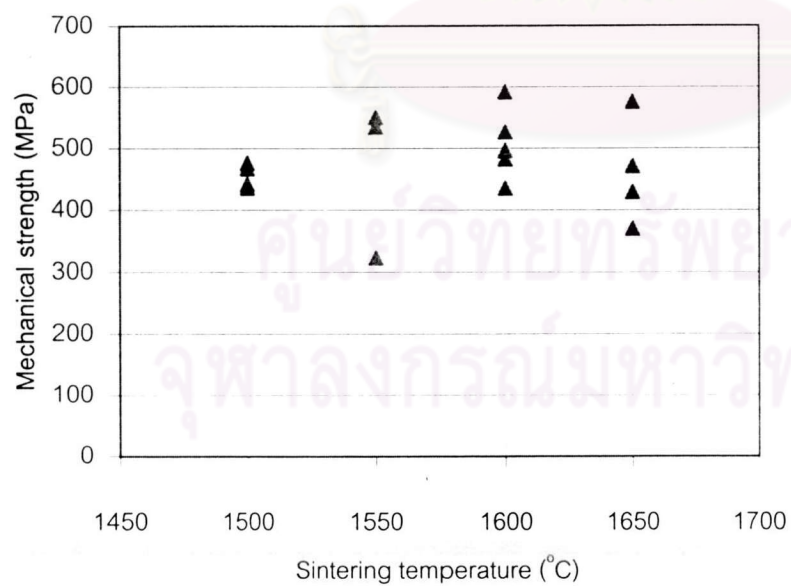
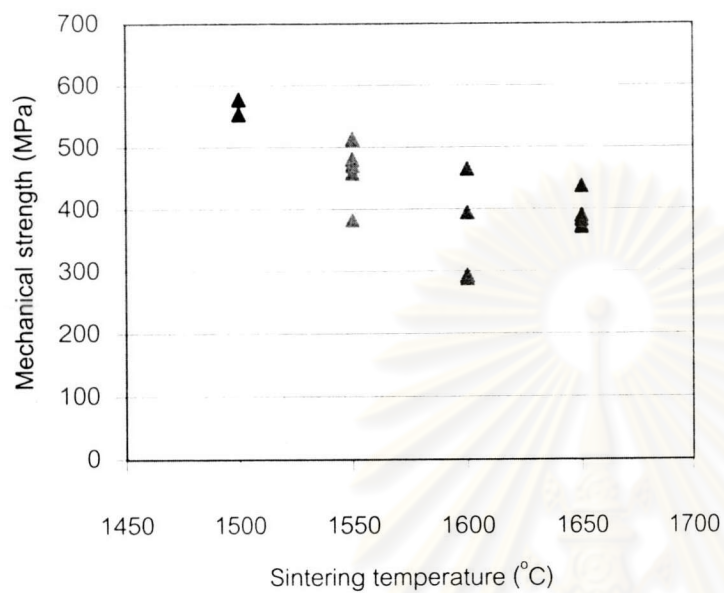
Average value of bulk density, relative density and water absorption of specimens

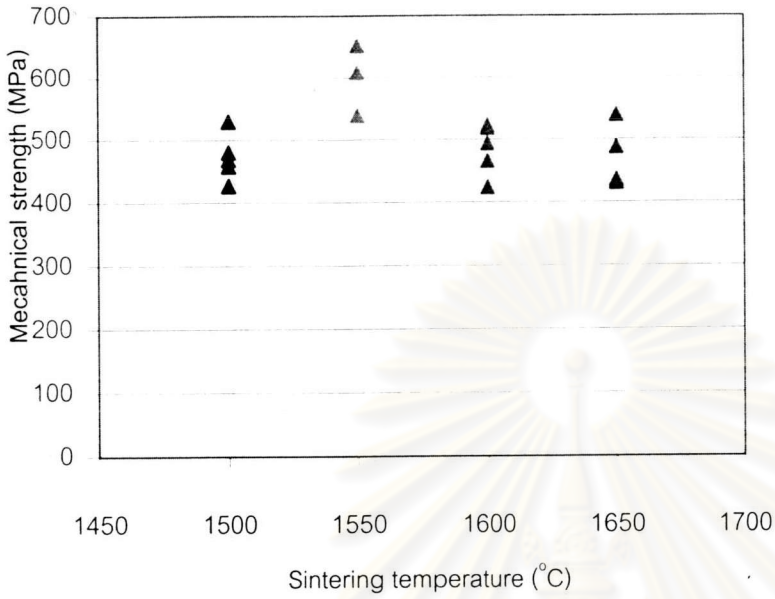
for mechanical strength measurement

1. Pure AKP-30			
Sintering temperature (°C)	Average bulk density (g/cm ³)	Average relative density (%)	Average water absorption (%)
1500	3.811	96.0	1.72
1550	3.881	97.8	0.73
1600	3.929	99.0	0.05
1650	3.849	97.0	0.11
2. AKP-30+0.5% MgO			
Sintering temperature (°C)	Average bulk density (g/cm ³)	Average relative density (%)	Average water absorption (%)
1500	3.752	94.6	1.91
1550	3.879	97.7	0.01
1600	3.925	98.9	0.01
1650	3.825	96.4	0.08
3. AKP-30+1.5% ZrO ₂			
Sintering temperature (°C)	Average bulk density (g/cm ³)	Average relative density (%)	Average water absorption (%)
1500	3.871	97.0	0.14
1550	3.912	98.0	0.03
1600	3.911	98.0	0.02
1650	3.872	97.0	0.02
4. AKP-30+3.0%ZrO ₂			
Sintering temperature (°C)	Average bulk density (g/cm ³)	Average relative density (%)	Average water absorption (%)
1500	3.841	95.8	0.68
1550	3.916	97.6	0.32
1600	3.928	97.9	0.04
1650	3.895	97.1	0.03

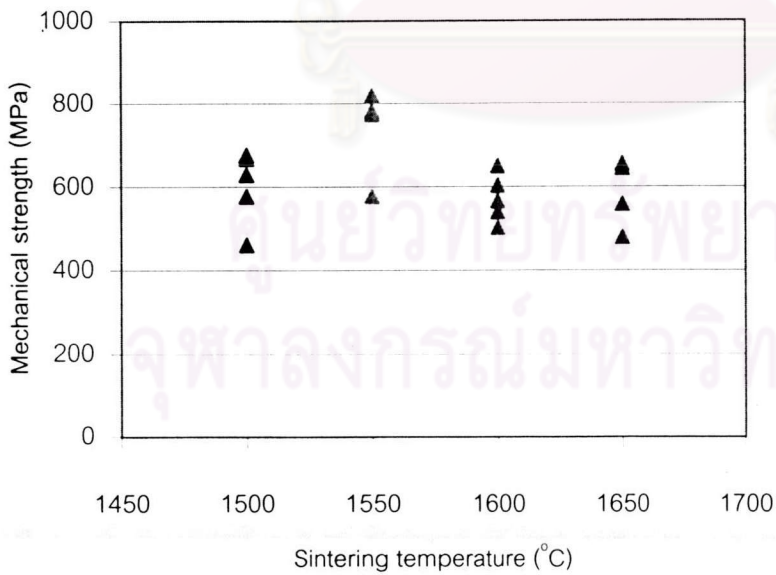
Appendix 4

The relationship between mechanical strength and sintering temperature





Mechanical strength of AKP-30+1.5% ZrO₂



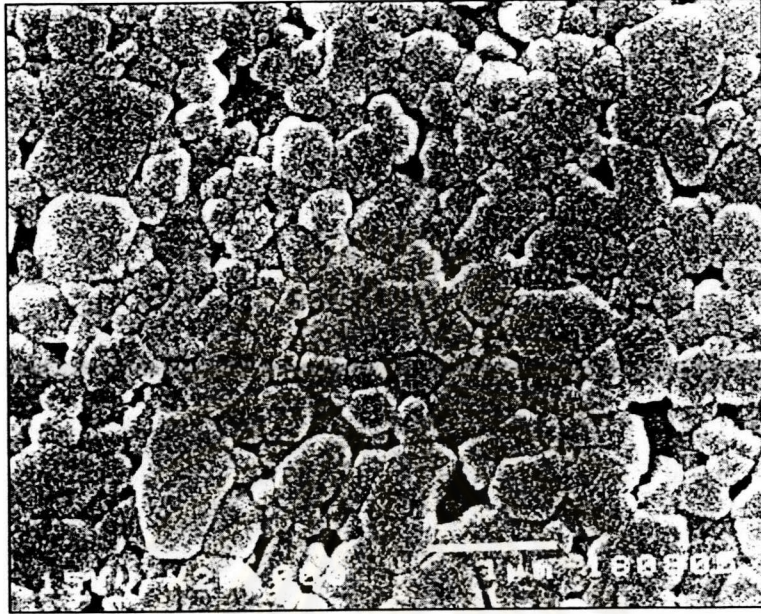
Strength measurement of AKP-30+3.0% ZrO₂

Appendix 5

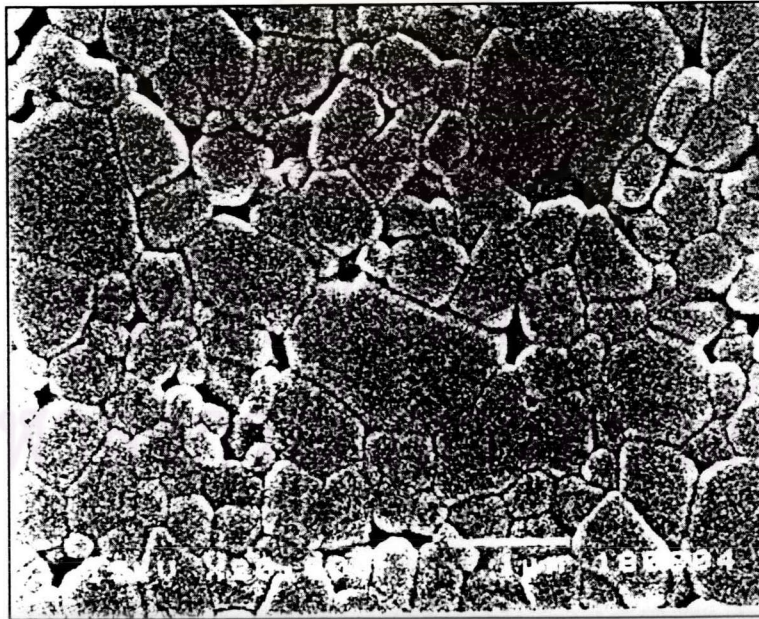
Data of specimens for microstructure observation

1. Pure AKP-30							
No.	Sintering temperature (°C)	Suspended weight (g)	Saturated weight (g)	Dry weight (g)	Bulk density (g/cm ³)	Relative density (%)	Water absorption (%)
1/2.	1500	0.5218	0.7100	0.7022	3.715	93.6	4.14
1/5.	1550	0.5217	0.7075	0.7010	3.757	94.6	3.50
1/8.	1600	0.4569	0.6154	0.6127	3.849	97.0	1.70
1/10.	1650	0.5036	0.6835	0.6833	3.782	95.3	0.11
2. AKP-30+0.5% MgO							
No.	Sintering temperature (°C)	Suspended weight (g)	Saturated weight (g)	Dry weight (g)	Bulk density (g/cm ³)	Relative density (%)	Water absorption (%)
2/3.	1500	0.5261	0.7139	0.7103	3.766	94.9	1.92
2/4.	1550	0.5113	0.7225	0.7225	3.406	85.8	0.00
2/9.	1600	0.5004	0.6776	0.6776	3.807	95.9	0.00
2/10.	1650	0.5241	0.7064	0.7063	3.858	97.2	0.05
3. AKP-30+1.5% ZrO ₂							
No.	Sintering temperature (°C)	Suspended weight (g)	Saturated weight (g)	Dry weight (g)	Bulk density (g/cm ³)	Relative density (%)	Water absorption (%)
3/3.	1500	0.5083	0.6955	0.6841	3.639	91.2	6.09
3/5.	1550	0.5010	0.6729	0.6728	3.897	97.7	0.06
3/9.	1600	0.5196	0.6966	0.6966	3.919	98.2	0.00
3/12.	1650	0.4926	0.6600	0.6595	3.923	98.3	0.30
4. AKP-30+3.0% ZrO ₂							
No.	Sintering temperature (°C)	Suspended weight (g)	Saturated weight (g)	Dry weight (g)	Bulk density (g/cm ³)	Relative density (%)	Water absorption (%)
4/2.	1500	0.5256	0.7186	0.7083	3.654	91.1	5.34
4/5.	1550	0.5224	0.6953	0.6947	4.001	99.8	0.35
4/8.	1600	0.5370	0.7199	0.7193	3.916	97.6	0.33
4/11.	1650	0.5023	0.6742	0.6739	3.903	97.3	0.17

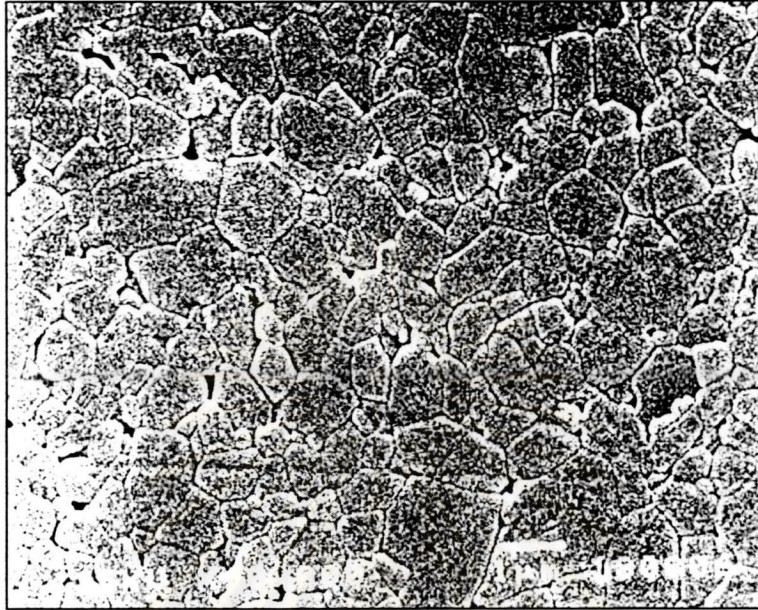
Appendix 6

SEM micrograph of sintered specimens

SEM micrograph of undoped AKP-30 alumina sintered at 1500 °C 2 hours



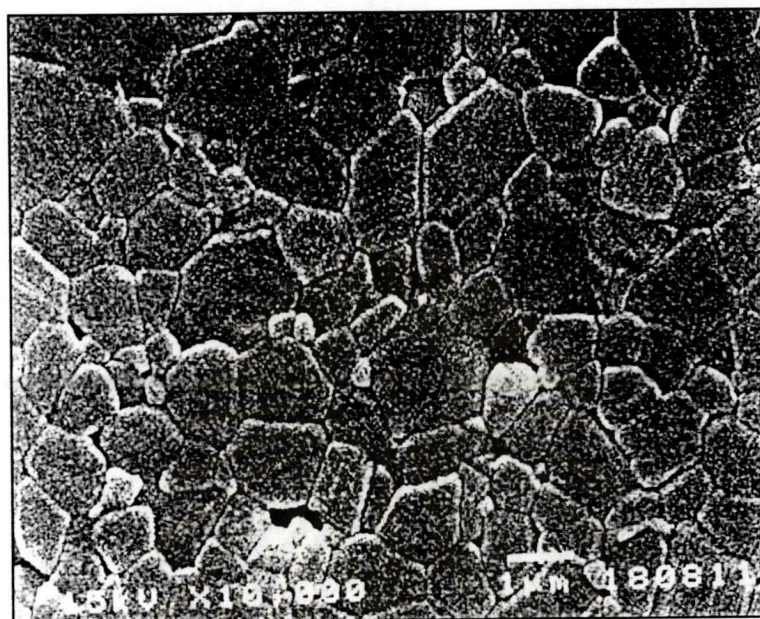
SEM micrograph of undoped AKP-30 alumina sintered at 1550 °C 2 hours



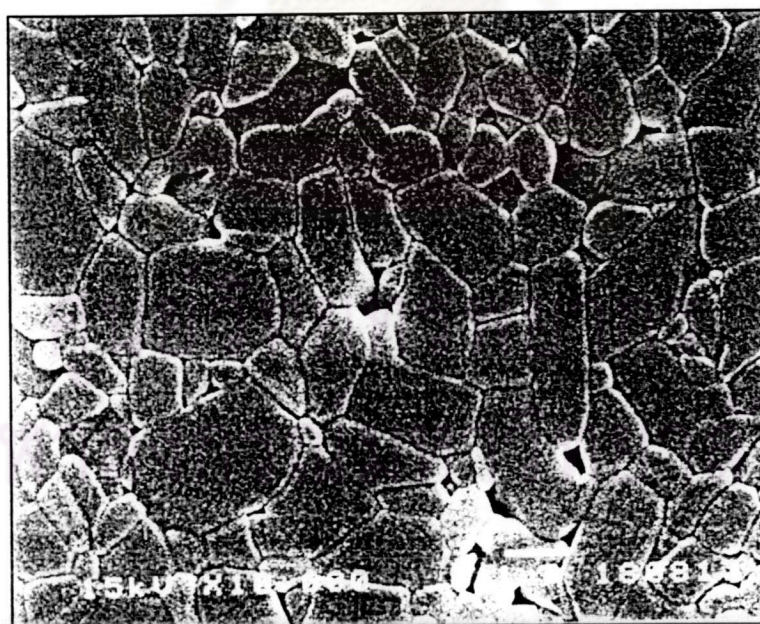
SEM micrograph of undoped AKP-30 alumina sintered at 1600 °C 2 hours



SEM micrograph of undoped AKP-30 alumina sintered at 1650 °C 2 hours



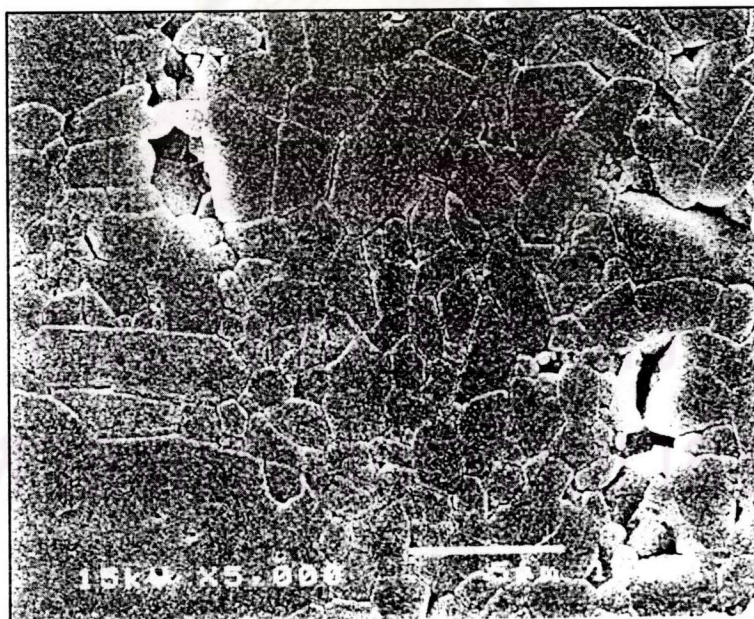
SEM micrograph of 0.5% MgO doped AKP-30 alumina sintered at 1500 °C 2 hours



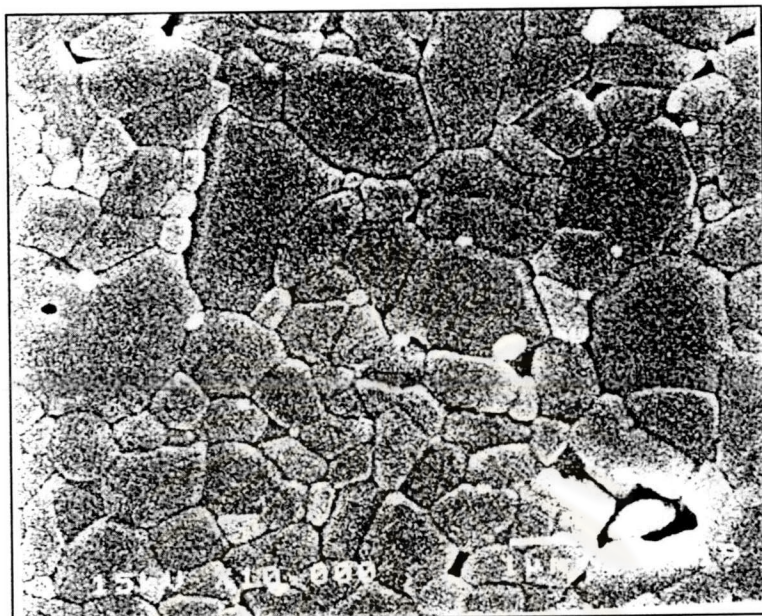
SEM micrograph of 0.5% MgO doped AKP-30 alumina sintered at 1550 °C 2 hours



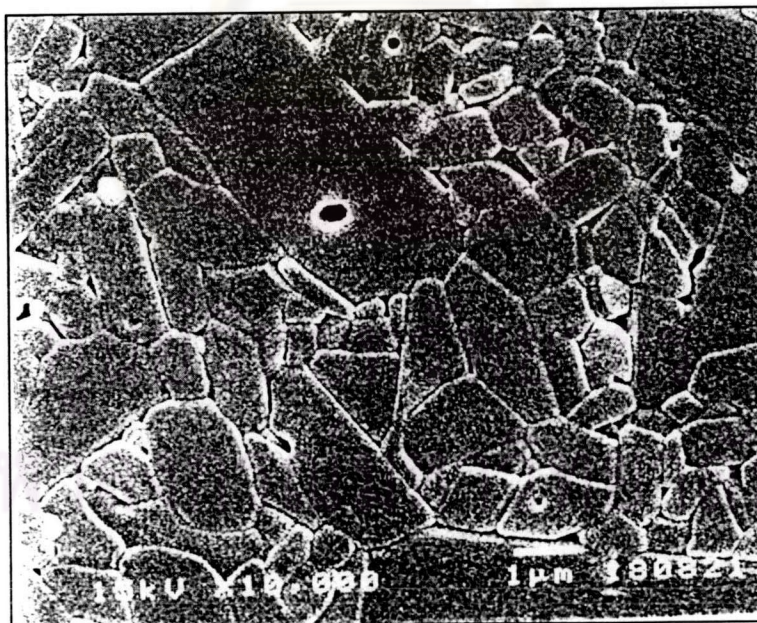
SEM micrograph of 0.5% MgO doped AKP-30 alumina sintered at 1600 °C 2 hours



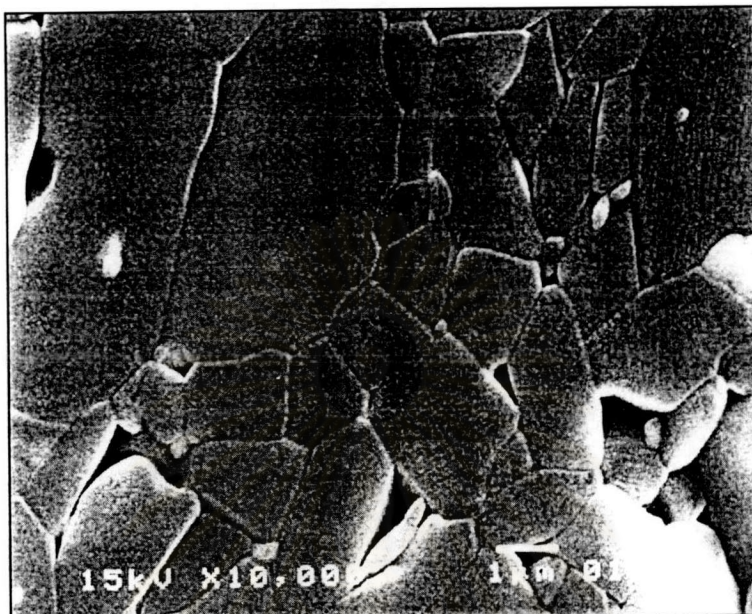
SEM micrograph of 0.5% MgO doped AKP-30 alumina sintered at 1650 °C 2 hours



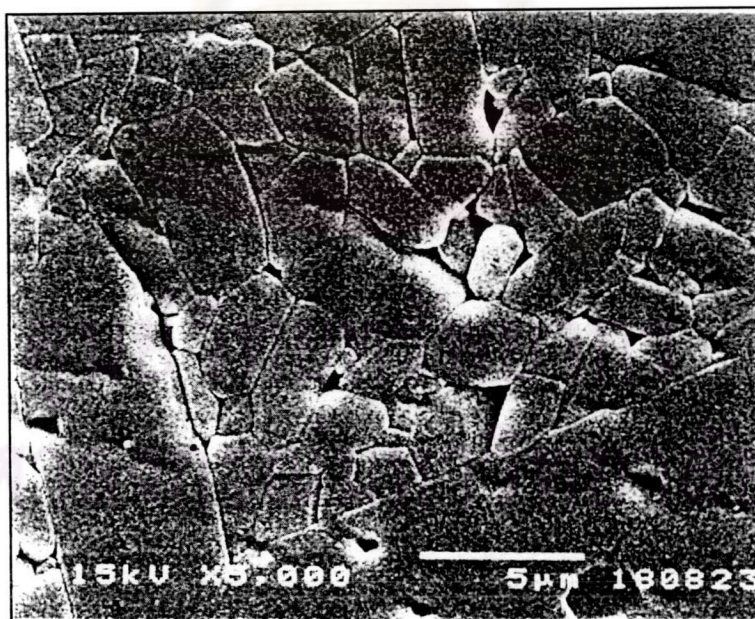
SEM micrograph of 1.5% ZrO₂ doped AKP-30 alumina sintered at 1500 °C 2 hours



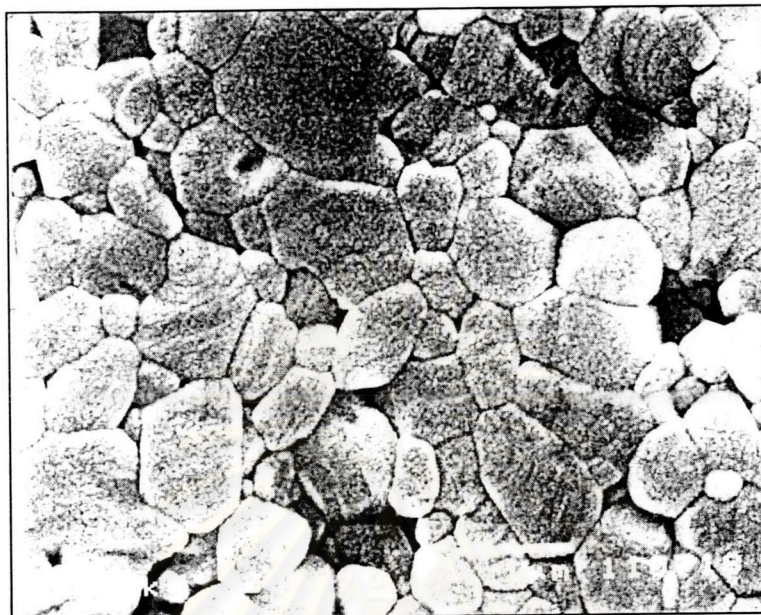
SEM micrograph of 1.5% ZrO₂ doped AKP-30 alumina sintered at 1550 °C 2 hours



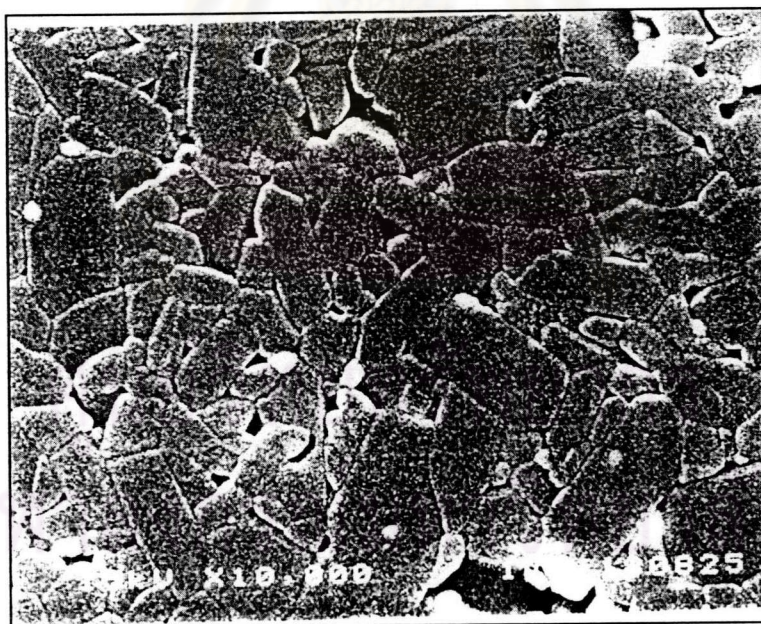
SEM micrograph of 1.5% ZrO₂ doped AKP-30 alumina sintered at 1600 °C 2 hours



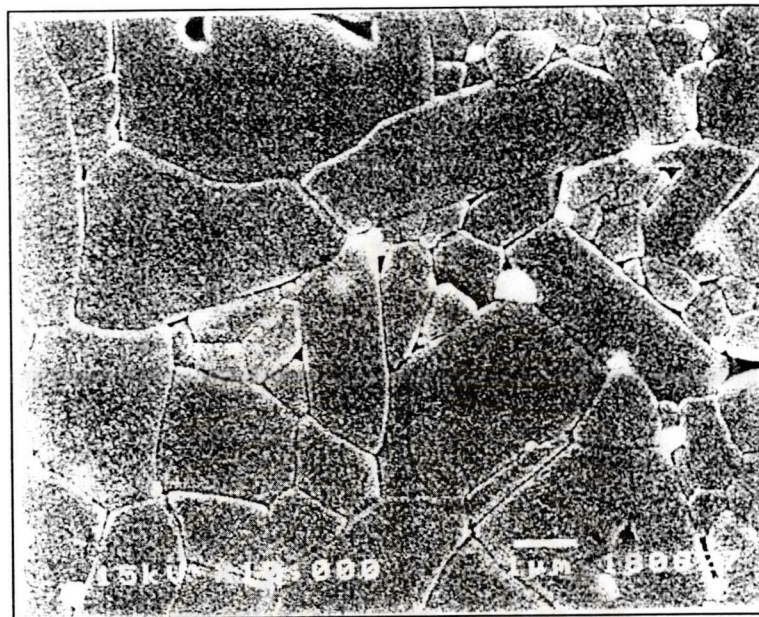
SEM micrograph of 1.5% ZrO₂ doped AKP-30 alumina sintered at 1650 °C 2 hours



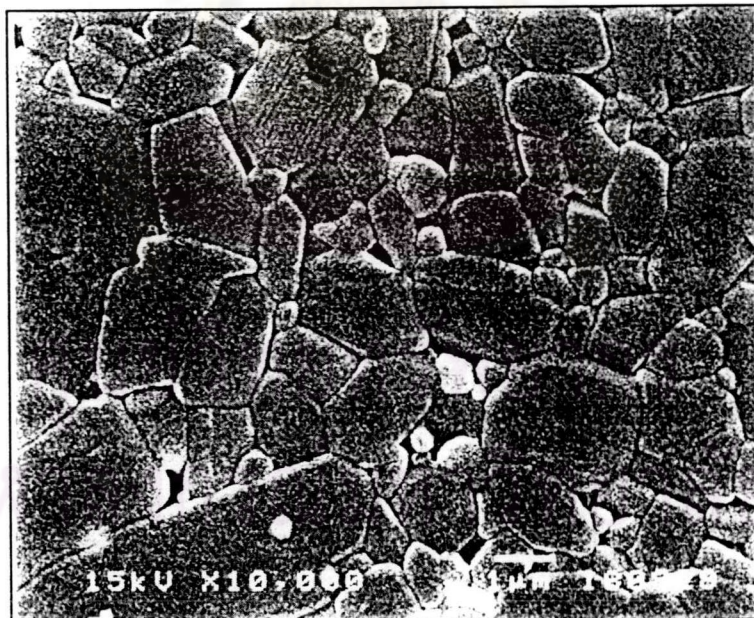
SEM micrograph of 3.0% ZrO₂ doped AKP-30 alumina sintered at 1500 °C 2 hours



SEM micrograph of 3.0% ZrO₂ doped AKP-30 alumina sintered at 1550 °C 2 hours



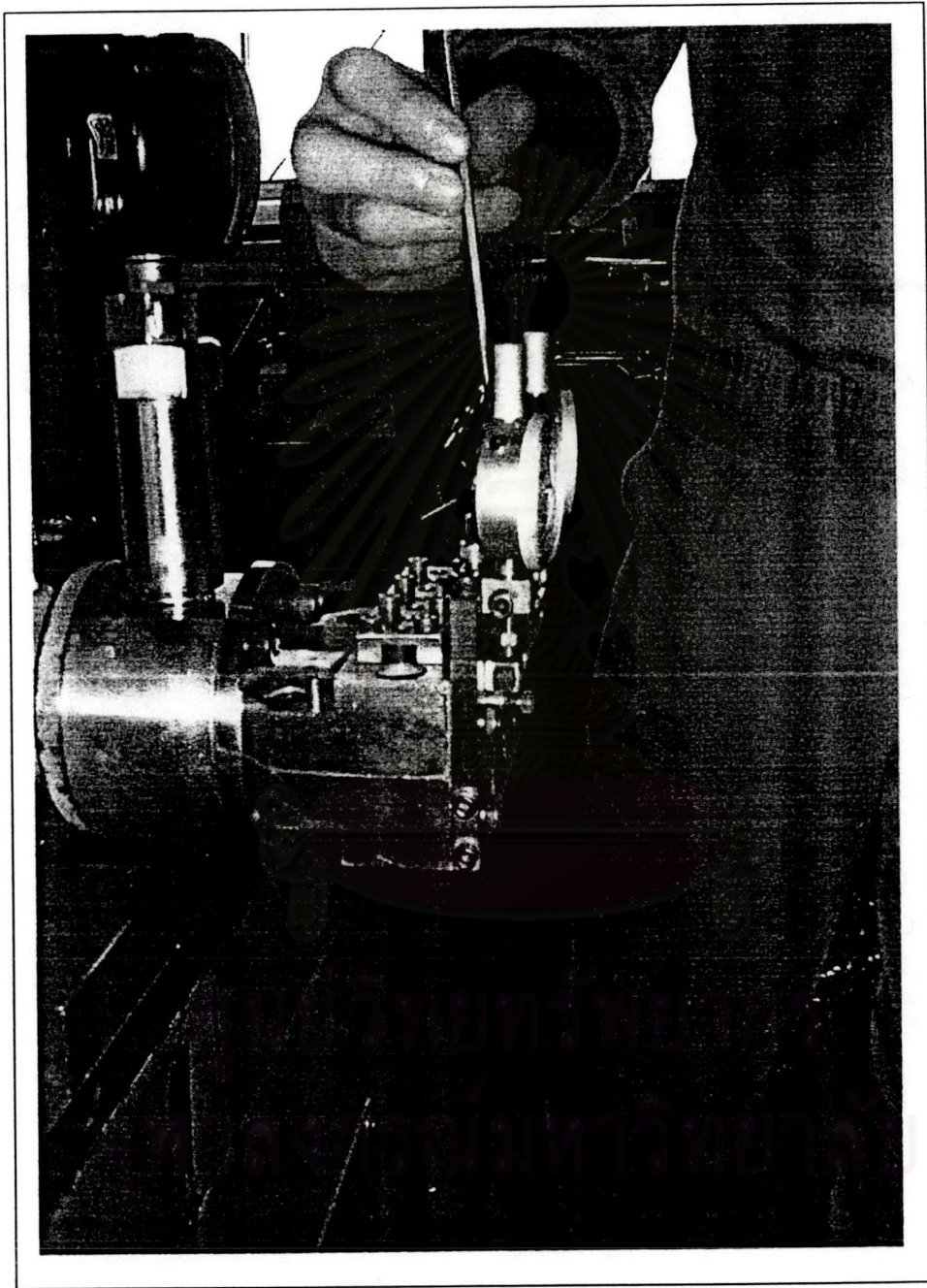
SEM micrograph of 3.0% ZrO₂ doped AKP-30 alumina sintered at 1600 °C 2 hours

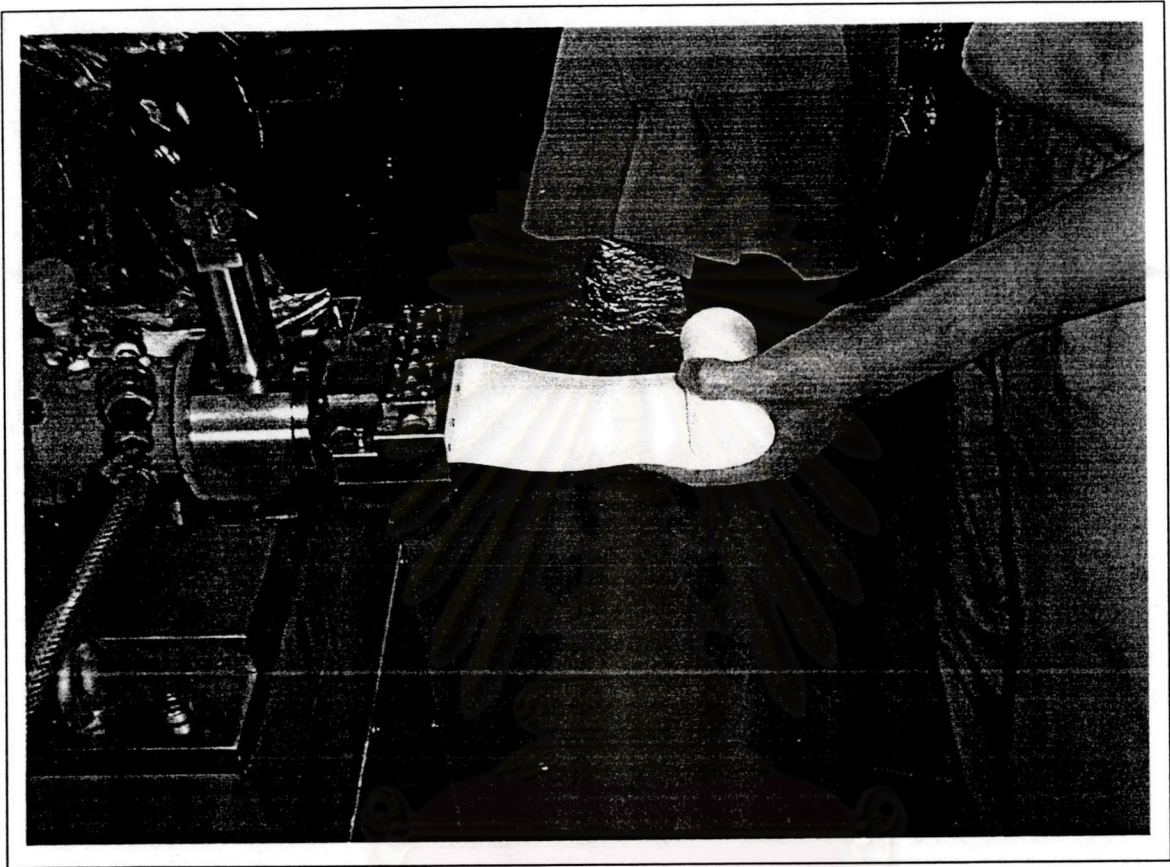


SEM micrograph of 3.0% ZrO₂ doped AKP-30 alumina sintered at 1650 °C 2 hours

Appendix 7

Photographs of the extrusion process

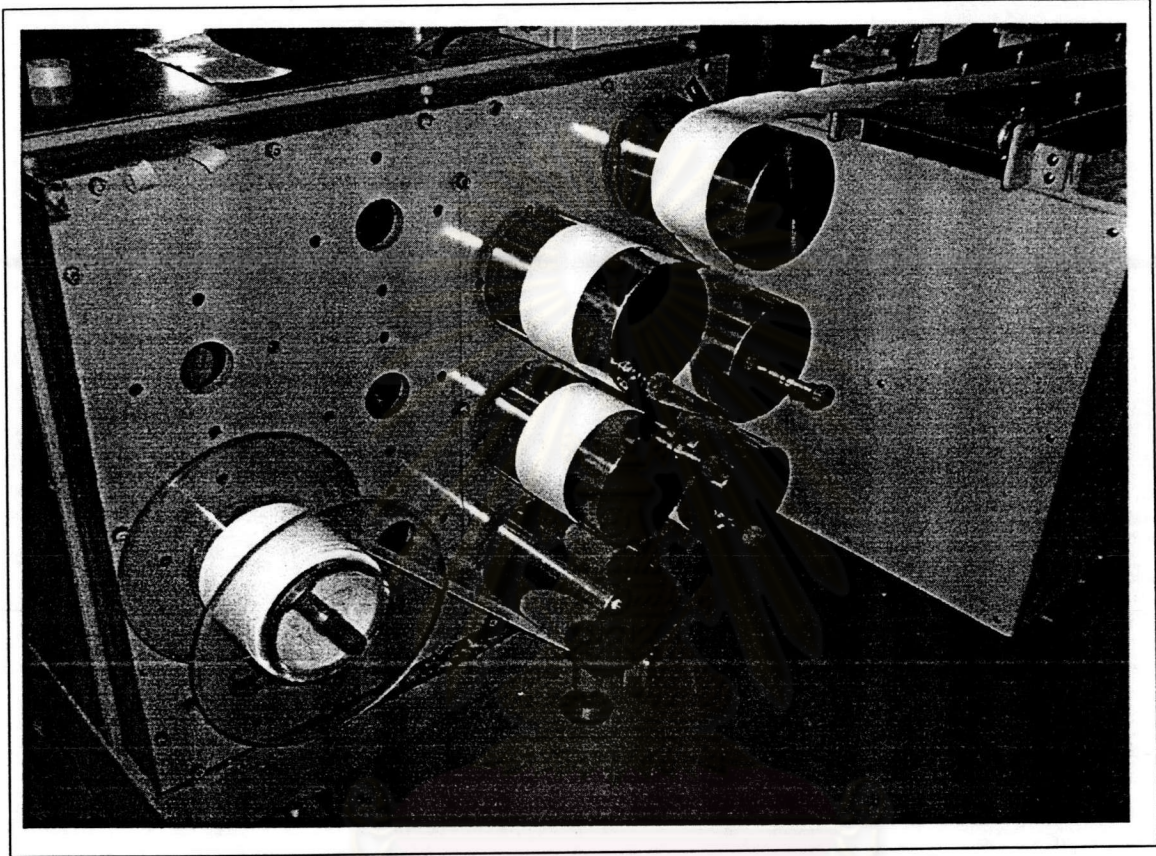




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Appendix 8

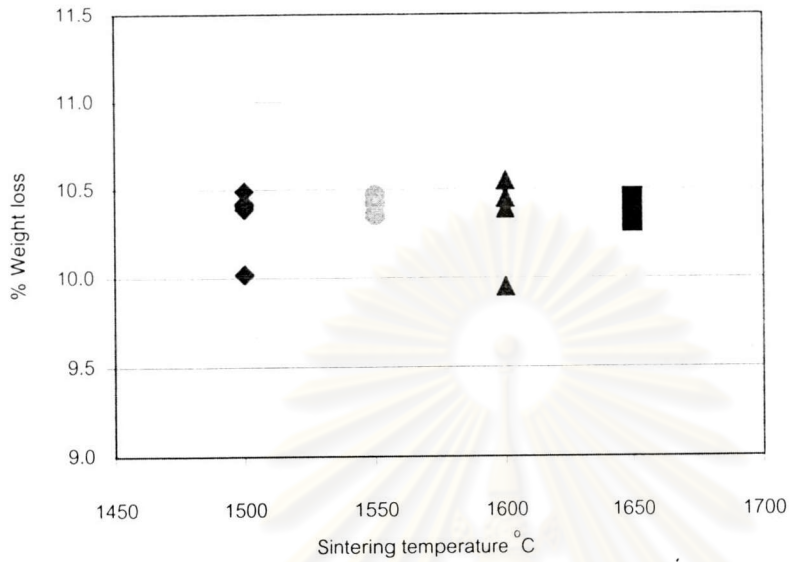
Average value of bulk density, relative density and water absorption data of tape specimens

1. Yuken binder			
Sintering temperature (°C)	Average bulk density (g/cm ³)	Average relative density (%)	Average water absorption (%)
1500	3.807	95.9	0.39
1550	3.831	96.5	0.20
1600	3.861	97.3	0.03
1650	3.852	97.0	0.11
2. Miyazaki binder			
Sintering temperature (°C)	Average bulk density (g/cm ³)	Average relative density (%)	Average water absorption (%)
1500	3.776	95.1	0.55
1550	3.850	97.0	0.17
1600	3.863	97.3	0.58
1650	3.887	97.9	0.03

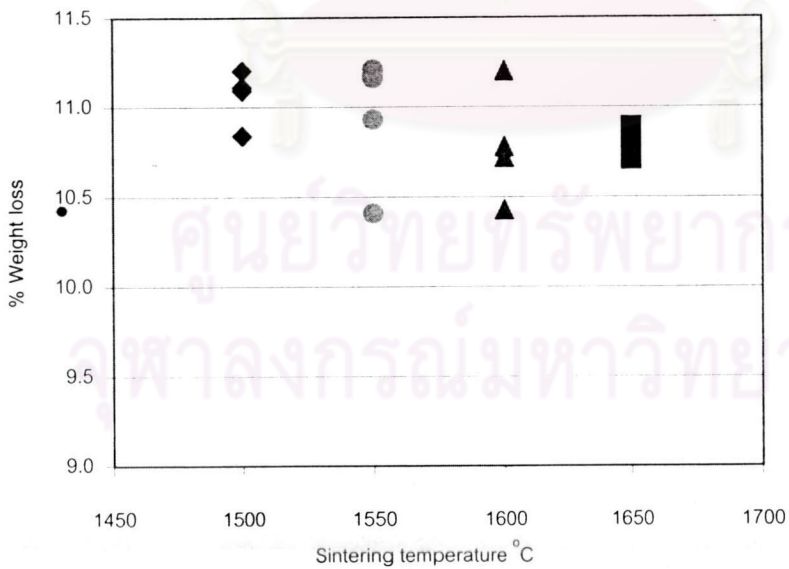
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Appendix 9

The relationship between weight loss and sintering temperature



% Weight loss of Yuken tape



% Weight loss of Miyazaki tape

Appendix 10

Shrinkage data of tape specimens after sintering

1.Yuken binder				
No.	Sintering temperature (°C).	Before sintering width (cm.)	After sintering width (cm.)	Shrinkage of width (%)
1	1500	3.03	2.54	16.03
2	1500	3.02	2.50	17.08
3	1500	2.98	2.51	15.77
4	1500	3.02	2.55	15.56
5	1500	3.04	2.56	15.79
	average	3.02	2.53	16.05
6	1550	3.04	2.55	16.12
7	1550	2.98	2.48	16.78
8	1550	3.02	2.54	15.89
9	1550	3.00	2.54	15.33
10	1550	3.00	2.53	15.83
	average	3.01	2.53	15.99
11	1600	3.05	2.51	17.70
12	1600	3.04	2.53	16.78
13	1600	3.00	2.52	16.00
14	1600	3.00	2.52	16.17
15	1600	3.05	2.55	16.39
	average	3.03	2.53	16.61
16	1650	3.04	2.50	17.76
17	1650	3.00	2.48	17.33
18	1650	3.00	2.49	17.00
19	1650	3.00	2.49	17.00
20	1650	3.00	2.52	16.00
	average	3.01	2.50	17.02
	Total average	3.02	2.52	16.42

2. Miyazaki binder				
No.	Sintering temperature (°C).	Before sintering width (cm.)	After sintering width (cm.)	Shrinkage of width (%)
1	1500	3.02	2.52	16.56
2	1500	3.02	2.54	15.89
3	1500	3.02	2.49	17.55
4	1500	3.03	2.54	16.17
5	1500	3.00	2.52	16.00
	average	3.02	2.52	16.43
6	1550	3.02	2.50	17.22
7	1550	3.02	2.53	16.23
8	1550	3.02	2.50	17.22
9	1550	2.98	2.48	16.78
10	1550	3.00	2.53	15.67
	average	3.01	2.51	16.62
11	1600	3.05	2.51	17.70
12	1600	3.02	2.50	17.22
13	1600	3.00	2.48	17.33
14	1600	2.98	2.48	16.78
15	1600	3.00	2.53	15.67
	average	3.01	2.50	16.94
16	1650	3.03	2.52	16.83
17	1650	3.02	2.52	16.56
18	1650	3.01	2.48	17.61
19	1650	3.04	2.52	17.11
20	1650	3.03	2.52	16.83
	average	3.03	2.51	16.99
	Total average	3.02	2.51	16.75

Appendix 11 A

Data of thin tape for mechanical strength measurement

1.Yuken binder							
No.	Sintering temperature (°C)	Suspended weight (g)	Saturated weight (g)	Dry weight (g)	Bulk density (g/cm ³)	Relative density (%)	Water absorption (%)
1	1550	0.8251	1.1091	1.1088	3.891	98.0	0.11
2	1550	0.8558	1.1482	1.1482	3.913	98.6	0.00
3	1550	0.8866	1.1862	1.1841	3.938	99.2	0.70
4	1550	0.8017	1.0782	1.0777	3.884	97.8	0.18
5	1550	0.8562	1.1489	1.1486	3.910	98.5	0.10
6	1550	0.8168	1.0988	1.0986	3.882	97.8	0.07
7	1550	0.8069	1.0825	1.0825	3.914	98.6	0.00
8	1550	0.8473	1.1366	1.1366	3.915	98.6	0.00
9	1550	0.8771	1.1772	1.1772	3.909	98.5	0.00
10	1550	0.8465	1.136	1.1355	3.909	98.5	0.17
11	1550	0.8843	1.1855	1.1853	3.921	98.8	0.07
12	1550	0.8318	1.1159	1.1156	3.913	98.6	0.11
Average					3.908	98.4	0.13
13	1600	0.8717	1.1791	1.1790	3.822	96.3	0.03
15	1600	0.8560	1.1469	1.1469	3.929	99.0	0.00
16	1600	0.8703	1.1664	1.1656	3.923	98.8	0.27
17	1600	0.8763	1.1735	1.1729	3.933	99.1	0.20
18	1600	0.8116	1.0872	1.0867	3.929	99.0	0.18
19	1600	0.8708	1.1679	1.1679	3.917	98.7	0.00
20	1600	0.8655	1.1634	1.1624	3.888	97.9	0.34
21	1600	0.8871	1.1875	1.1874	3.939	99.2	0.03
23	1600	0.8791	1.1817	1.1817	3.891	98.0	0.00
24	1600	0.8748	1.1739	1.1735	3.910	98.5	0.13
Average					3.908	98.4	0.12

2. Miyazaki binder							
No.	Sintering temperature (°C)	Suspended weight (g)	Saturated weight (g)	Dry weight (g)	Bulk density (g/cm ³)	Relative density (%)	Water absorption (%)
1	1550	0.7250	0.9752	0.9749	3.883	97.8	0.12
2	1550	0.7462	1.0024	1.0023	3.898	98.2	0.04
3	1550	0.7701	1.0333	1.0333	3.912	98.5	0.00
4	1550	0.7636	1.0255	1.0252	3.901	98.3	0.11
5	1550	0.7409	0.9944	0.9942	3.908	98.4	0.08
6	1550	0.7271	0.9772	0.9770	3.893	98.1	0.08
7	1550	0.7475	1.0068	1.0068	3.869	97.5	0.00
8	1550	0.7376	0.9901	0.9896	3.905	98.4	0.20
9	1550	0.7496	1.0069	1.0069	3.900	98.2	0.00
10	1550	0.7537	1.0107	1.0105	3.918	98.7	0.08
11	1550	0.7677	1.0305	1.0305	3.908	98.4	0.00
12	1550	0.7339	0.9866	0.9866	3.891	98.0	0.00
Average					3.899	98.2	0.06
13	1600	0.8533	1.1417	1.1414	3.944	99.3	0.10
14	1600	0.8870	1.1876	1.1876	3.937	99.2	0.00
15	1600	0.8457	1.1320	1.1318	3.939	99.2	0.07
16	1600	0.8695	1.1660	1.1660	3.919	98.7	0.00
17	1600	0.8672	1.1628	1.1628	3.920	98.7	0.00
18	1600	0.8128	1.0906	1.0900	3.910	98.5	0.22
19	1600	0.9075	1.2132	1.2132	3.955	99.6	0.00
20	1600	0.8566	1.1461	1.1461	3.945	99.4	0.00
21	1600	0.8954	1.1977	1.1976	3.948	99.4	0.03
22	1600	0.8754	1.1742	1.1739	3.915	98.6	0.10
23	1600	0.8424	1.1288	1.1281	3.925	98.9	0.24
24	1600	0.8730	1.1698	1.1696	3.927	98.9	0.07
Average					3.932	99.0	0.07

3. AISIN tape							
No.	Sintering temperature (°C)	Suspended weight (g)	Saturated weight (g)	Dry weight (g)	Bulk density (g/cm ³)	Relative density (%)	Water absorption (%)
Aisin1	Unknown	0.9018	1.2341	1.2341	3.701	93.2	0.00
Aisin2		0.9124	1.2474	1.2468	3.709	93.4	0.18
Aisin3		0.9112	1.2450	1.2448	3.716	93.6	0.06
Average					3.709	93.4	0.08



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Appendix 11 B

Data of thin tape for mechanical strength measurement (Controlled size and sintered in Japan)

1. Yuken binder							
No.	Sintering temperature (°C)	Suspended weight (g)	Saturated weight (g)	Dry weight (g)	Bulk density (g/cm ³)	Relative density (%)	Water absorption (%)
1/1.	1450	1.1313	1.5242	1.5167	3.847	96.9	1.91
1/2.	1450	1.0888	1.4669	1.4588	3.845	96.9	2.15
1/3.	1450	1.0830	1.4603	1.4521	3.835	96.6	2.17
Average					3.842	96.8	2.08
2/1.	1500	1.0898	1.4598	1.4596	3.931	99.0	0.05
2/2.	1500	1.1360	1.5207	1.5207	3.939	99.2	0.00
2/3.	1500	1.1357	1.5228	1.5221	3.918	98.7	0.18
Average					3.929	99.0	0.08
3/1.	1550	1.0858	1.4543	1.4540	3.932	99.0	0.08
3/2.	1550	1.1044	1.4770	1.4770	3.950	99.5	0.00
3/3.	1550	1.0959	1.4671	1.4671	3.938	99.2	0.00
Average					3.940	99.2	0.03

2. Miyazaki binder							
No.	Sintering temperature (°C)	Suspended weight (g)	Saturated weight (g)	Dry weight (g)	Bulk density (g/cm ³)	Relative density (%)	Water absorption (%)
4/1.	1450	1.0613	1.4305	1.4247	3.845	96.9	1.57
4/2.	1450	1.0923	1.4721	1.4644	3.842	96.8	2.03
4/3.	1450	1.0622	1.4339	1.4297	3.833	96.5	1.13
Average					3.840	96.7	1.58
5/1.	1500	1.0139	1.3588	1.3585	3.925	98.9	0.09
5/2.	1500	1.1342	1.5185	1.5185	3.938	99.2	0.00
5/3.	1500	1.1385	1.5277	1.5275	3.911	98.5	0.05
Average					3.925	98.9	0.05
6/1.	1550	1.1589	1.5515	1.5513	3.938	99.2	0.05
6/2.	1550	1.0851	1.453	1.4530	3.936	99.1	0.00
6/3.	1550	1.0889	1.4574	1.4572	3.941	99.3	0.05
Average					3.938	99.2	0.03

3. Otake tape							
No.	Sintering temperature (°C)	Suspended weight (g)	Saturated weight (g)	Dry weight (g)	Bulk density (g/cm ³)	Relative density (%)	Water absorption (%)
A	1450	0.8942	1.2093	1.2020	3.801	95.7	2.32
B	1450	0.7501	1.0218	1.0174	3.731	94.0	1.62
A	1500	0.8992	1.2058	1.2056	3.918	98.7	0.07
B	1500	0.7583	1.0289	1.0289	3.789	95.4	0.00
A	1550	0.8913	1.1936	1.1936	3.935	99.1	0.00
B	1550	0.7548	1.0218	1.0214	3.812	96.0	0.15

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Appendix 12 A

Data of mechanical strength of thin tape

1.Yuken binder				
No.	Sintering temperature (°C)	Load (N)	Thickness (mm.)	Mechanical strength (MPa.)
1/2.	1550	25.24	0.395	419
1/4.	1550	31.50	0.375	580
1/5.	1550	17.78	0.392	300
1/6.	1550	26.07	0.374	483
1/7.	1550	17.62	0.373	328
1/8.	1550	30.28	0.390	516
Average		24.75	0.383	438
STDEV		5.96	0.01	109
1/13.	1600	25.74	0.378	467
1/15.	1600	30.98	0.377	565
1/16.	1600	22.44	0.379	405
1/17.	1600	24.35	0.394	406
1/18.	1600	15.77	0.385	276
1/19.	1600	27.36	0.400	443
average		24.44	0.386	427
STDEV		5.14	0.01	94

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2. Miyazaki binder				
No.	Sintering temperature (°C)	Load (N)	Thickness (mm.)	Mechanical strength (MPa.)
2/2.	1550	20.49	0.334	476
2/3.	1550	20.23	0.338	459
2/4.	1550	27.09	0.335	625
2/5.	1550	14.44	0.352	302
2/7.	1550	15.91	0.332	374
Average		19.63	0.338	447
STDEV		4.94	0.01	122
2/13.	1600	33.81	0.383	597
2/14.	1600	21.16	0.387	366
2/15.	1600	25.48	0.383	450
2/16.	1600	19.28	0.388	332
2/18.	1600	26.52	0.384	466
2/19.	1600	20.50	0.379	370
Average		24.46	0.384	430
STDEV		5.41	0.00	97

3. AISIN tape			
No.	Load (N)	Thickness (mm.)	Mechanical strength (MPa.)
2/1.	21.45	0.320	543
2/2.	14.43	0.332	339
2/3.	19.53	0.328	470
2/4.	21.59	0.328	520
2/5.	18.17	0.321	457
2/7.	27.00	0.336	619
Average			491
STDEV			86

Appendix 12 B

Data of Mechanical strength of thin tape (Controlled size and sintered in Japan)

1.Yuken binder				
No.	Sintering temperature (°C)	Load (N)	Thickness (mm.)	Mechanical strength (MPa.)
1/1.	1450	40.95	0.362	809
1/2.	1450	32.23	0.357	655
1/3.	1450	28.33	0.344	620
1/4.	1450	32.20	0.354	665
1/5.	1450	23.79	0.364	465
1/6.	1450	28.75	0.362	568
1/7.	1450	31.39	0.363	617
1/8.	1450	41.37	0.360	827
1/9.	1450	31.06	0.373	578
1/10.	1450	39.48	0.372	739
1/11.	1450	32.67	0.389	559
1/12.	1450	23.03	0.348	493
Average				633
STDEV				114
2/1.	1500	44.71	0.351	940
2/2.	1500	30.88	0.365	600
2/3.	1500	22.52	0.363	443
2/4.	1500	32.90	0.352	688
2/5.	1500	39.65	0.370	750
2/6.	1500	37.14	0.369	706
2/7.	1500	36.05	0.371	678
2/8.	1500	33.37	0.363	656
2/9.	1500	33.47	0.348	716
2/10.	1500	40.13	0.348	858
2/11.	1500	44.38	0.349	944
2/12.	1500	27.77	0.346	601
Average				715
STDEV				145

1.Yuken binder				
No.	Sintering temperature (°C)	Load (N)	Thickness (mm.)	Mechanical strength (MPa.)
3/1.	1550	37.65	0.351	792
3/2.	1550	36.73	0.352	768
3/3.	1550	23.89	0.349	508
3/4.	1550	24.32	0.347	523
3/5.	1550	35.75	0.352	747
3/6.	1550	27.79	0.344	608
3/7.	1550	33.81	0.350	715
3/8.	1550	27.35	0.361	543
3/9.	1550	29.27	0.349	622
3/10.	1550	23.85	0.345	519
3/11.	1550	28.58	0.346	618
3/12.	1550	35.79	0.345	779
Average				645
STDEV				110

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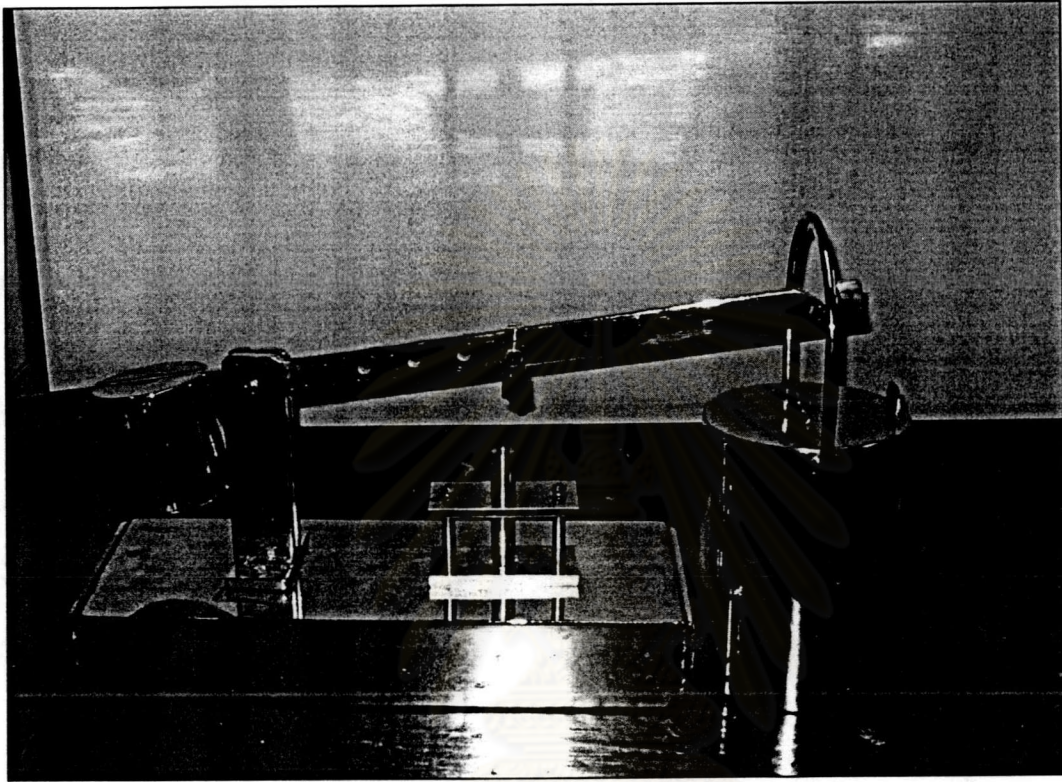
2. Miyazaki binder				
No.	Sintering temperature (°C)	Load (N)	Thickness (mm.)	Mechanical strength (MPa.)
4/1.	1450	49.31	0.351	1037
4/2.	1450	49.23	0.353	1023
4/3.	1450	30.28	0.352	633
4/4.	1450	32.54	0.355	669
4/5.	1450	49.54	0.348	1059
4/6.	1450	35.96	0.350	760
4/7.	1450	41.87	0.327	1014
4/8.	1450	31.29	0.331	740
4/9.	1450	31.29	0.334	726
4/10.	1450	37.49	0.331	779
4/11.	1450	46.40	0.353	964
4/12.	1450	31.10	0.320	787
Average				849
STDEV				158
5/1.	1500	29.56	0.336	678
5/2.	1500	35.70	0.370	675
5/3.	1500	39.11	0.369	744
5/4.	1500	55.52	0.353	1154
5/5.	1500	57.93	0.385	1012
5/6.	1500	32.51	0.373	605
5/7.	1500	32.30	0.362	638
5/8.	1500	26.51	0.364	518
5/9.	1500	56.82	0.360	1135
5/10.	1500	39.27	0.367	755
5/11.	1500	49.86	0.338	1130
5/12.	1500	48.32	0.339	1089
Average				845
STDEV				239

2. Miyazaki binder				
No.	Sintering temperature (°C)	Load (N)	Thickness (mm.)	Mechanical strength (MPa.)
6/1.	1550	35.06	0.372	656
6/2.	1550	46.77	0.351	983
6/3.	1550	39.44	0.352	825
6/4.	1550	39.11	0.348	836
6/5.	1550	38.66	0.350	817
6/6.	1550	39.54	0.376	724
6/7.	1550	42.66	0.373	794
6/8.	1550	32.54	0.349	692
6/9.	1550	50.80	0.344	1112
6/10.	1550	47.34	0.346	1024
6/11.	1550	43.01	0.346	931
6/12.	1550	36.62	0.348	783
Average				848
STDEV				138

3. Otake tape				
No.	Sintering temperature (°C)	Load (N)	Thickness (mm.)	Mechanical strength (MPa.)
A	1450	38.67	0.285	1233.22
B	1450	18.84	0.260	721.77
A	1500	38.52	0.276	1309.54
B	1500	21.42	0.264	795.94
A	1550	51.83	0.293	1563.75
B	1550	17.33	0.241	772.63

Appendix 13

Photograph of the equipment of mechanical strength measurement of thin tape



Photograph of the equipment for mechanical strength measurement of thin tape

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Appendix 14

Data of the efficiency in sintering of thin tape

Sintering temperature (°C)	Bulk density of pressed specimens (g/cm ³)	Bulk density of tape sintered by C.U.		Bulk density of tape sintered by Otake			
		Yuken	Miyazaki	Yuken		Miyazaki	
				*C.U.	*Otake	*C.U.	*Otake
1500	3.81	3.80	3.78	3.94	3.95	3.95	3.97
1550	3.88	3.83	3.85	–	–	3.95	–
1600	3.93	3.86	3.86	3.96	3.97	3.96	3.97
1650	3.85	3.85	3.89	–	–	–	–

* measured by



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Biography

Mr. Pao Na Nakorn was born on the 6th of May 1978 in Bangkok, Thailand. He received a Dip. degree in Analytical chemistry from Analytical Chemistry Training, Chulalongkorn University in 1998 and B.Sc. degree in ceramic technology from Faculty of Science, Chulalongkorn University in 2001. He continued a further study in Master degree in ceramic technology and graduated in March 2004.



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