哈爾濱工業大學
HARBIN INSTITUTE OF TECHNOLOGY

Thermal evolution and crystallization behavior of K/Cs activated aluminosilicate geopolymer

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材料科学与工程学院
特种陶瓷研究所

Institute for Advanced Ceramics

School of Mater Sci & Eng

哈爾濱工業大學
HARBIN INSTITUTE OF TECHNOLOGY

May, 2011

材料科学与工程学院

School of Mater Sci & Eng

——Introduction

Staff: 260

Professor: 83

Associate professor: 67

Student: 1880

Undergraduate student: 990

Master student: 520

Ph. D student: 370

Sub-divisions of School of Mater Sci & Eng

- Department of Materials Science
- Department of Materials Engineering
- Department of Welding Science and Engineering
- Department of Materials Physics and Chemistry
- Department of Optoelectronic Materials & Quantum Devices
- State Key Laboratory of Advanced Welding Production Technology
- National Key Laboratory of Precision Hot Processing of Metals
- National Key Laboratory of Space Materials and Environment
- Analysis and Measurement Center
- Experimental Center for Education

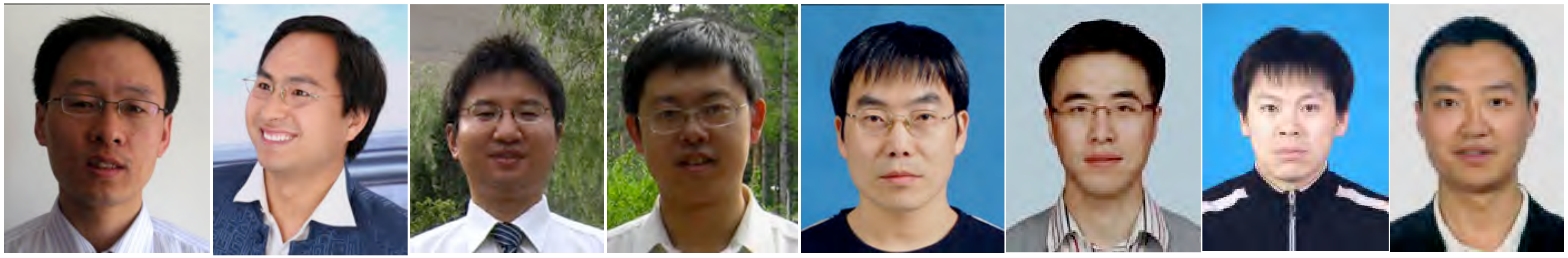
Institute for Advanced Ceramics

2. Team members

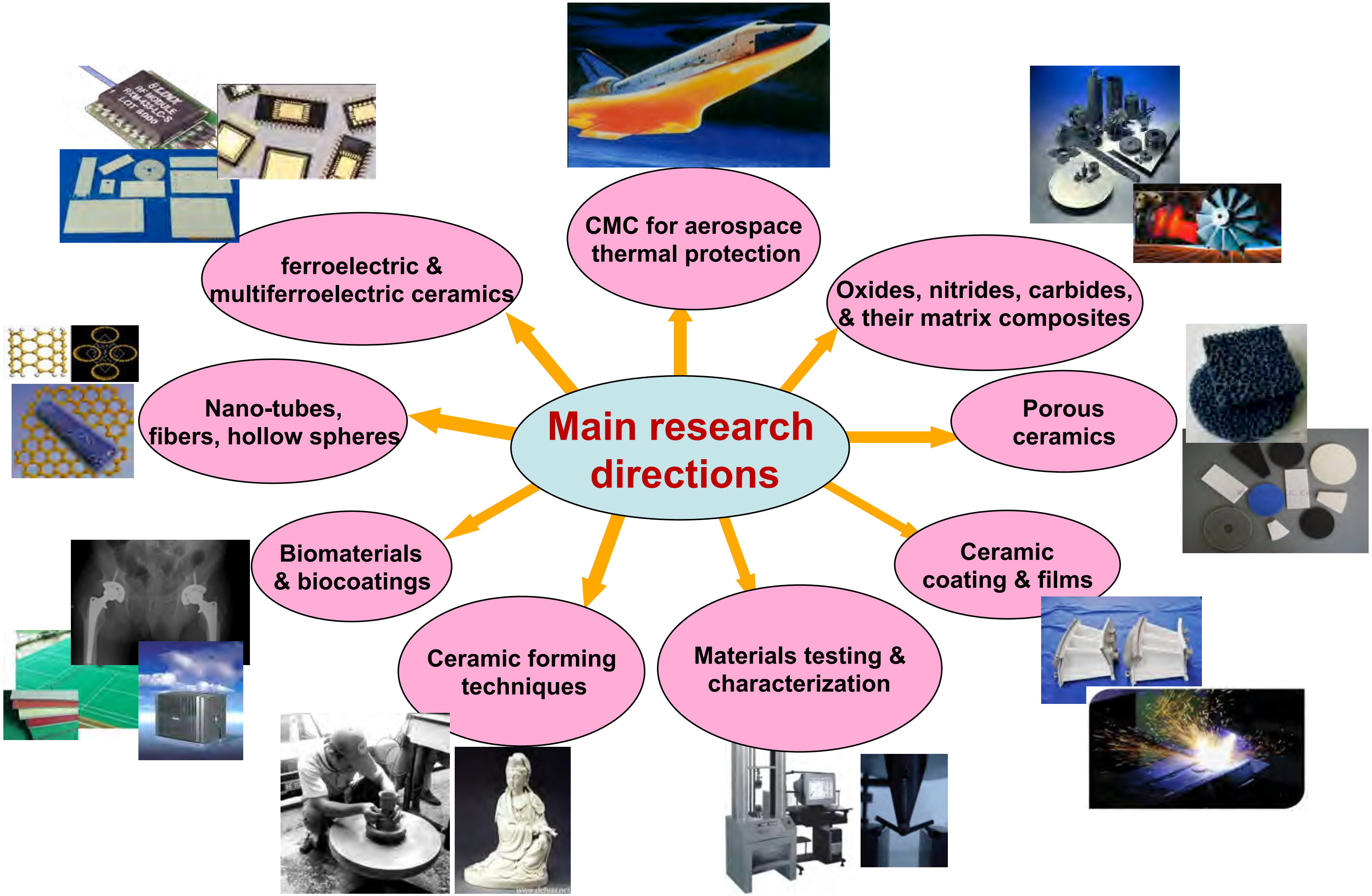
As one of the largest research groups in HIT, IAC has 17 full-time faculty members including 6 full prof., 6 associate prof. and 5 lecturers, as well as 4 technical staffs.

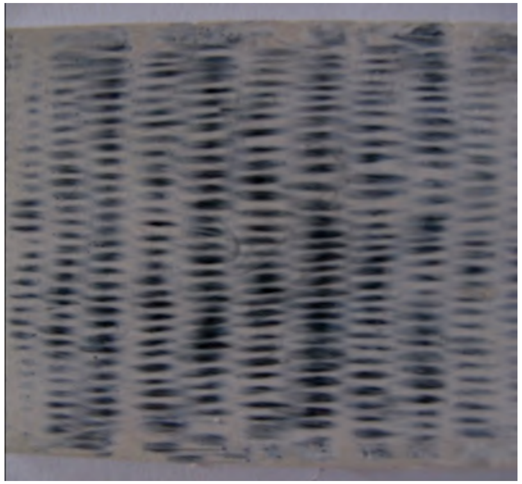
- 1 Academician of Chinese Academy of Engineering (CAE)
- 1 Changjiang Scholars
- 2 Alexander von Humboldt Fellows

over 60 graduate students for MS & PhD. and 5 Postdoctors



Research directions



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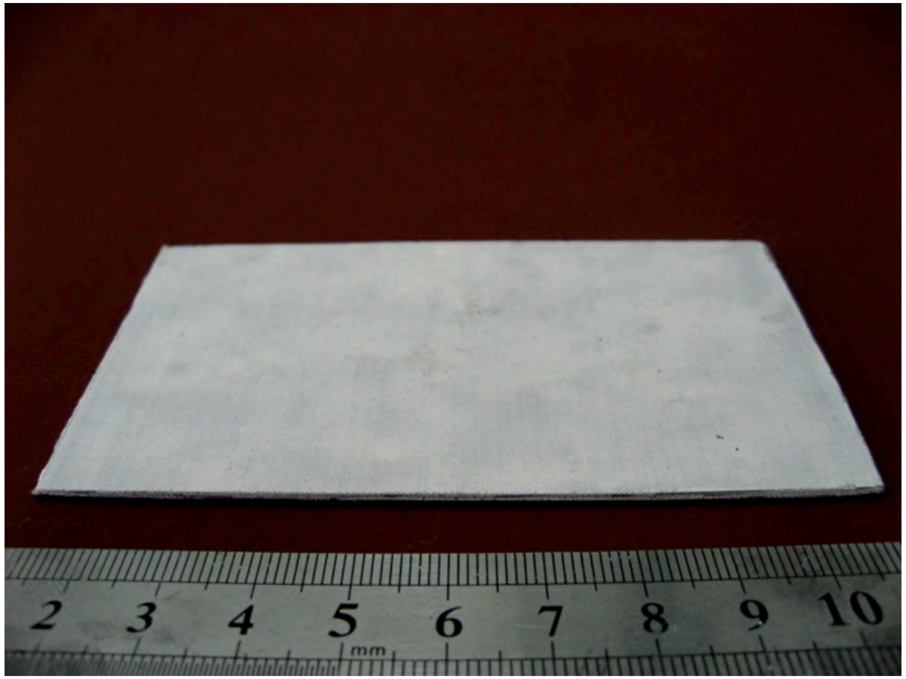
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Outlines

1. **Thermal evolution behavior of KGP**

2.Effect of Cesium substitution on the thermal evolution of KGP

3.Summary

1. Thermal evolution behavior of KGP

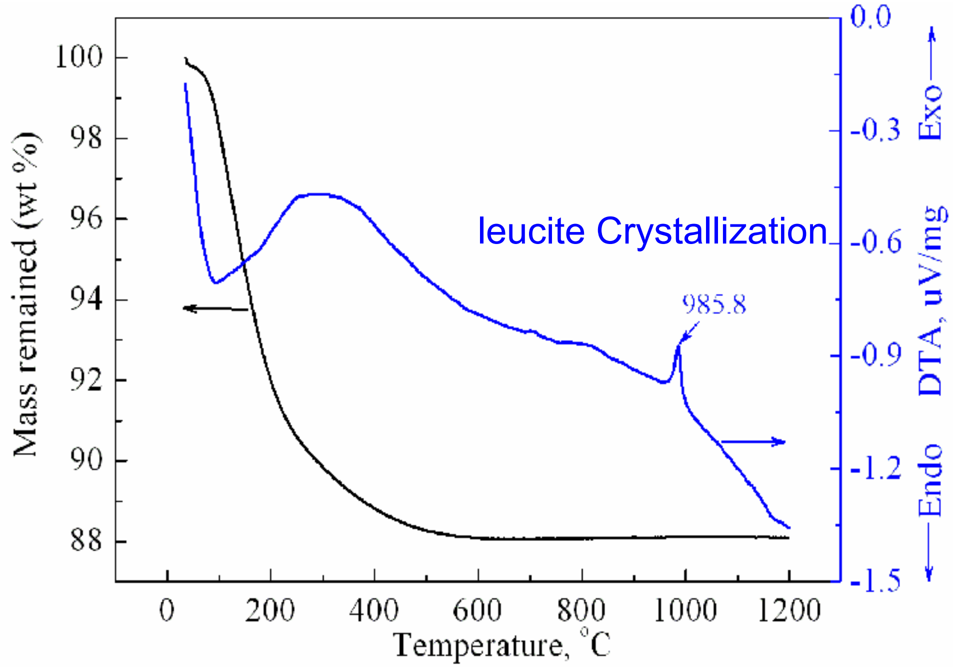

Fig. 1 TG/DTA of KGP

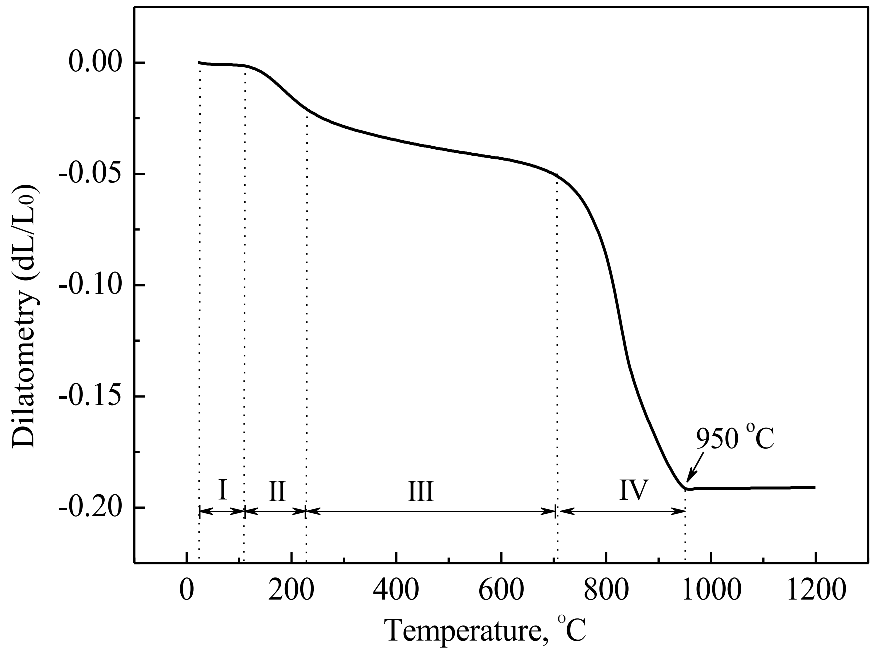

Fig.2 Thermal shrinkage of KGP

---- Peigang He, Dechang Jia. *Ceramics International*. 2011, 37 (1), 59-63.

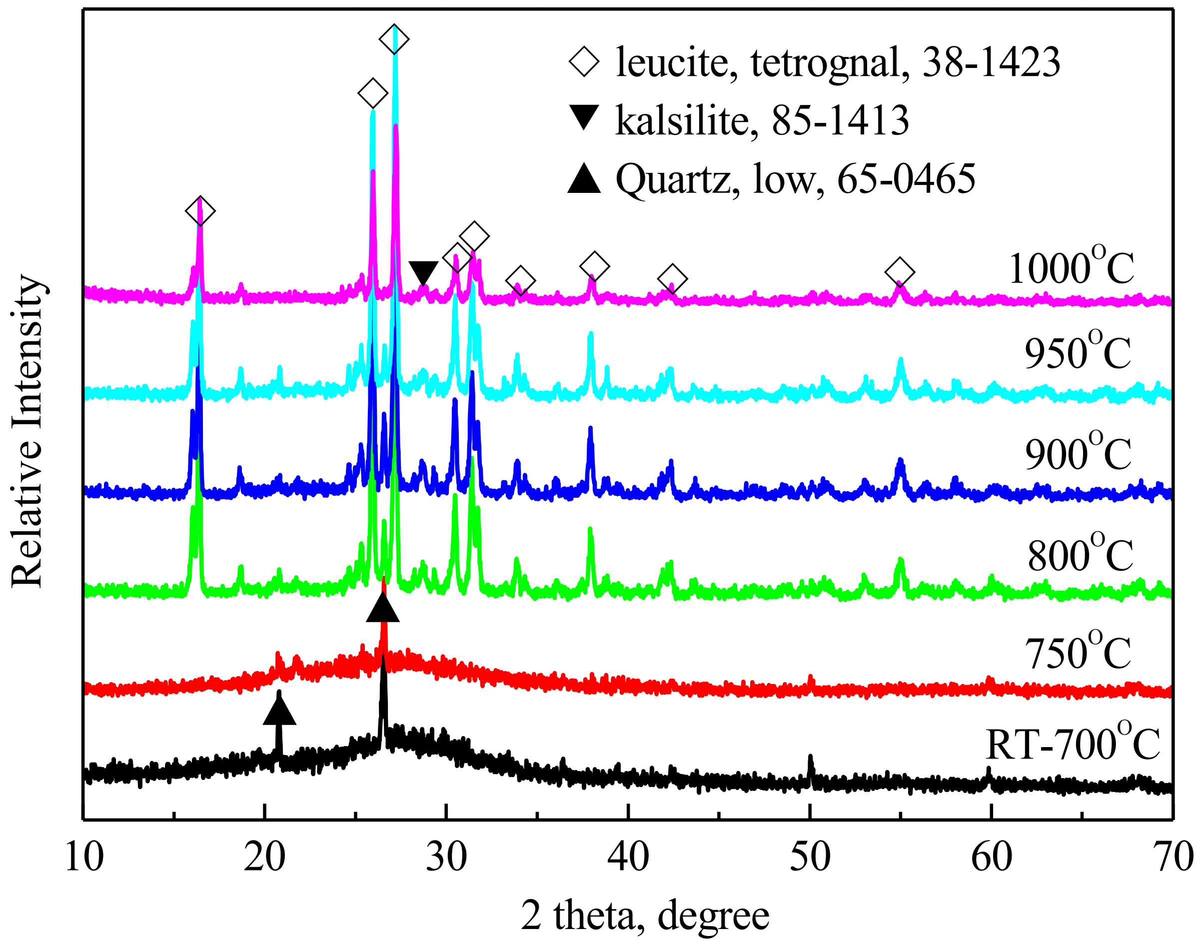

Fig. 3 XRD pattern of KGP soaked at different temperature for 2h

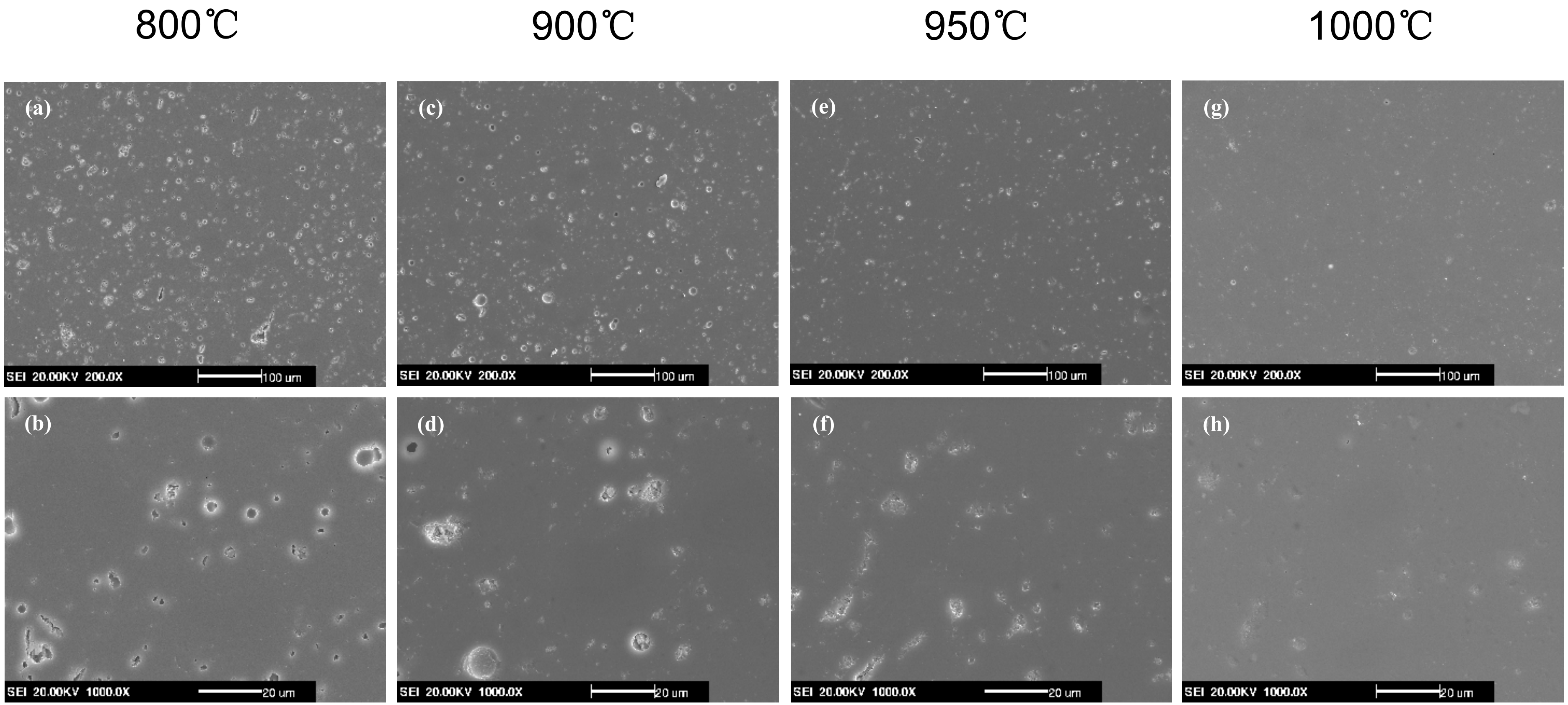

Fig. 4 Microstructure of KGP soaked at different temperature for 2h.
(a), (b) 800℃; (c), (d) 900℃; (e), (f) 950℃; (g), (h) 1000℃.

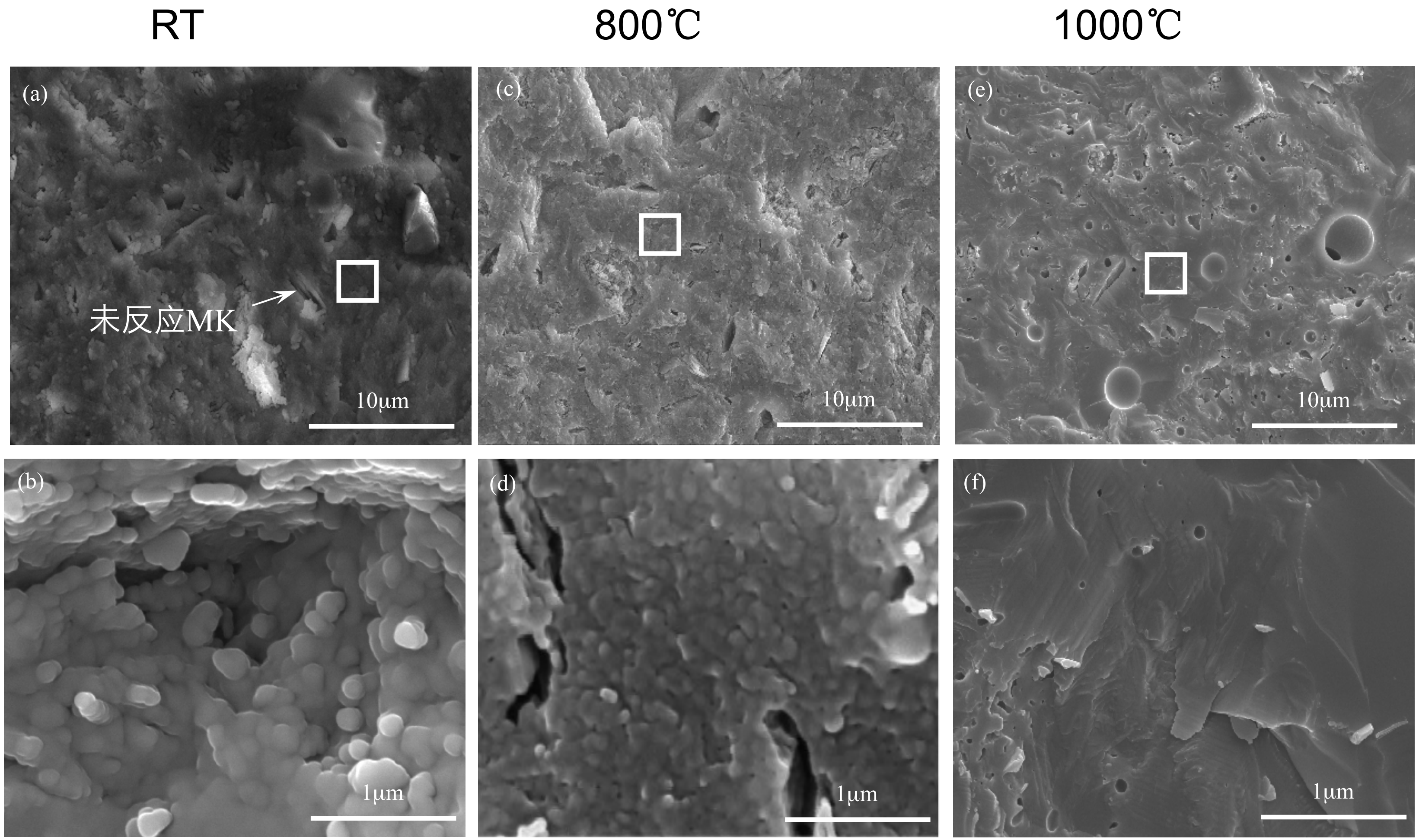

Fig. 5 Fractographs of KGP soaked at different temperature for 2h
(a), (b) RT; (c), (d) 800℃; (e), (f) 1000℃

---- Peigang He, Dechang Jia. *Ceramics International*. 2011, 37 (1), 59-63.

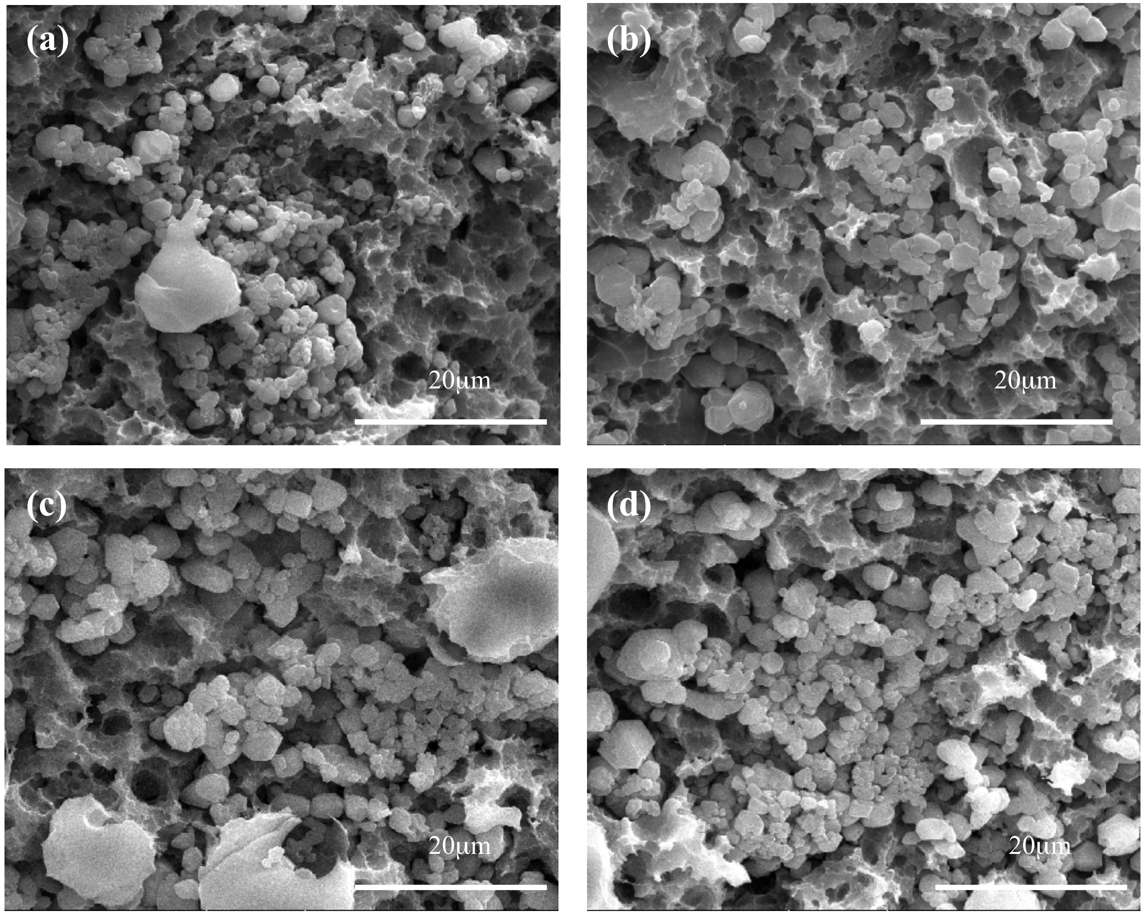

Fig. 6 Fracture surface morphology of the KGP treated at different temperature and etched in 3wt.% HF at room temperature for 30s: (a) 800℃, (b) 900℃, (c) 950℃, (d) 1000℃

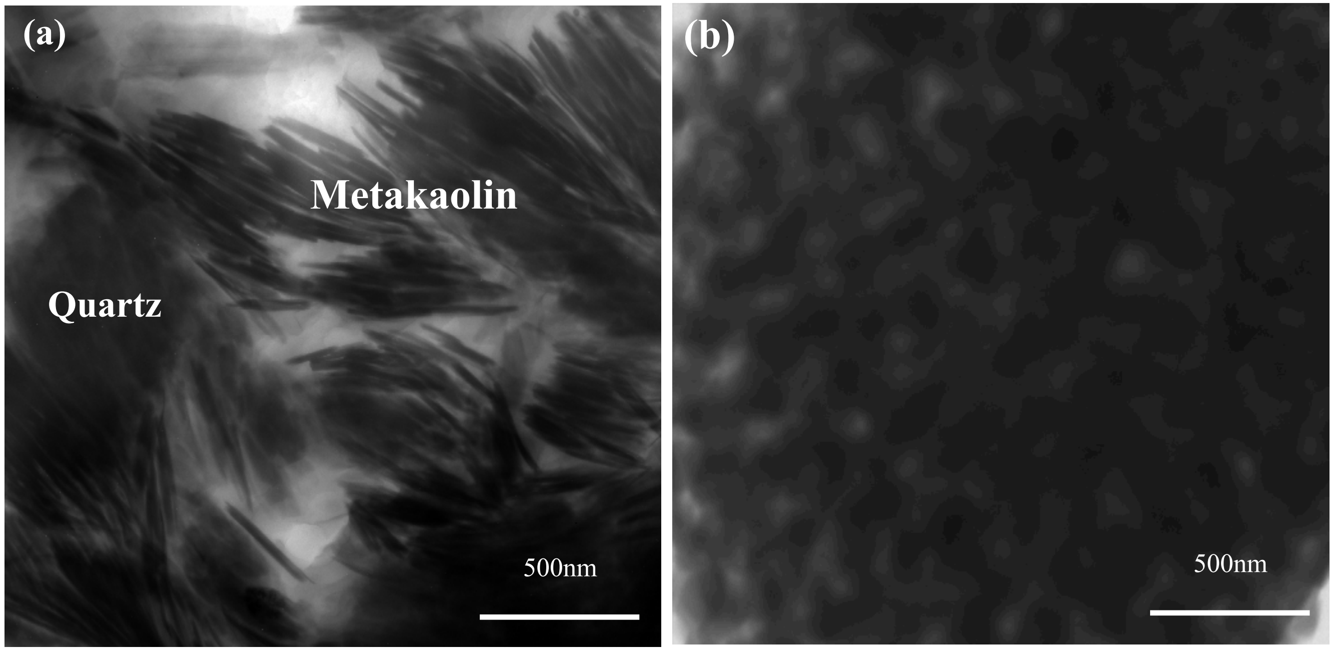

Fig. 7 TEM images of: metakaolin (a) and the resulted geopolymer (b)

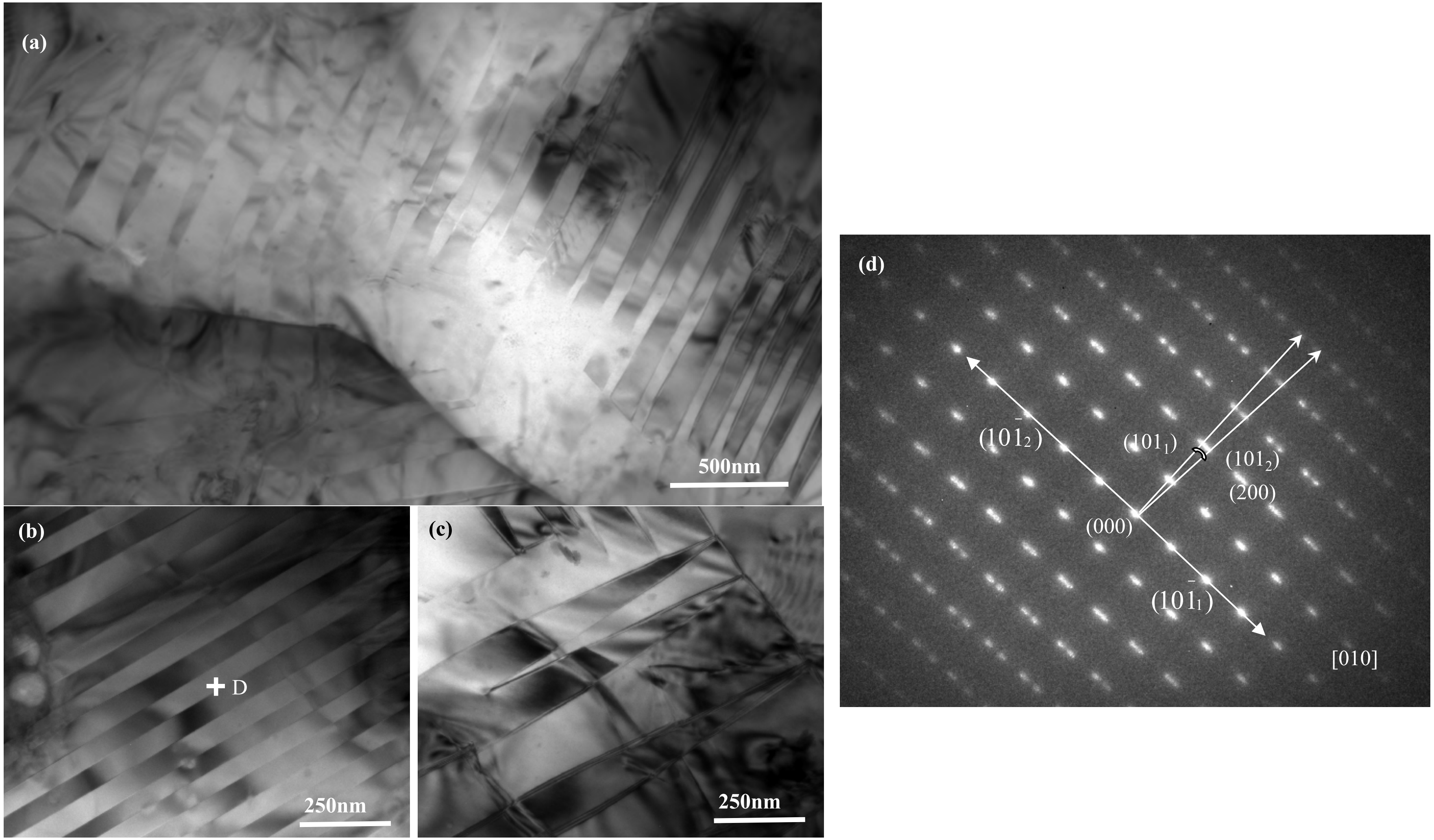

Fig. 8 TEM observation of geopolymer treated at 1000℃ for 2h:
(a) low magnification, (b) and (c) high magnification, (d) SAD pattern of area D

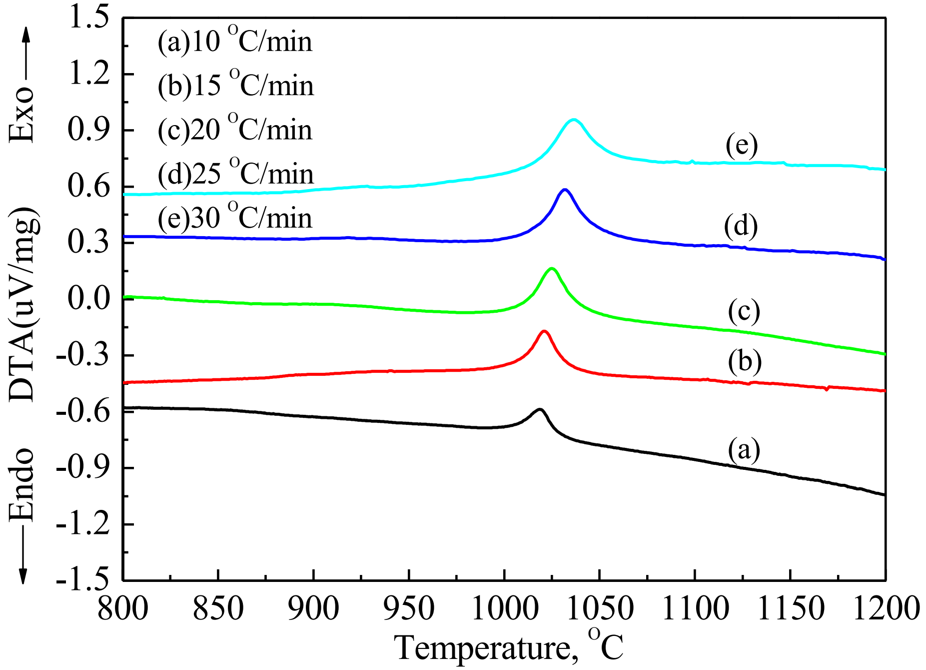

Fig.9 DTA of KGP using different heating rates

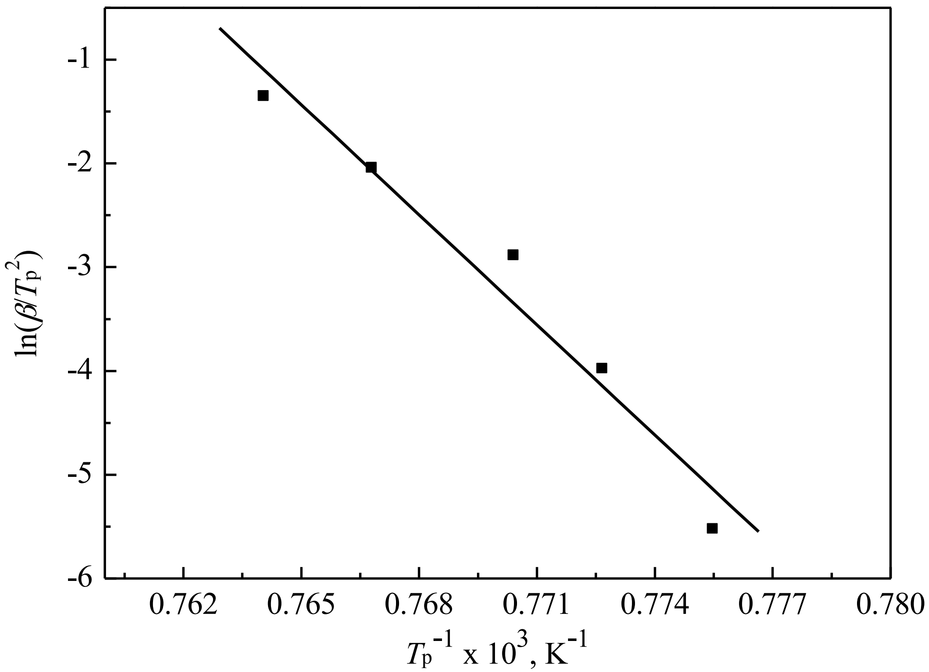

Fig. 10 Kissinger plot of $\ln(\beta/T_p^2)$ vs. T_p^{-1}

Kissinger method: $$\ln\left(\frac{T_p^{\ 2}}{\beta}\right) = -\frac{E_c}{RT_p} + \ln\frac{E}{R\upsilon}$$

Augis-Bennett: $$n = \frac{2.5RT_p^2}{\Delta TE}$$

n=3.89, Ea=455.9 kJ/mol

Three dimensional crystal growth mechanism

---- Peigang He, Dechang Jia. *Ceramics International*. 2011, 37 (1), 59-63.

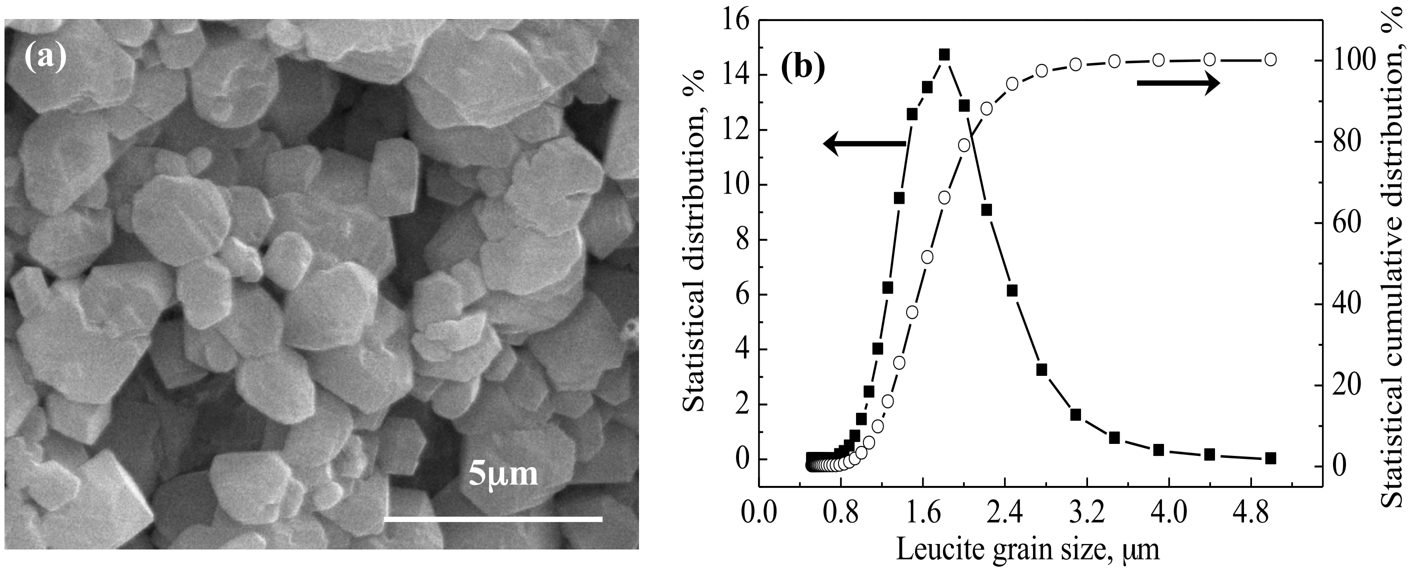

Fig. 11 SEM micrographs of leucite grains (a) and size distribution (b)

Table 1 Mechanical properties of the geopolymer and the resulted leucite ceramic

Specimen	Flexural strength (MPa)	Young's modulus (GPa)	Fracture toughness ($MPa \cdot m^{1/2}$)	Vickers hardness (GPa)
KGP	12.3±1.2	10.3±1.2	0.2±0.04	0.68±0.04
Leucite ceramic	70.0±6.8	65.0±6.3	1.3±0.16	7.39±0.24

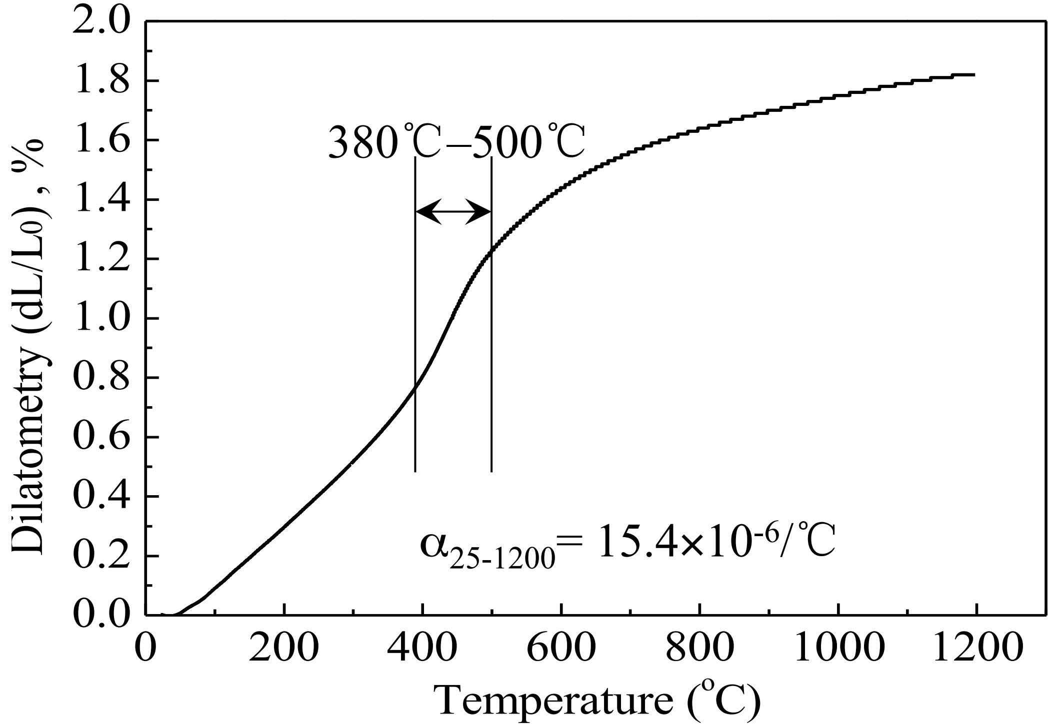

Fig.12 Thermal expansion of the ceramics derived from KGP

2. Effect of Cesium substitution on the thermal evolution of KGP

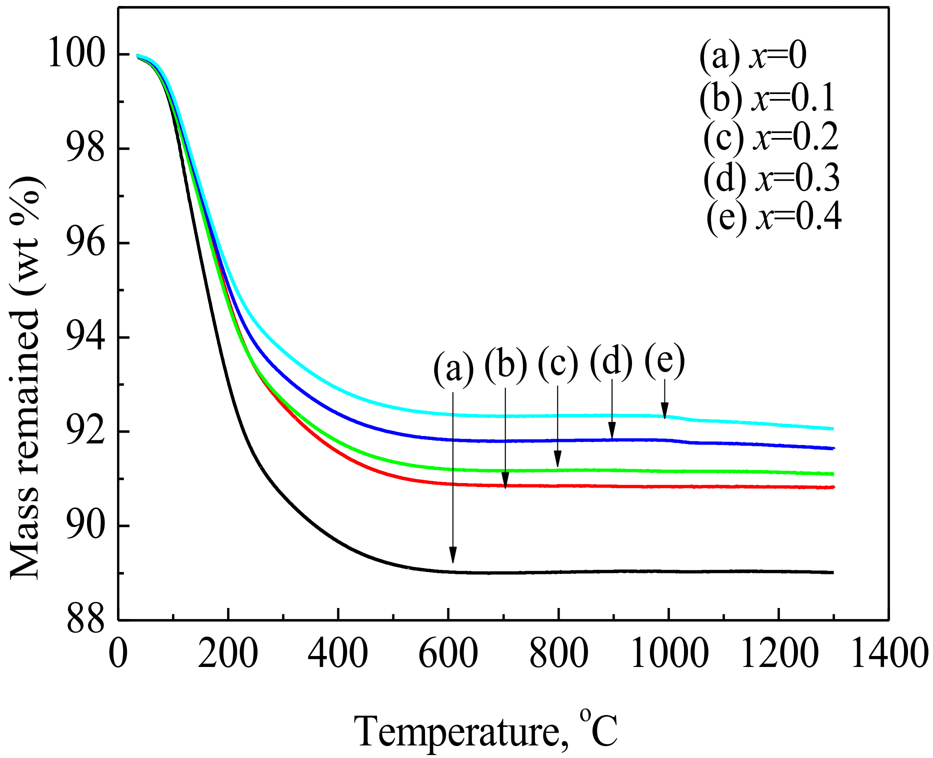

Fig. 13 Weight loss of $Cs_xK_{(1-x)}GP$

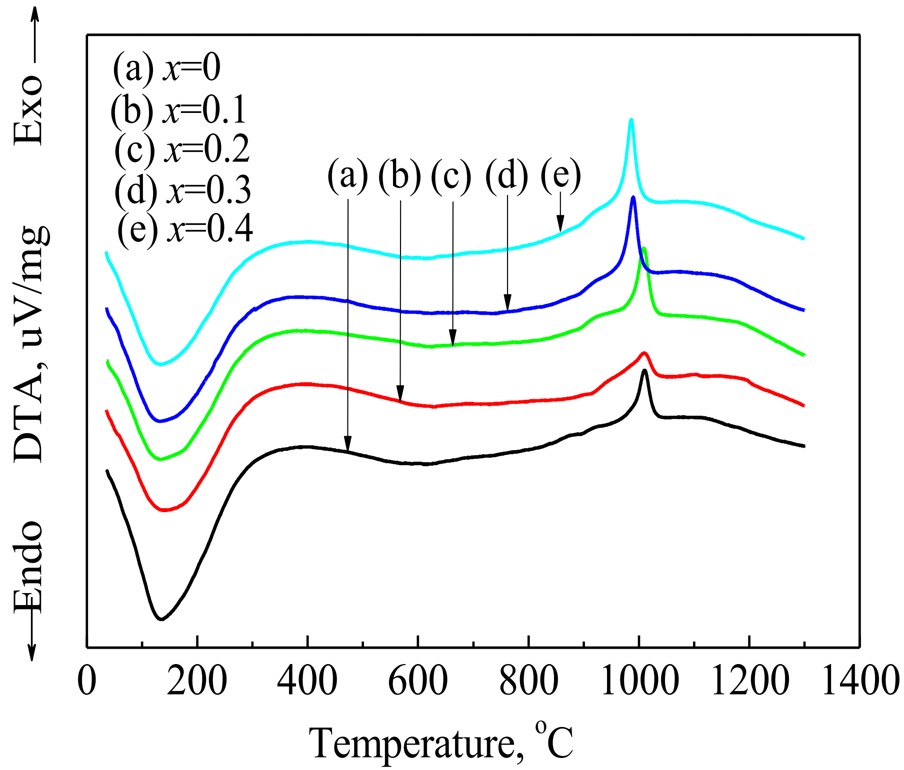

Fig. 14 DTA of $Cs_xK_{(1-x)}GP$

---- Peigang He, Dechang Jia. *Ceramics International*. 2010, 36 (8), 2395-2400.

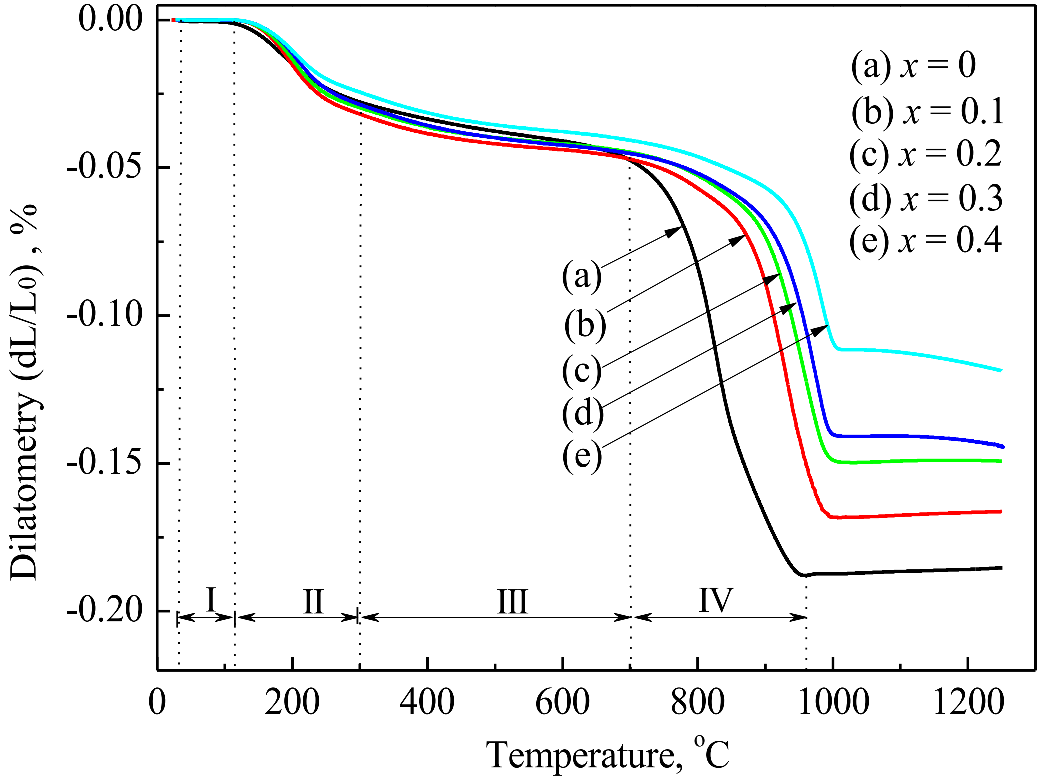

Fig.15 Thermal shrinkage of $Cs_xK_{(1-x)}GP$

---- Peigang He, Dechang Jia. *Ceramics International*. 2010, 36 (8), 2395-2400.

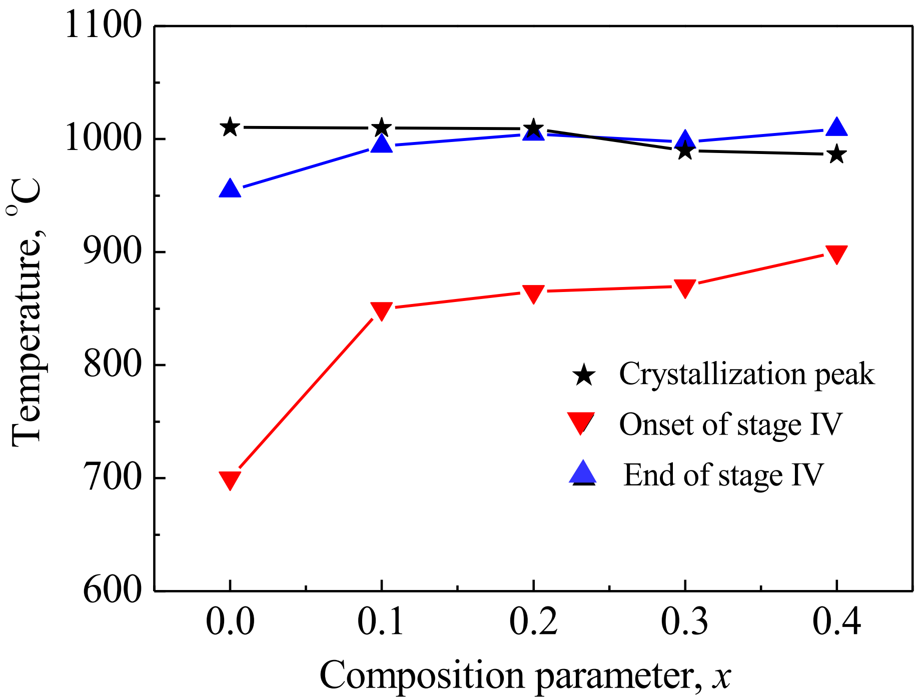

Fig. 16 Onset and end temperature of stage IV and crystallization temperature of $Cs_xK_{(1-x)}GP$

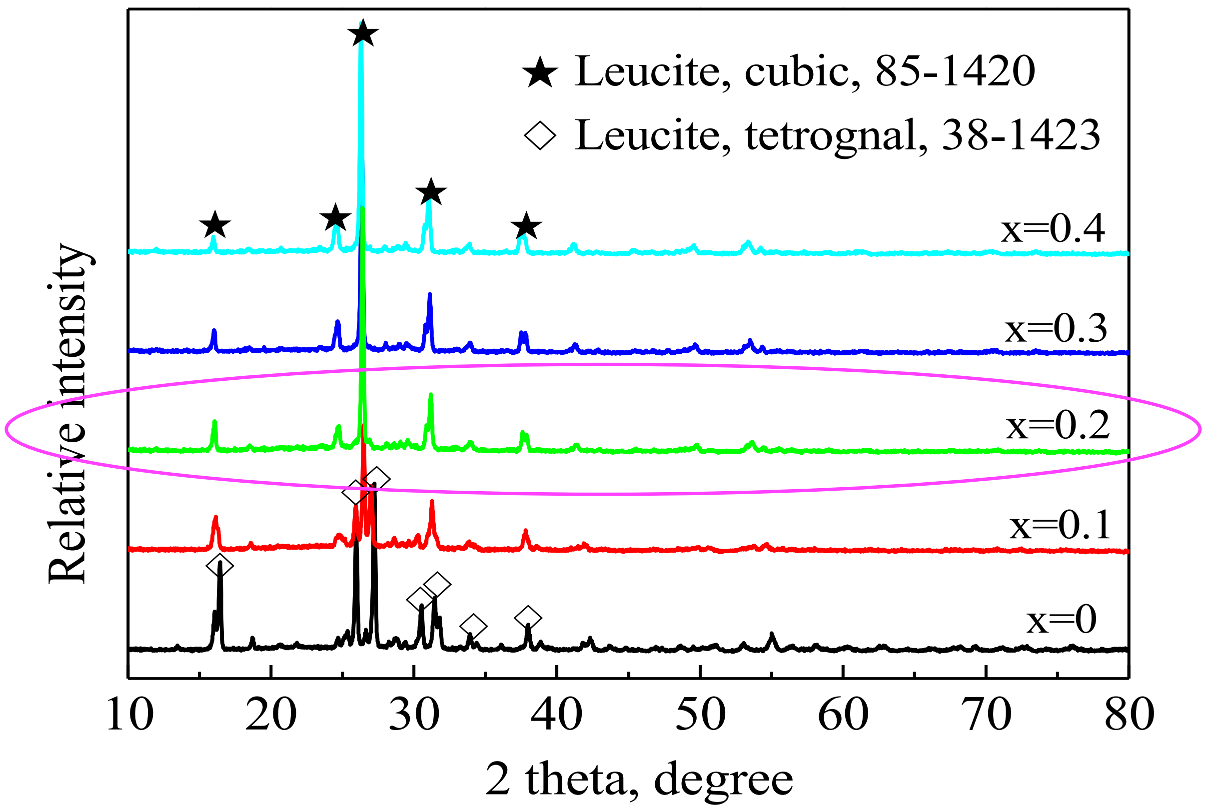

Fig. 17 XRD patterns of leucite ceramics derived from $Cs_xK_{(1-x)}$GP soaked at 1200℃/2h

---- Peigang He, Dechang Jia. *Ceramics International*. 2010, 36 (8), 2395-2400.

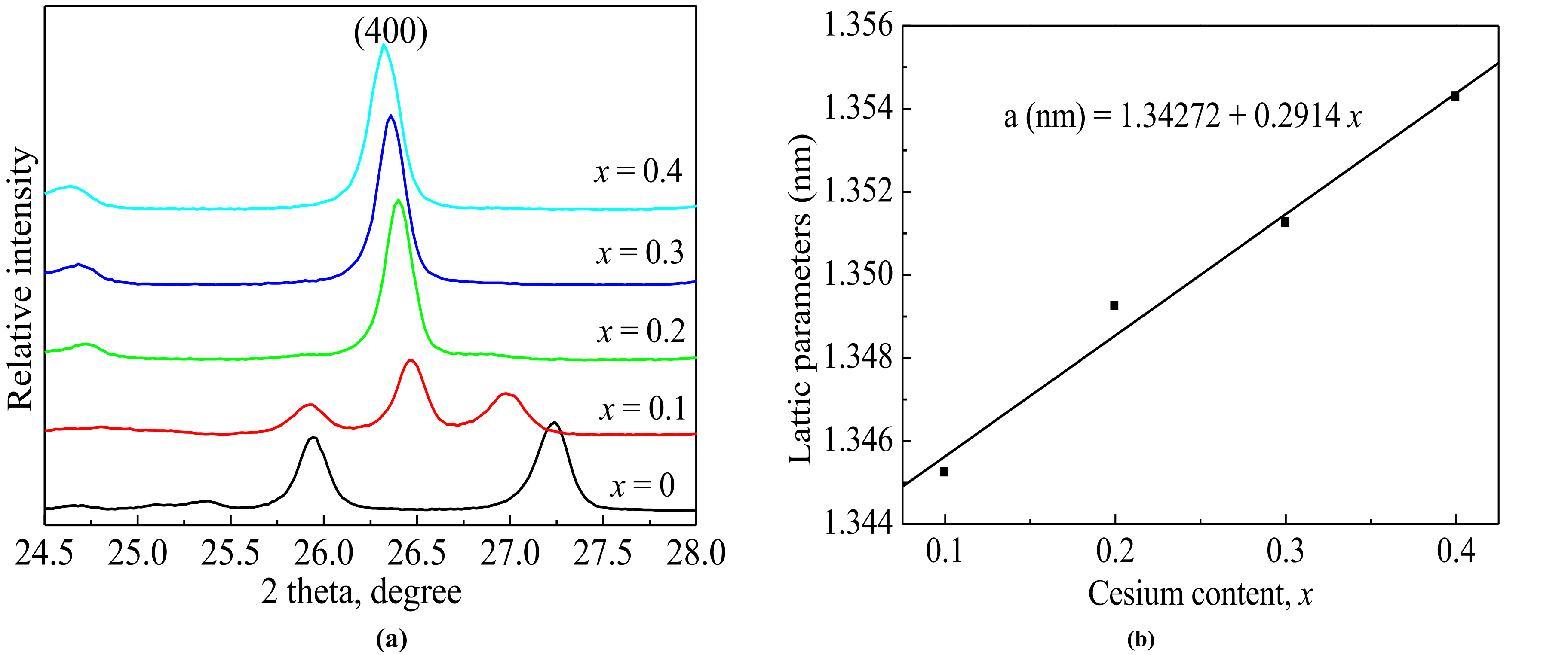

Fig. 18 Slow step-scan XRD patterns in a 2θ range of 24.5~28° (a) and the calculated lattice parameters (b) of leucite

---- Peigang He, Dechang Jia. *Ceramics International*. 2010, 36 (8), 2395-2400.

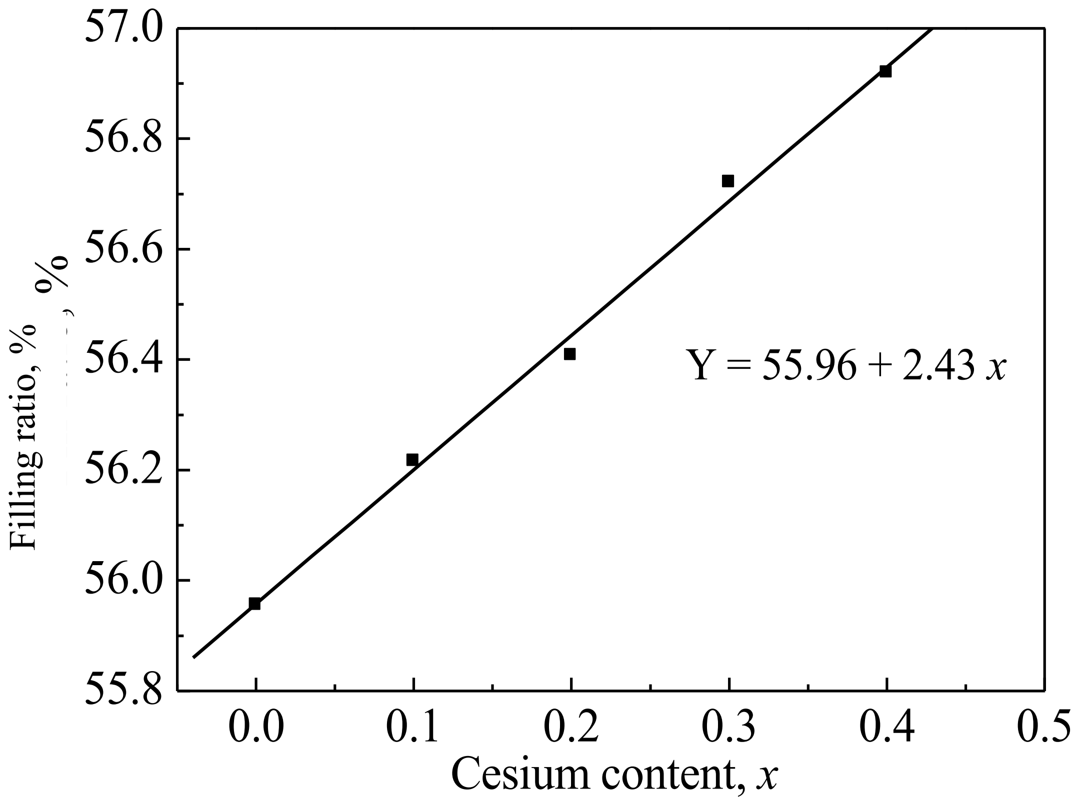

Fig. 19 The filling ratio of leucite crystal cell derived from $Cs_xK_{(1-x)}GP$

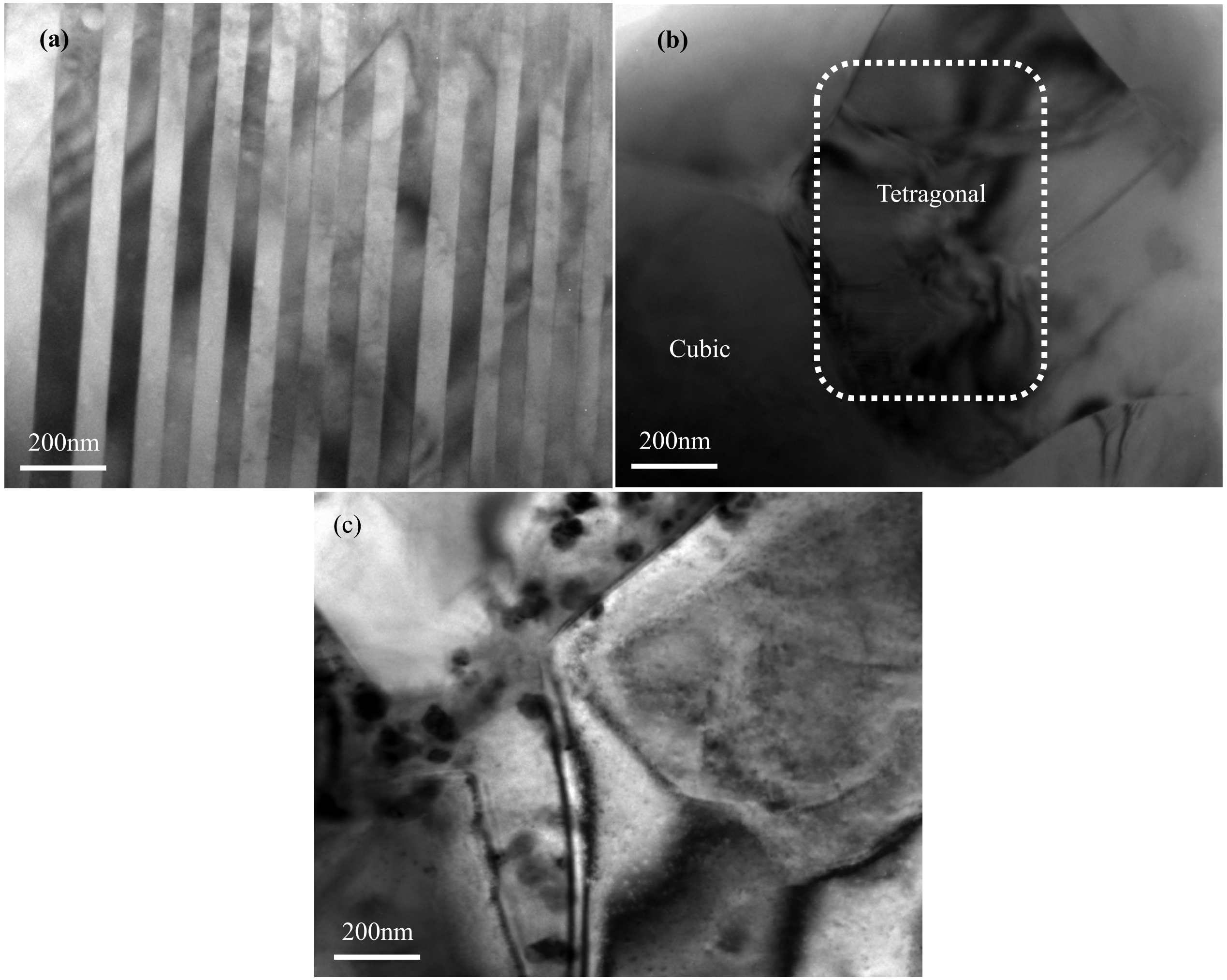

Fig. 20 TEM micrographs of the leucite ceramics derived from $Cs_xK_{(1-x)}$GP: (a) x=0, (b) x=0.1, (c) x=0.2.

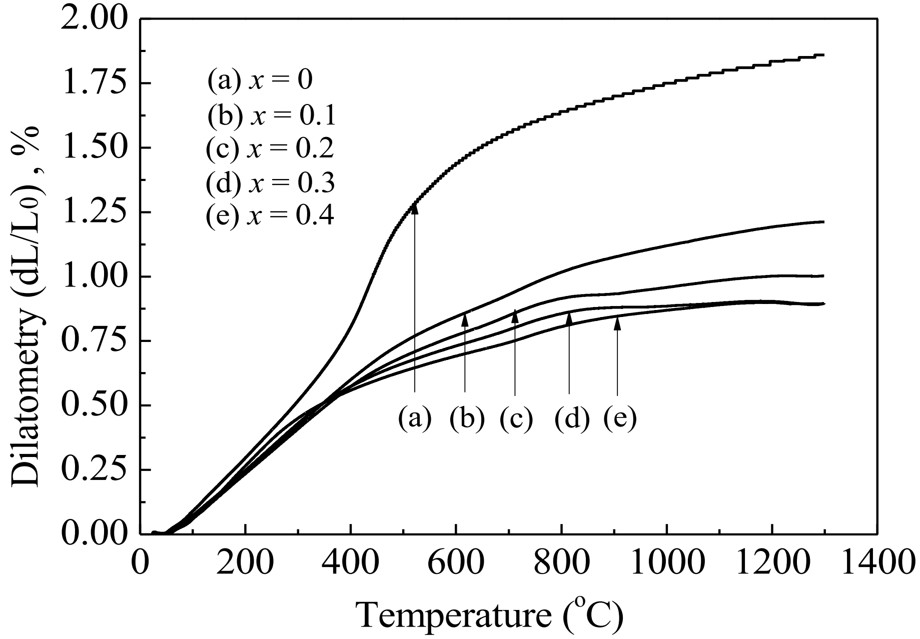

Fig. 21 Thermal expansion curves of leucite ceramic derived from $Cs_xK_{(1-x)}GP$

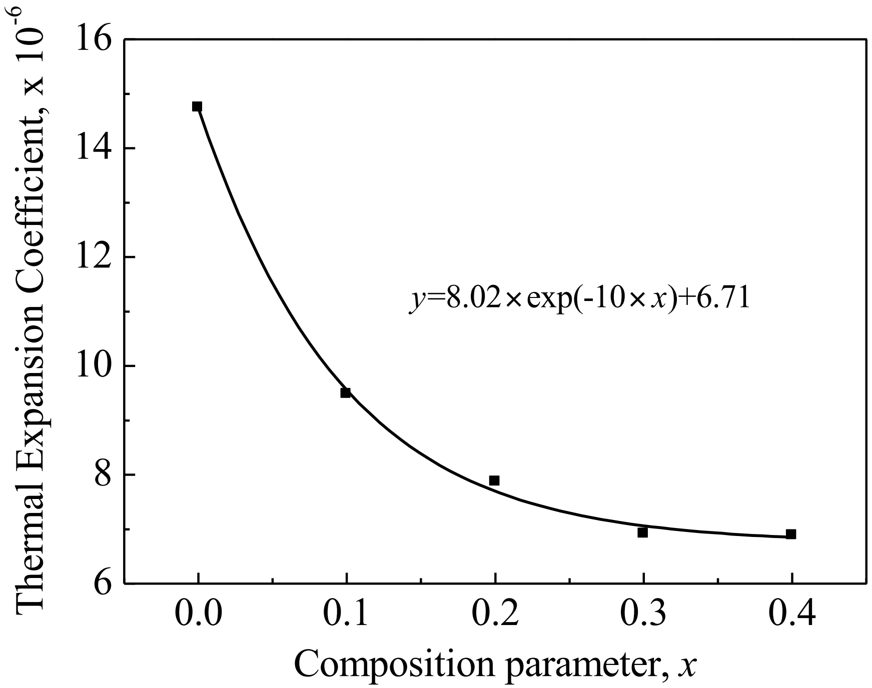

Fig. 22 Linear coefficient of thermal expansion of leucite ceramic derived from $Cs_xK_{(1-x)}GP$

---- Peigang He, Dechang Jia. *Ceramics International*. 2010, 36 (8), 2395-2400.

Summary

- Thermal shrinkage of KGP during heat treatment can be divided into 4 stages: structural resilience, dehydration, dehydroxylation and sintering.
- For the KGP, leucite crystallization appeared after the sintering stage and the Avarami parameter indicates the three-dimensional crystal growth mechanism.
- Geopolymer technology provides a novel method to fabricate leucite ceramic with relatively good mechanical properties.
- Leucite ceramic derived from Cs_xK_{1-x}GP posses an tunable thermal expansion coefficient by doping cesium ions.

Thanks for your attention！