Development of Electrically Conductive ZrO2-CaO-Fe2O3-V2O5 Glass and Glass-Ceramics as a New Cathode Active Material for Na-ion Batteries with High Performance

KHAN, Irfan, ZHANG, Bofan, MATSUDA, Koken, BINGHAM, Paul <http://orcid.org/0000-0001-6017-0798>, KITAJOU, Ayuko, INOISHI, Atsushi, OKADA, Shigeto, YOSHIOKA, Satoru, NISHIDA, Tetsuaki, HOMONNAY, Zoltan, KUZMANN, Erno and KUBUKI, Shiro

Published version

KHAN, Irfan, ZHANG, Bofan, MATSUDA, Koken, BINGHAM, Paul, KITAJOU, Ayuko, INOISHI, Atsushi, OKADA, Shigeto, YOSHIOKA, Satoru, NISHIDA, Tetsuaki, HOMONNAY, Zoltan, KUZMANN, Erno and KUBUKI, Shiro (2022). Development of Electrically Conductive ZrO2-CaO-Fe2O3-V2O5 Glass and Glass-Ceramics as a New Cathode Active Material for Na-ion Batteries with High Performance. Journal of Alloys and Compounds, 899.

Table 1 ^{57}Fe-Mössbauer parameters of *x*ZFV glasses before and after heat treatment at 500 °C for 100 min.

x mol%	before				after			
	A %	δ mm s^{-1}	Δ mm s^{-1}	Γ mm s^{-1}	*A* %	δ mm s^{-1}	Δ mm s^{-1}	Γ mm s^{-1}
0	100	0.40	0.67	0.50	59 41	0.37 0.30	0.33 1.09	0.35 0.56
10	100	0.40	0.68	0.50	71 29	0.38 0.31	0.28 1.27	0.31 0.58
20	100	0.38	0.74	0.52	81 19	0.37 0.31	0.28 1.55	0.34 0.54
30	100	0.39	0.72	0.52	82 18	0.38 0.29	0.28 1.24	0.31 0.78

A: absorption area (±0.5%), δ: isomer shift (±0.01 mm s^{-1}), Δ: quadrupole splitting(±0.02 mm s^{-1}), , Γ: Linewidth (±0.02 mm s^{-1})

Table 2 ^{57}Fe- Mössbauer spectra of *x*ZCFV glasses before and after heat treatment at 500 ºC for 100 min.

x mol%	before				after			
	A %	δ mm s^{-1}	Δ mm s^{-1}	Γ mm s^{-1}	*A* %	δ mm s^{-1}	Δ mm s^{-1}	Γ mm s^{-1}
0	100	0.38	0.76	0.52	36	0.39	0.65	0.35
					33	0.39	0.33	0.35
					31	0.32	1.12	0.35
5	100	0.37	0.77	0.49	53	0.38	0.66	0.33
					18	0.40	0.34	0.33
					29	0.35	1.16	0.33
10	100	0.39	0.75	0.50	37	0.38	0.66	0.32
					34	0.40	0.34	0.32
					28	0.33	1.13	0.32
15	100	0.38	0.74	0.49	100	0.40	0.30	0.37

A: absorption area (±0.5%), δ: isomer shift (±0.01 mm s^{-1}), Δ: quadrupole splitting(±0.03 mm s^{-1}), , Γ: Linewidth (±0.02 mm s^{-1})

Table 3 Comparison of the capacity of Na-ion batteries containing sodium vanadate as a cathode active material.

compounds	current density [mA g^{-1}]	capacity [mAh g^{-1}]	maintenance rate[%] (cycle)	ref.
$Na_{0.33}V_2O_5$	0.02	83	65(30)	[49]
NaV_6O_{15}	100	92	74(30)	[50]
$Na_{2.46}V_6O_{16}$	50	62	88(100)	[51]
$Na_{1.1}V_3O_{7.9}$	50	125	66(190)	[52]
$Na_{1.25}V_3O_8$	200	158	95(200)	[53]
$Na_{0.282}V_2O_5$	300	104	76(1000)	[54]
$25Na_2O•65V_2O_5•10P_2O_5$	5	184	- (5)	[17]
$HT25Na_2O•65V_2O_5•10P_2O_5$	5	173	- (5)	[17]
$HT20ZrO_2•70V_2O_5•10Fe_2O_3$	50	153	45(30)	this study
$HT20CaO•70V_2O_5•10Fe_2O_3$	50	138	59(30)	this study

HT: heat-treated