



R&D  
material

## Sodium-ion conducting materials for sodium-ion batteries

### Solid electrolytes for use in advanced sodium (Na)-ion batteries

#### In liquid-electrolyte batteries

- Cathode composites for increasing ion conductivity
- Coatings on polymer membranes for increasing safety

#### In all- or almost-solid-state batteries

- Sintered cathode composites for increasing ion conductivity
- Solid-electrolyte membranes with high conductivities
- Hybrid electrolytes for enhancing ion conductivity and improving mechanical properties

### Glass-ceramic manufacturing process

#### Benefits

- Scalability<sup>1</sup>
- Homogeneous, high-purity material
- High reproducibility
- Customization of material

#### Customization options

- Sintering temperature can be tailored via adjustment of glass-ceramic synthesis process and composition.
- Surface functionalization can be added to particles, optimizing the material's use as additive in polymer composite electrolytes.
- Chemical compositions and grain size can be adapted to specific cell designs.

# Performance data<sup>2</sup>

General information	
Material class	Silicates $\text{Na}_5\text{RSi}_4\text{O}_{12}$ (R rare earth)
Production process	Glass-ceramic process (melting, ceramization) and powder processing

Electric properties	
Na-conductivity, total (at 25 °C) <sup>3</sup>	$> 1 \cdot 10^{-3}$ S/cm
Electronic conductivity <sup>3</sup>	$< 1 \cdot 10^{-9}$ S/cm
Activation energy	0.3 eV - 0.35 eV

(Electro-) chemical properties	
(Electro-) chemical stability <sup>4</sup>	Stable against Na-metal
Interface resistance to $\text{Na}^4$	$< 50 \Omega \cdot \text{cm}^2$

Other characteristics	
Bulk density	$\sim 3.1 \text{ g/cm}^3$
Powder particle size	Standard $D_{50}$ : 2-3 $\mu\text{m}$ (other sizes on request)
Sintering temperature	950 °C – 1050 °C

## Particle size distribution

Standard milling provides the following typical particle size distribution. Other distributions available on request.

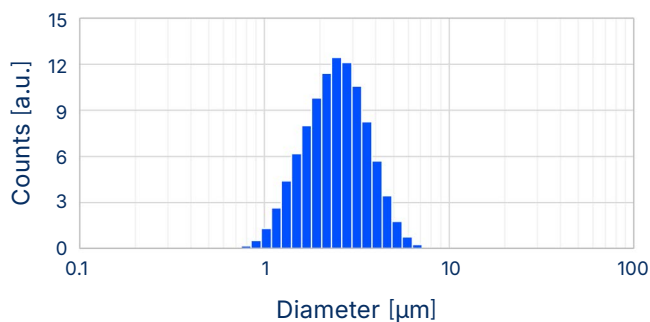


Figure 1: Volume-weighted particle size distribution, here:  $D_{50} = 2.4 \mu\text{m}$

## Crystal structure

XRD analysis shows a large fraction of crystalline  $\text{Na}_5\text{RSi}_4\text{O}_{12}$ .

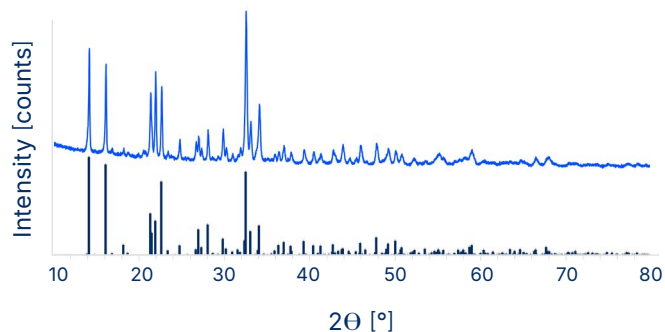


Figure 2: X-ray diffraction pattern of SCHOTT material (light blue) and  $\text{Na}_5\text{RSi}_4\text{O}_{12}$  reference spectrum (dark blue)<sup>5</sup>

## More information and sampling:



Get in contact!

- 1) 10 kg established, scalable to  $>1000$  t/y
- 2) All datasheet values are indicative only
- 3) Conductivity of sintered pellet. Relative density  $> 95\%$
- 4) No visual distinctive features in material cross section and stable interfacial resistance over time when contacted with molten Na
- 5) Source: Maksimov, B.A., Kharitonov, Y.A., Belov, N.Y. "Crystal structure of the Na-Y meta-silicate  $\text{Na}_5\text{Y-Si}_4\text{O}_{12}$ " (in English translation). Sov. Phys. Dokl. 18, 763–765 (1974)

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