

Solid electrolytes for fuel cells using nanosheets

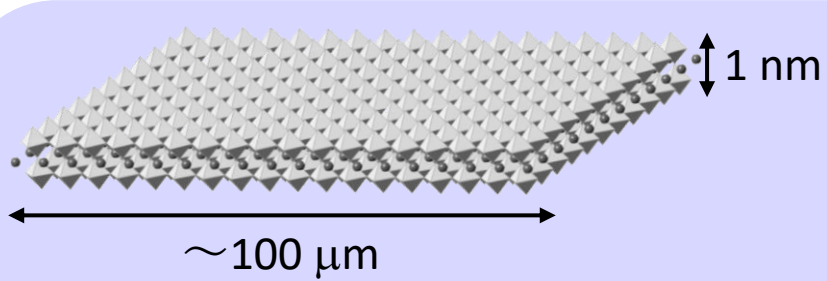
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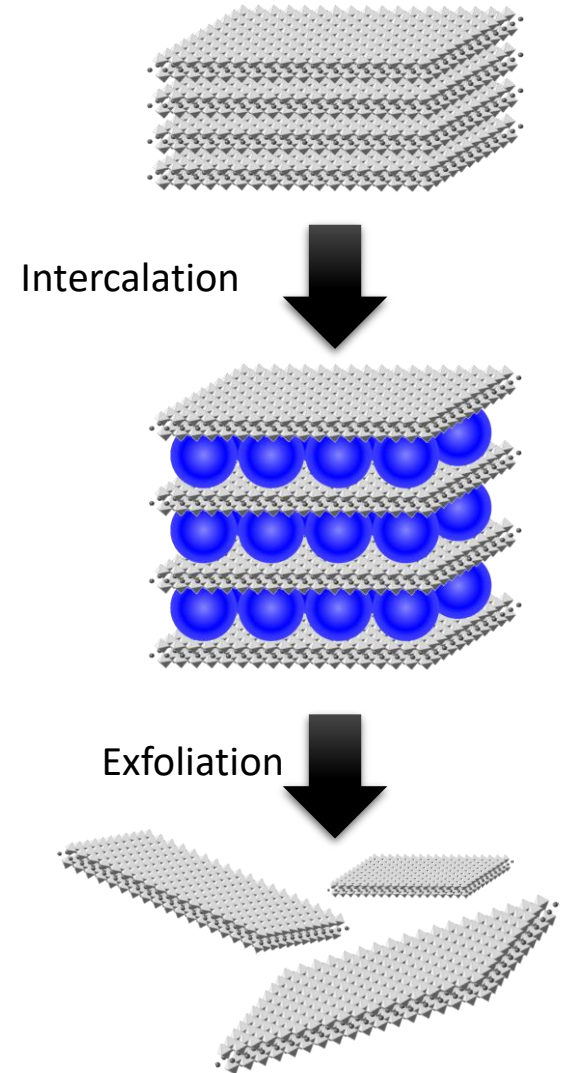
Nanosheets



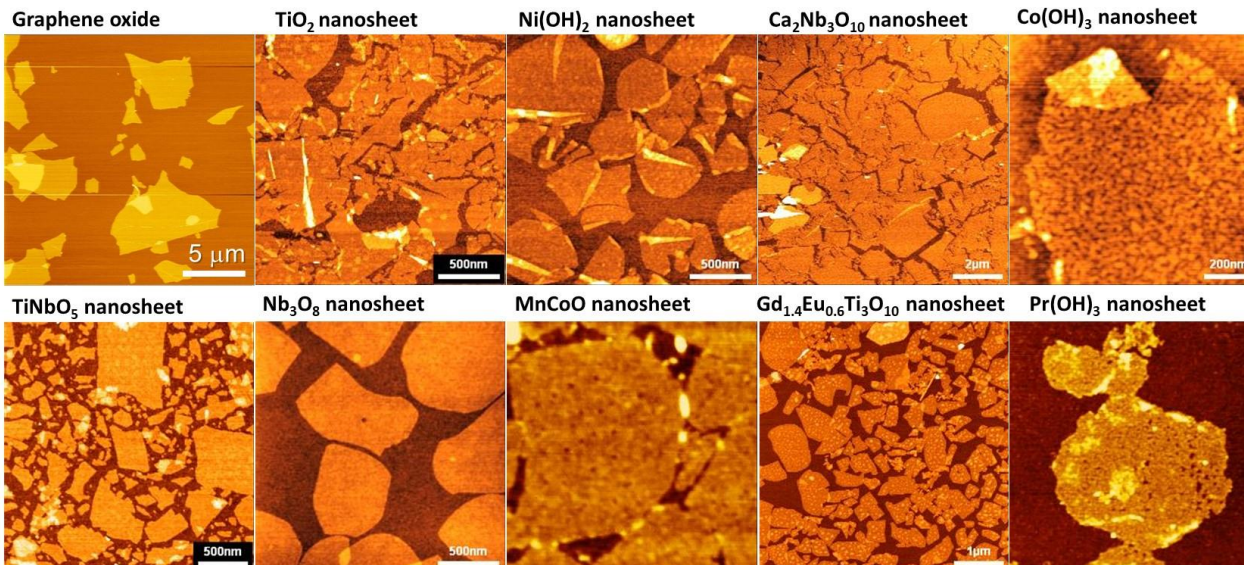
- Flexible
- Good mechanical strength
- Molecular barrier property
- Physical and chemical stability

Production nanosheets by exfoliating of layered structure

Advantageous for high yield and mass production



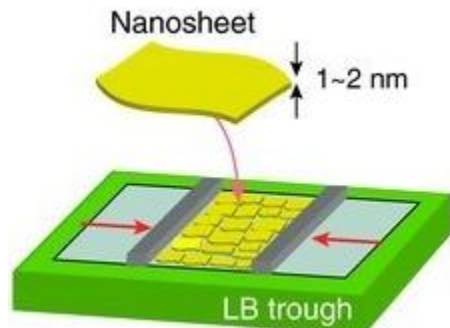
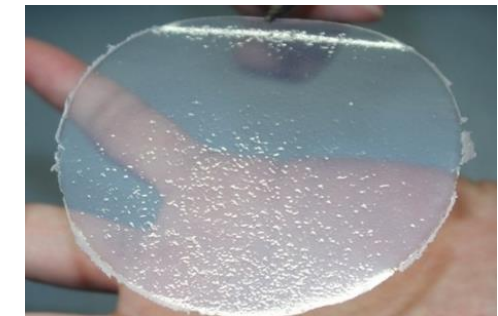
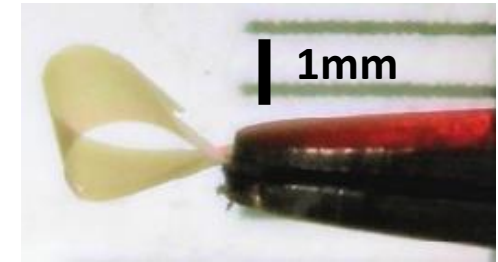
We can synthesis various nanosheets!



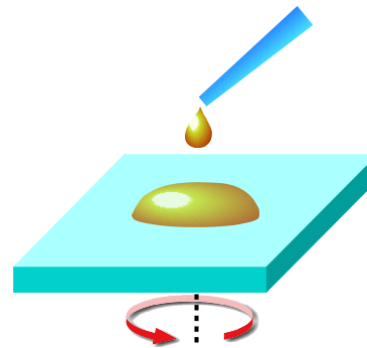
Nanosheet laminated films

We can fabricate nanosheet laminated films by various methods.

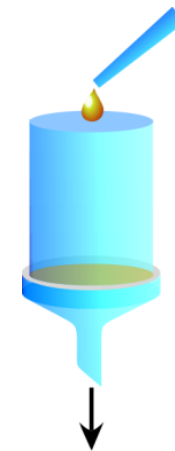
- Flexible
- Large-scale
- Free-standing (good mechanical strength)
- Stable



LB method

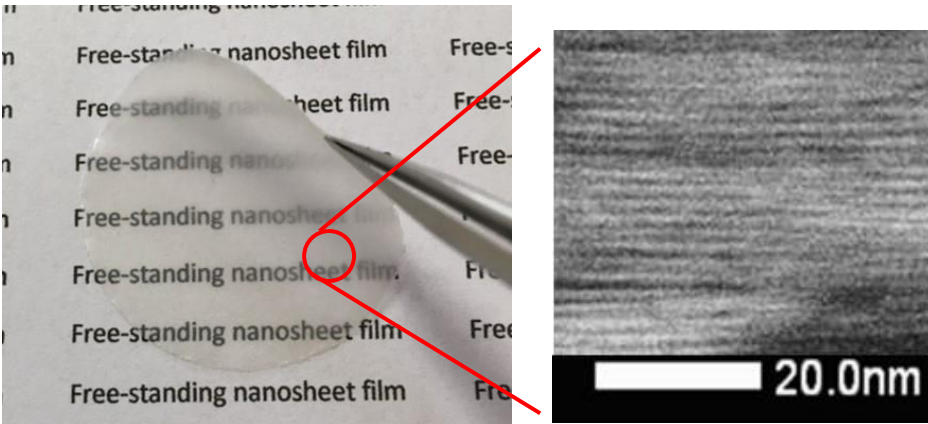


Spin coat method

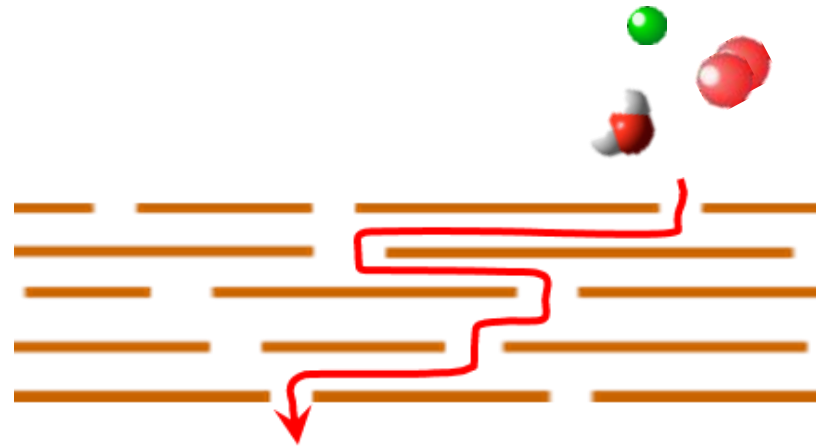


Vacuum filtration method

Nanosheet laminated films



Nanosheet laminated films have a highly oriented layered structure.

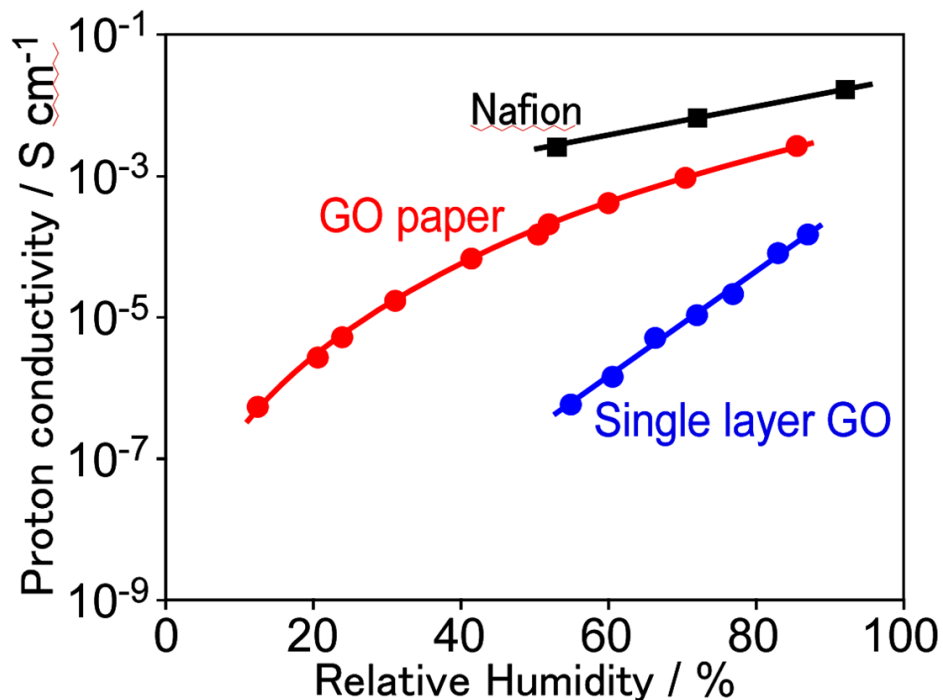


- Long path way for cross over
- Continue to receive interactions from nanosheets

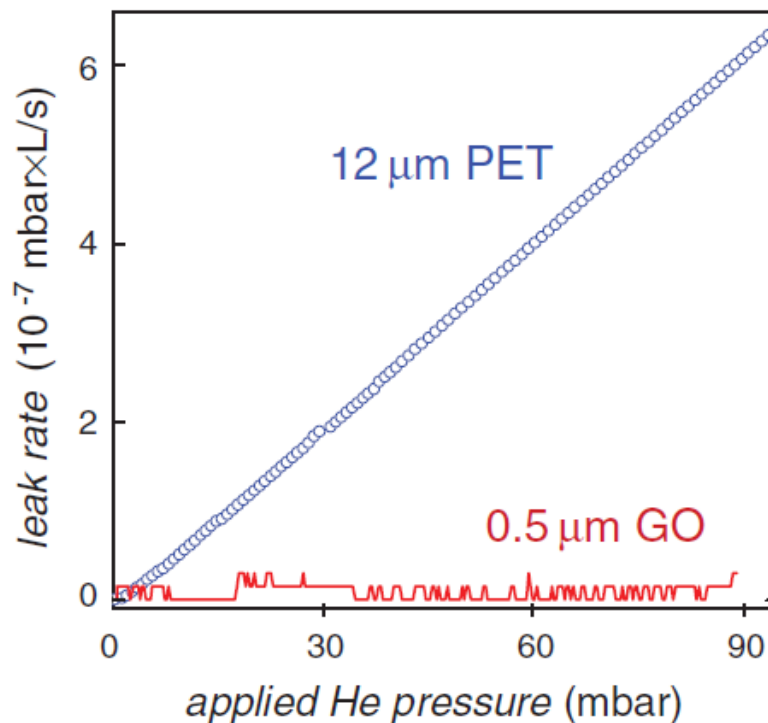
Unique permeation properties appear

Unique property of Nanosheet laminated films

In the case of graphene oxide film



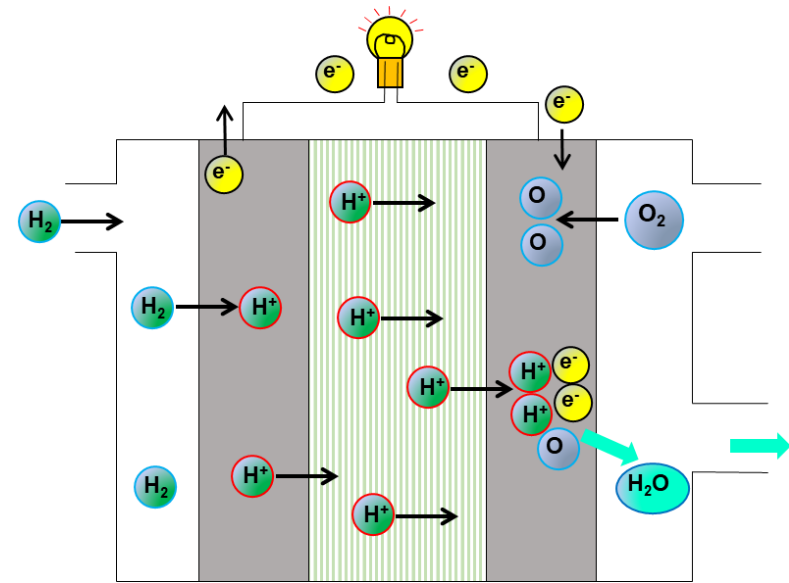
J. Am. Chem. Soc. **135**, 8097 (2013)
Angew. Chem., Int. Ed., **53**, 6997 (2014)



Science **335**, 442 (2012)

Protons move at high speed, but gases do not permeate.

Solid electrolytes for fuel cells using nanosheets



Solid electrolytes for fuel cells

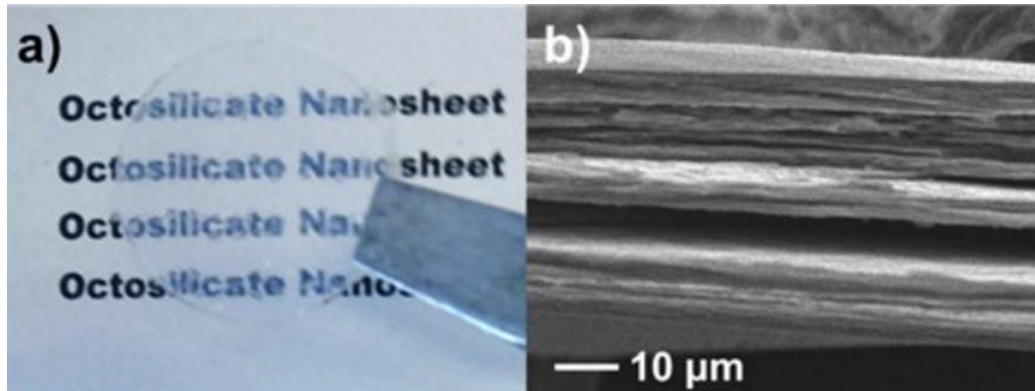
- Low proton resistivity
- High hydrogen barrier property
- High mechanical strength and flexibility

Nanosheet laminate films have high potential.

We have investigated the potential of various nanosheet laminated films as solid electrolytes for fuel cells.

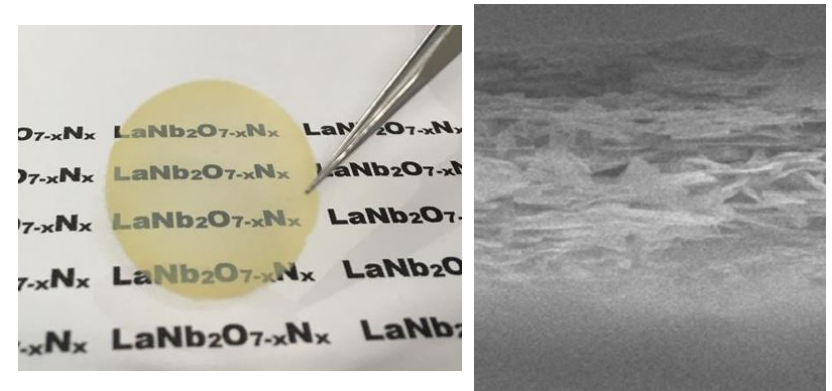
Fabrication of various nanosheet films

Silicate nanosheet



Chem. Commun. **2021**, 57, 6304.

Oxynitride nanosheet



Chem. Mater. **2021**, 33, 6068.

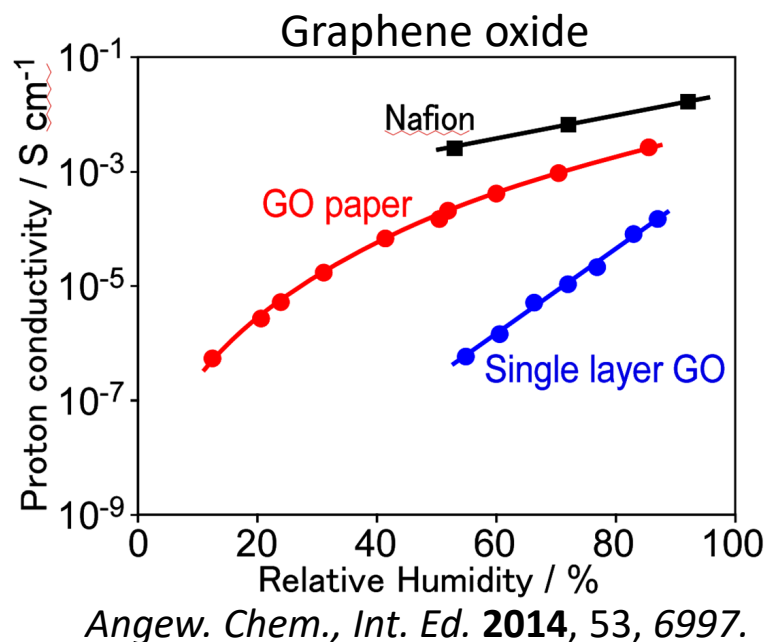
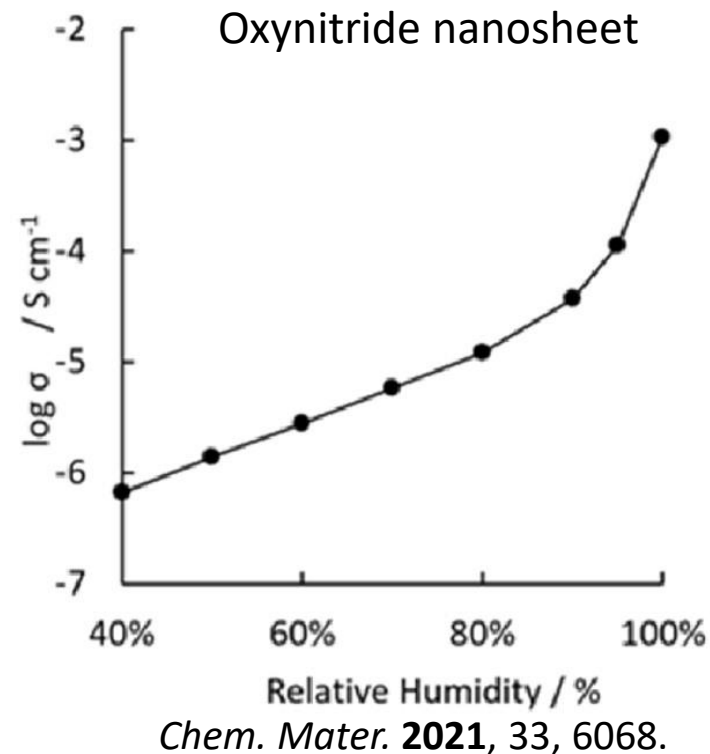
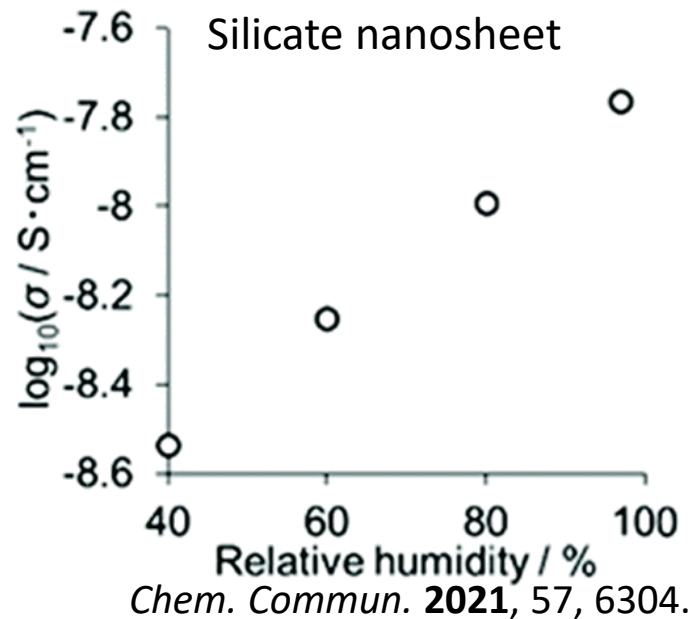
Graphene oxide



Macromolecular Rapid Commun., **2022**, 2100912.

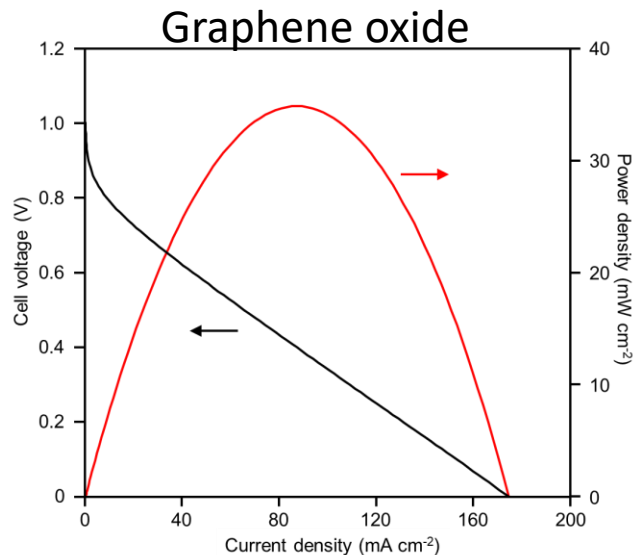
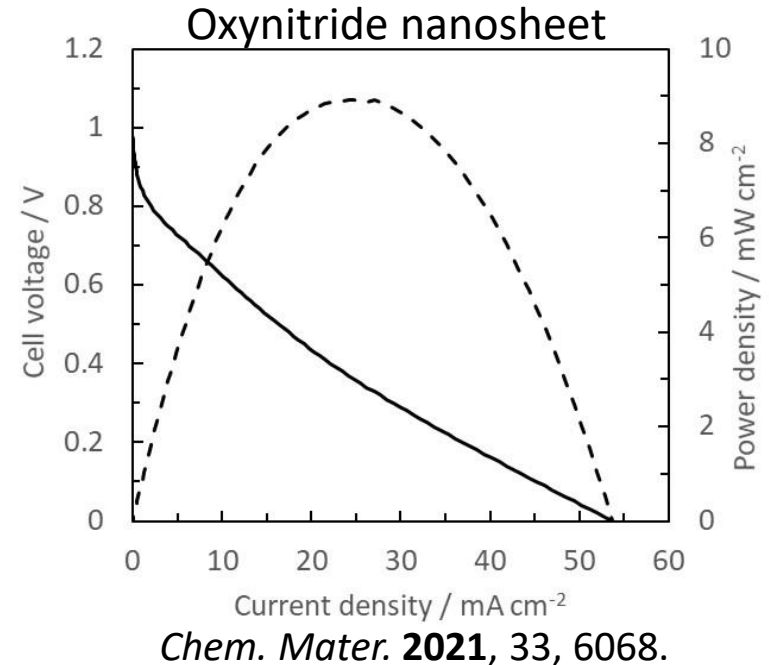
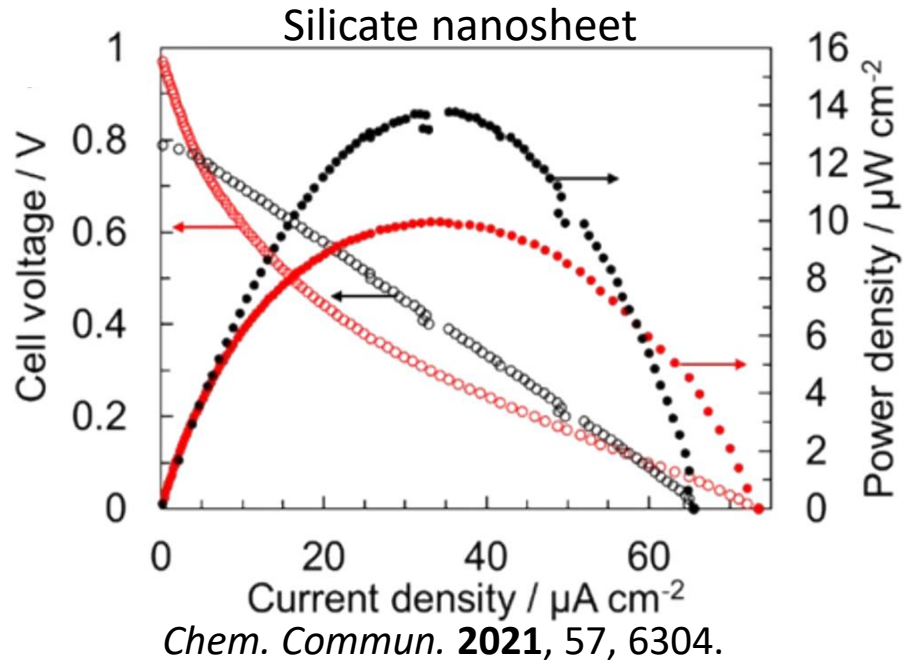
- Nanosheet films had the highly oriented layered structure.
- Nanosheet films showed the good mechanical property and flexibility.

Proton conductivity of various nanosheet films



- Some nanosheet film showed the high proton conductivity.
- Protons are transported by hopping (Grotthuss mechanism).

Performances of fuel cells using nanosheet films



- Nanosheet films can be used as solid electrolyte.
- OCV was almost 1 V, meaning that nanosheet films prevent H_2 crossover and effectively conduct protons.



Nanosheet films are expected as a material for solid electrolytes for next fuel cells.

Summery

Conventional solid electrolytes

Polymers

- High proton conductivity
- High mechanical strength and flexibility
- Low H₂ barrier property
- Low thermal stability (< 100 °C)
- Environmentally unfriendly

Solid oxides

- High ion conductivity
- High thermal, physical and chemical stability
- Operates only at high temperature (> 500 °C)
- Low flexibility

Electrolytes using nanosheet laminated films

- New concept
- High proton conductivity
- High mechanical strength and flexibility
- High H₂ barrier property
- High thermal, physical and chemical stability
- Low fuel cell performance

→ Performance can be improved by reducing the film thickness, optimizing the catalyst, etc.

Thank you for your kind attention!