COLD SINTERING OF CERAMIC MATERIALS

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ABSTRACT

Sintering ceramics usually needs a temperature of over 1000°C. To reduce the quantity of heat generated, a novel sintering process has been devised. It may sinter oxides, carbonates, bromides, fluorides, chlorides, phosphates and ceramic-based composites.

INTRODUCTION

Ceramics are frequently sintered by firing them at high temperatures - this is known as conventional sintering.

These approaches are hampered by the problem of physical and chemical incompatibility at high temperatures.

The significant benefit of cold sintering is the reduction in temperature and the speeding of the diffusion process through the use of mediate liquid phase and pressure.

As a result, many inorganic materials and ceramic-based composites may now be manufactured at far lower temperatures than previously thought possible.

METHODS

Cold sintering was used to create dense ceramics of Li_2MoO_4, $Na_2Mo_2O_7$, $K_2Mo_2O_7$, V_2O_5, and ZnO, as well as dense composites of Li_2MoO_4-$BaFe_{12}O_{19}$, Li_2MoO_4-PTFE, V_2O_5-CNF, and ZnO-MXene, et al.

The powders were wetted by aqueous solutions, and then the wet powders were heated pressed with a steel die into dense pellets at 80-600 MPa and 100-300 ℃, followed by the drying in an oven for 6-12 hours.

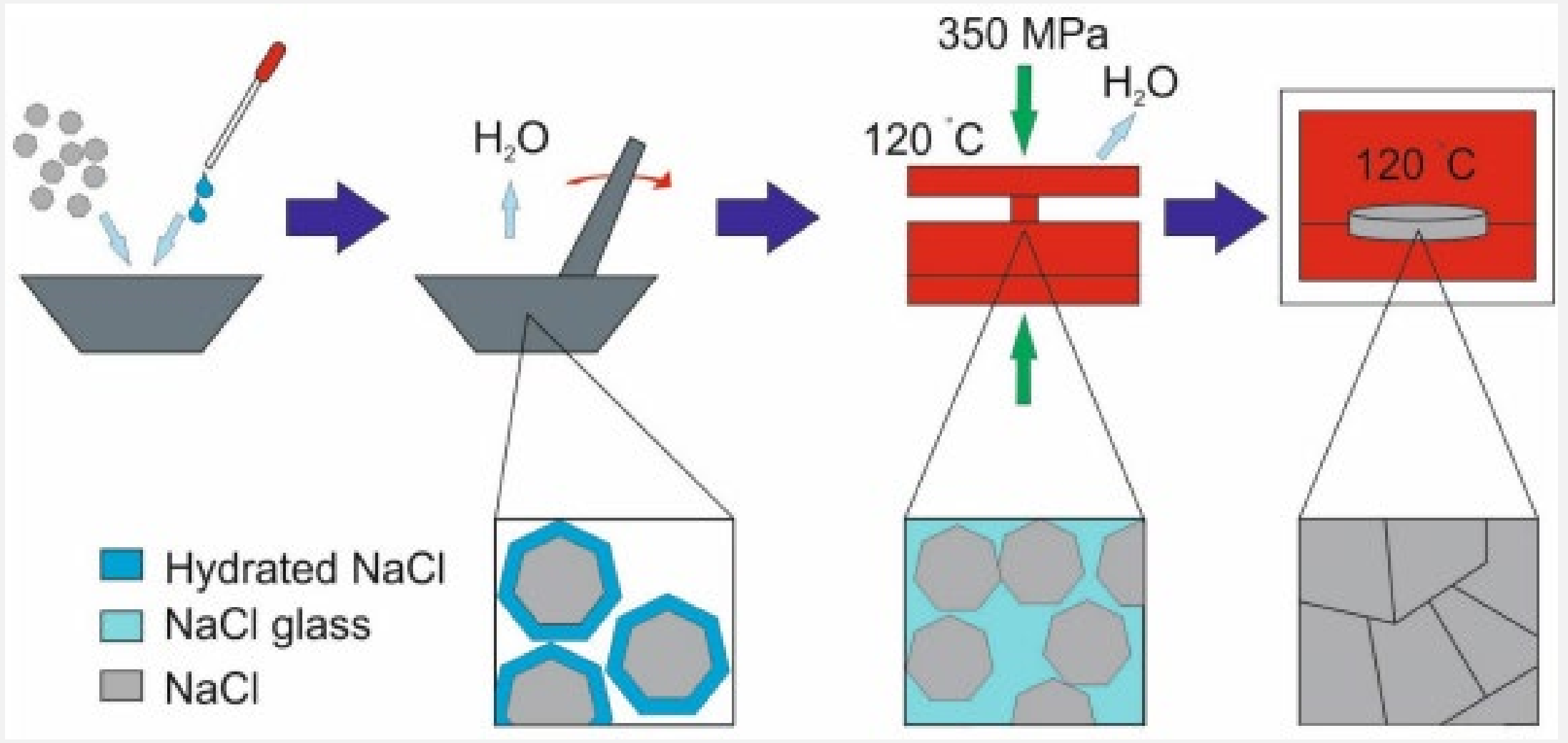
SIGNIFICANT RESULTS

Microstructures that are more than 90% dense after cold sintering process.

There are no visible impurities or second phases.

This experiment shows how to effectively employ mediate liquid phase and pressure to increase the driving force of sintering.

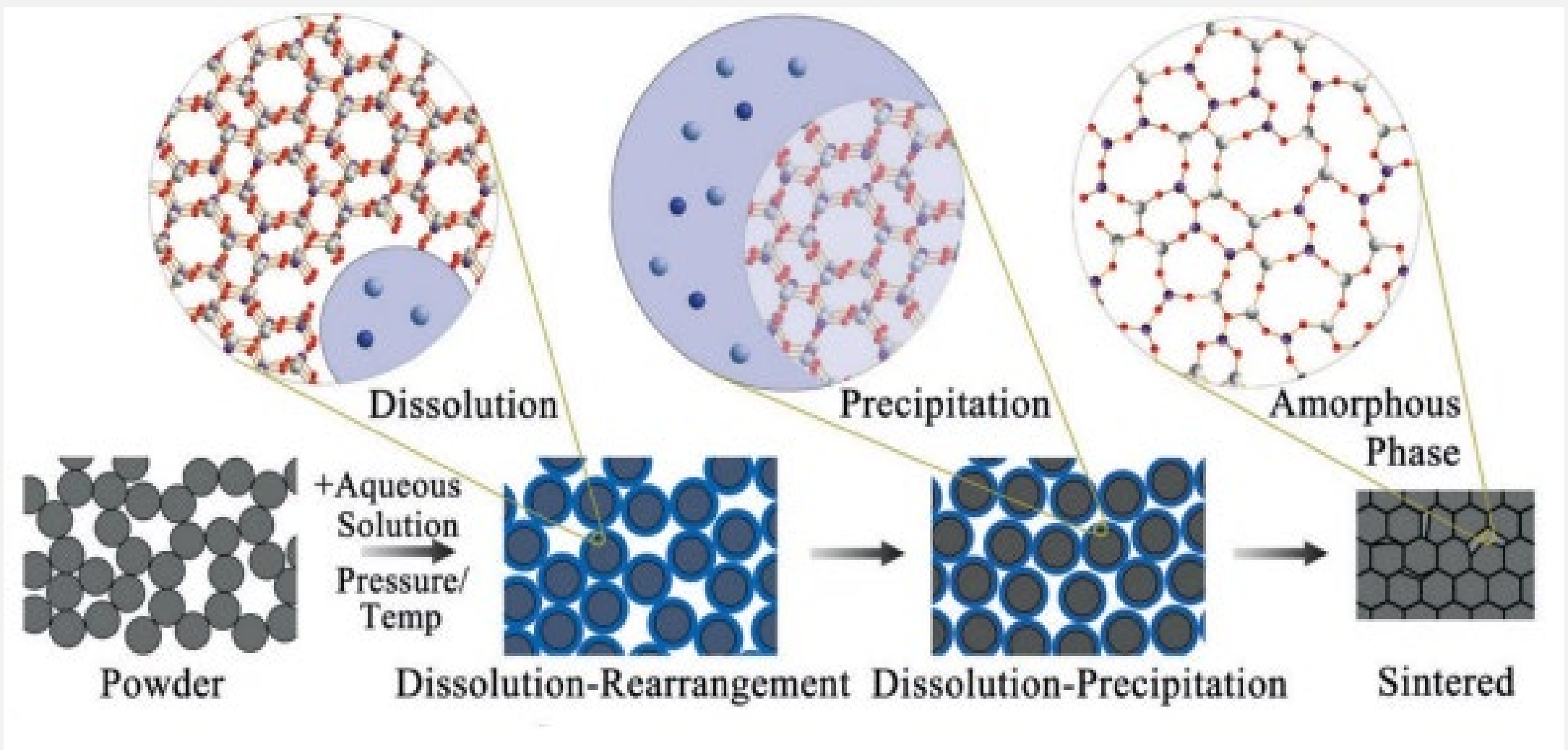
It is revealed that cold sintering process is feasible to fabricate ceramic-ceramic, ceramic-polymer, and ceramic-metal composites.



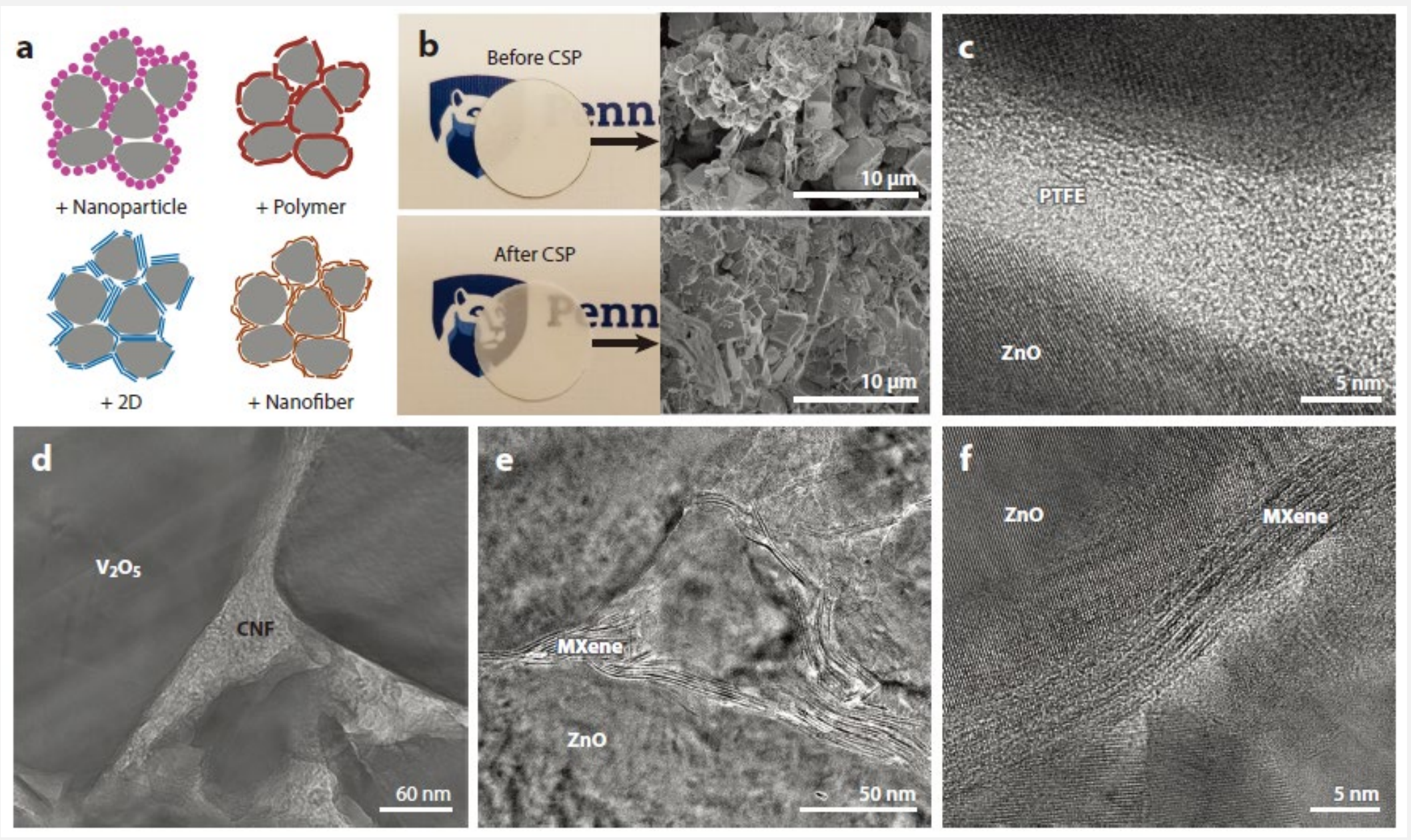
Cold Sintering

Table 1. The relative density of the selected cold sintered samples

Sample	Relative density	Pressure	Temperature
$K_2Mo_2O_7$	95.7%	350 MPa	120 $C°$
$Na_2Mo_2O_7$	95.7%	350 MPa	120 $C°$
$Li_2Mo_2O_7$	94.1%	350 MPa	120 $C°$
V_2O_5	90.2%	350 MPa	120 $C°$



Cold Sintering Mechanisms



Cold Sintered Composites

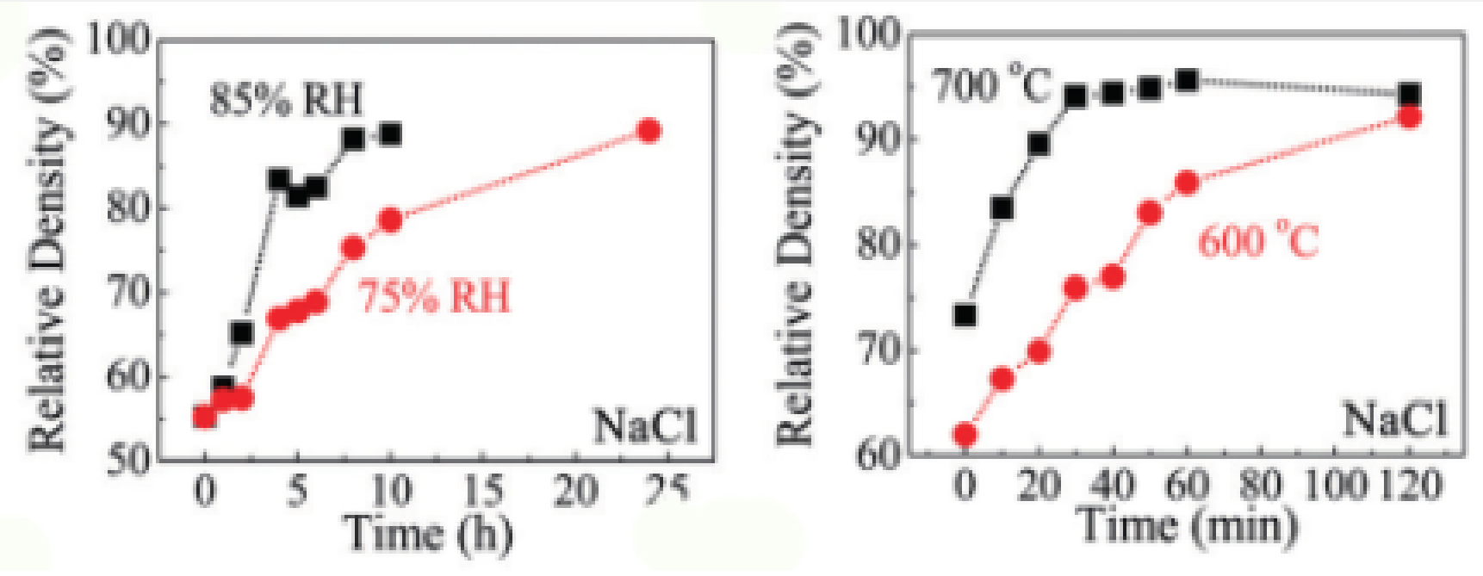


Figure 3 The left picture show the $NaCl$ cold sintered sample and the right the conventional sintered sample

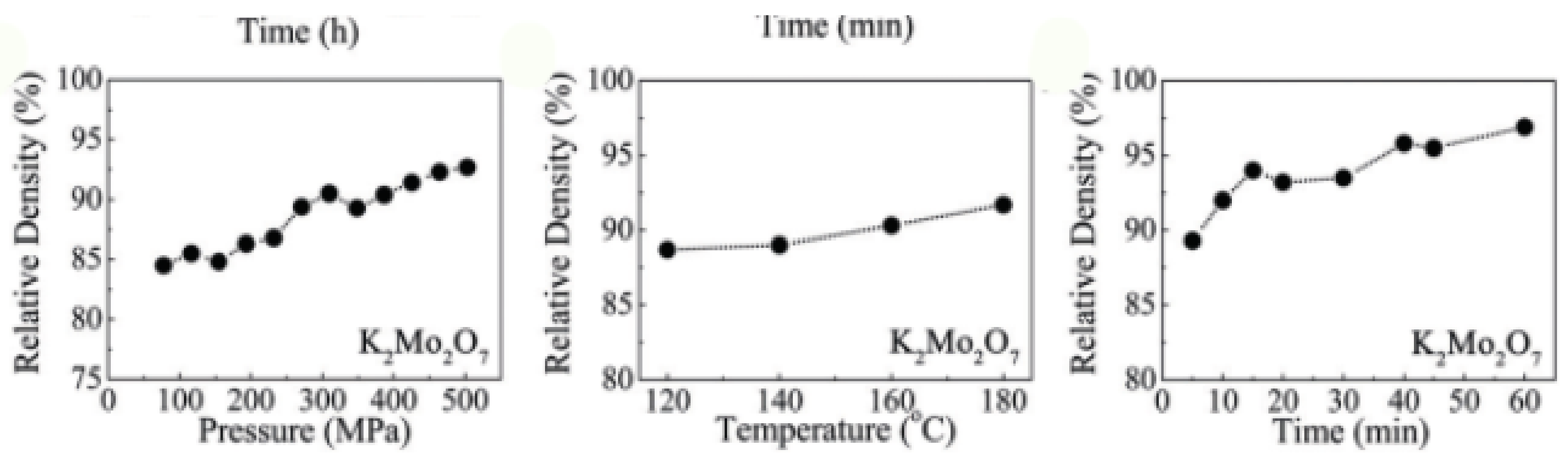
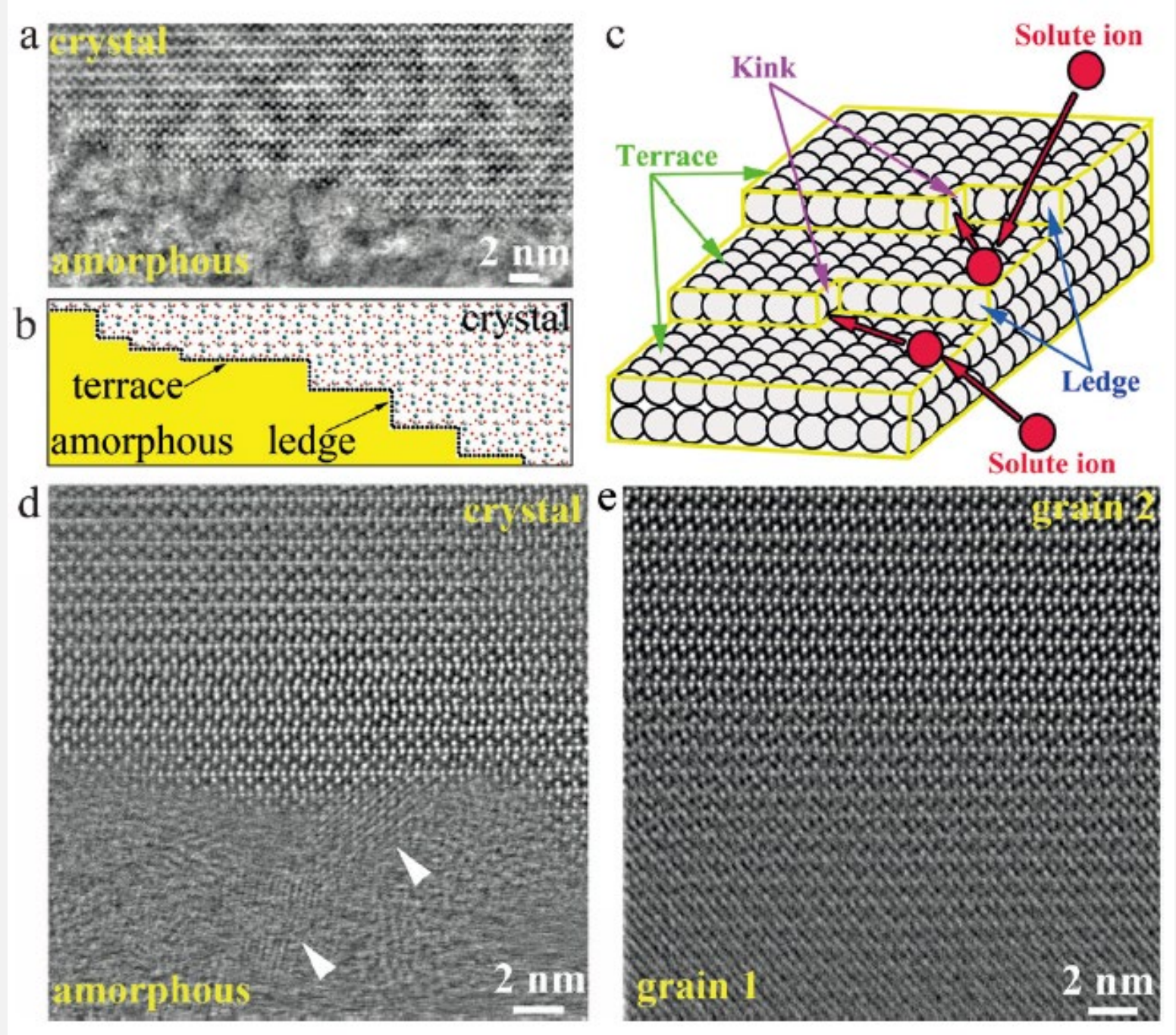


Figure 4: highlights the cold sintered sample of $K_2Mo_2O_7$ as a function of pressure, temperature, and time



Interfaces of cold-sintered ceramics and the Terrace–Ledge–Kink (TLK) model for crystal growth

CONCLUSIONS

Cold sintering has advantages over traditional sintering processes. After sintering, the materials have a high purity and density.

A significantly reduced thermal budget reduces energy use.

The benefits of organic and inorganic integration with the ideal combination.

FUTURE WORK

More understanding of the solvent-particle interface chemistry.

A deeper knowledge of the mechanisms and process aspects is required.

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