

Analysis of Dislocation Motion in NaCl Crystals by Acoustic Emission Method

Takayuki Shiraiwa

Department of Materials Engineering, School of Engineering, The University of Tokyo

Summary

Sodium chloride (NaCl) is vital across industries, where its mechanical properties, governed by defects like dislocations, are critical. This study aimed to elucidate the microscopic deformation and fracture mechanisms in NaCl single crystals under mechanical loading. A combined approach of in-situ digital microscopy and Acoustic Emission (AE) analysis was employed during uniaxial compression and stress relaxation tests at varying strain rates.

NaCl single crystals (approx. $10 \times 10 \times 10 \text{ mm}^3$) were compressed along the $\langle 100 \rangle$ axis. A DC motor-driven testing machine with a custom Arduino-based displacement control system was used. AE signals were captured using resonant M304A sensors and recorded at 10 MHz, while surface deformation was monitored with a Keyence VHX-8000 microscope. Compression tests (0.5 mm/min and 0.01 mm/min) showed stress-time curves with load drops corresponding to AE RMS voltage bursts. Deformation involved $\{100\}$ cleavage and $\{110\}\langle 011 \rangle$ slip. AE source location linked high-amplitude events to cleavage. Strain rate sensitivity was evident. The constant baseline AE RMS during continuous deformation suggested that AE from sustained dislocation glide was either very low or masked. Stress relaxation tests, with stepwise loading and 100-second holds, aimed to isolate AE from dislocation motion. No macroscopic crack growth occurred during holds, yet sporadic, small-amplitude AE events were detected, indicating microscopic slip. The stress exponent, m^* , derived from relaxation curves, was comparable to values for some metals.

This research demonstrates the utility of combined in-situ observation and AE for characterizing NaCl's deformation dynamics. High-amplitude AE is primarily linked to cleavage, while subtle AE during stress relaxation likely stems from dislocation activity. These insights are crucial for optimizing salt production, controlling crystal quality, and ensuring stability during industrial handling. Future work includes enhancing AE signal detection and further correlating AE with dislocation parameters like m^* .