Mapping Local Thermal and Thermoelectric Properties of MXenes Via Scanning Thermal Microscopy

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There is a growing need for the development of high-performance thermoelectric materials and devices that can efficiently convert heat energy into electricity. Some 2D materials have great potential for next-generation thermoelectric devices due to their large and tunable Seebeck coefficient and low thermal conductivity. MXenes are a new family of 2D materials consisting of transition metal carbides and nitrides, which are predicted to show outstanding thermoelectric properties based on theoretical calculations [1]. However, few experimental studies have been performed so far to confirm their potential. Scanning thermal microscopy (SThM) is a powerful tool that provides effective local thermal and thermoelectric measurements with nanoscale spatial resolution [2].

We investigated the thermal transports and thermoelectric properties of several MXene flakes, including Ti_3C_2, Mo_2TiC_2, and Nb_4C_3, with varying thickness by using SThM to map their local thermal conductance [3] and thermovoltage [4]. The results showed that MXenes have ultralow thermal conductivity, which benefits their thermoelectric performance. We further used the SThM probe to locally heat MXenes homostructure to study their local thermoelectric properties. Significant thermovoltage changes were observed along at junctions formed between MXene flakes and at wrinkles. We extracted the local Seebeck coefficient variations from the thermovoltage image via deconvolution methods and revealed the structurally, defect, strain and stacking order dependent changes in the Seebeck coefficient [5] and compared the thermoelectric properties of different kinds of MXenes. Our work may pave the way for engineering new phases of thermoelectricity in 2D materials.

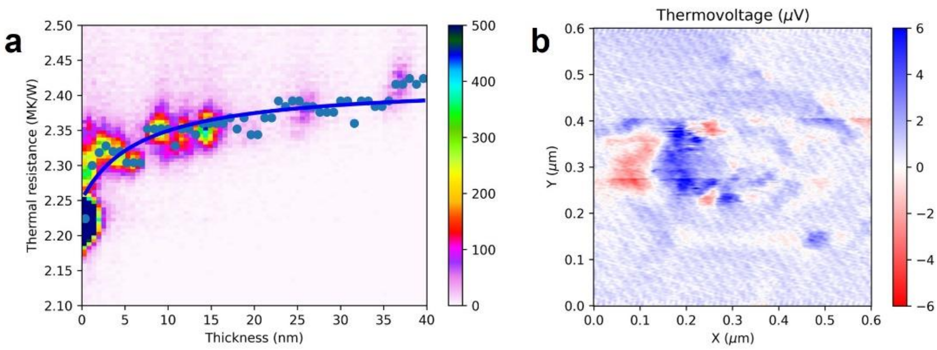

Figure 1. (a) Thermal resistance of the Ti_3C_2 MXene as a function of flake thickness and a model [3] fitting (blue line). (b) Thermovoltage image of Ti_3C_2 MXene device.

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