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Electric field control of thermoelectric properties in layered two dimensional materials

The reduction of the dimensionality leads to the manifestation of quantum phenomena and the development of electronic correlation. Such low dimensional effects often become even more pronounced in nano-scale materials including exfoliated atomic layers and their hetero structures, triggering the emergence of the novel electronic, optical, and magnetic properties. One important characteristic of low dimensional systems can be found in thermoelectric effect, which has been theoretically proposed to be favorably controllable by reducing the dimensionality [1]; the thermoelectric effect would be improved due to the low dimensional confinement effect of conduction carriers [2,3]. Although the recent progress in materials fabrications and measurement techniques has allows us to investigate the thermoelectric properties in some nano-scale materials, it is still a challenging issue to perform a systematic study of low-dimensional materials and to reveal its low-dimensional nature. In this poster presentation, we report the thermoelectric transport of the 2D systems formed in electric double layer transistor (EDLT) configurations. EDLT is a kind of field effect transistor, which has ionic liquids as gate dielectrics. This structure enables us to accumulate an extremely large carrier density due to the formation of the electric double layer on the surface of semiconductor channels. The strong electric field formed at the electric double layer confines electron carriers and reduces the effective thickness of the channel to several nanometers. Another approach to create 2D systems is to utilize chemical etching, which is induced by applying large gate bias, resulting in the actual thinning of channel materials in a layer-by-layer manner [4]. We have systematically investigated the Seebeck effect in two dimensional semiconductors such as FeSe [5], ZnO [6], and WSe_2 [7]. Especially, we found that the Seebeck effect of FeSe thin films is enhanced by reducing the thickness, achieving the highest power factor below room temperatures as shown in Figure 1. Our approach opens up a novel route to exploit the peculiar behavior of 2D electronic states and realize thermoelectric devices with advanced functionalities. [This work was partly supported by JSPS KAKENHI Grant Numbers JP17H02928 and JP17K19060.]

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Figures

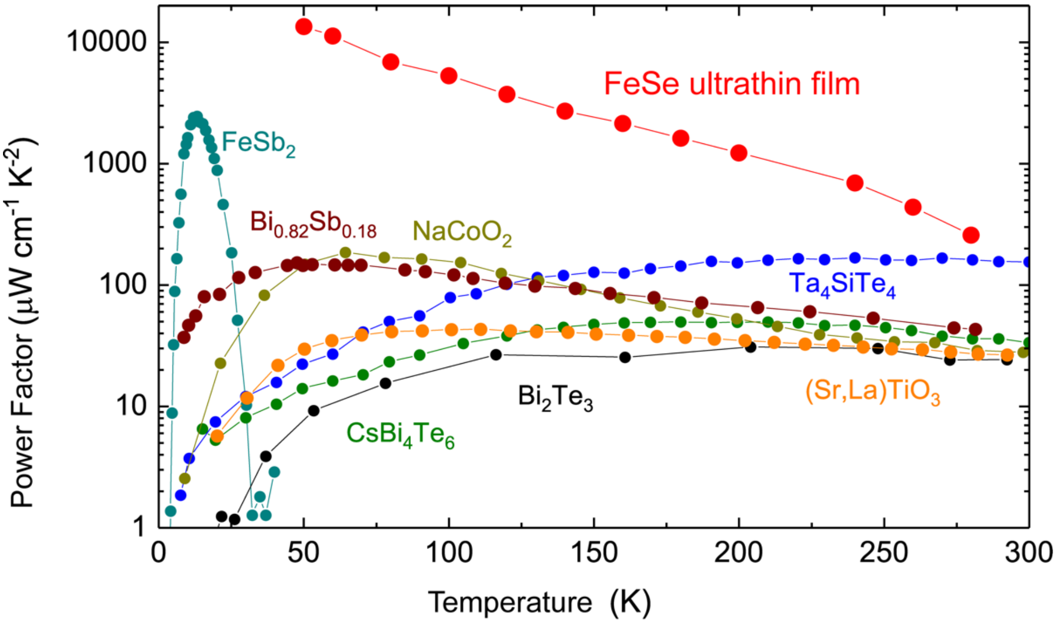

Figure 1: Temperature dependence of thermoelectric power factor in FeSe ultrathin film and typical thermoelectric materials.