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Raman spectroscopy of 2D transition metal carbides and nitrides (MXenes)

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Abstract

Raman spectroscopy has been a versatile tool for materials characterization. It is a fast, non-invasive, and easy processable technique for fingerprinting of molecules. An especially big impact Raman spectroscopy had in the field of 2D materials. This technique is sensitive to molecular structure, composition, chemical interactions, strain and temperature. In the recent years, those correlations were applied to 2D materials: graphene, transition metal dichalcogenides, boron nitride and others. Raman spectroscopy made advancement in studying physical properties, number of layers, flake coupling, thermal conductivity and mechanical properties. This big impact on the field shows that Raman spectroscopy can give a lot of information about 2D materials, therefore is an essential tool for study the new families of 2D materials. One of those families is MXenes, 2-dimensional transition metal carbides and nitrides, discovered at Drexel University at 2011, which gained already a lot of interest in a variety of applications, however still lacking in fundamental understanding in materials behavior

Therefore, the proposed research is focusing on Raman spectroscopy being used as a fast, easy and non-invasive method for identifying fingerprints and properties of family of 2-dimensional materials, MXenes. Specifically, Raman can used to better understand the MXene composition (meaning the M and X elemental compositions), the surface terminations, and the intercalation, dynamics of water, all of which strongly influence MXene properties. So far there was a lack of understanding of fundamental vibrational properties of MXenes, phonon dispersions and effect of temperature, stress and composition on it. While other 2D materials were extensively studied with Raman spectroscopy and achieved more understanding of behavior of phonon dispersion on micro level, MXene field remains untouched.