JCL 315 (Aug) (3-1-0)
Recent Trends in Inorganic and Nanomaterials
Instructor: Pratap Vishnoi

Extended inorganic solids:
Different types of complex metal oxides*;* perovskites (ABO_3), Ruddlesden–Popper*,* Dion-Jacobson, Aurivillius, Brownmillerite, hexagonal phases, Spinel and pyrochlore; synthesis, structure, band theory in solids, electronic properties, optical properties, transport properties, phonon properties; electrochemistry of transition metal oxides ($LiCoO_2$, $LiNiO_2$, $LiMn_2O_4$) and utility in energy storage.
Antiperovskites and their functional properties.
Metal pnictides; Skutterudites ($CoSb_3$ *etc.*), Zn_4Sb_3.
Metal chalcogenides; $CuFeS_2$ (chalcopyrite), AgCuTe, Bi_2Se_3 and other complex chalcogenides.
Intermetallics; Stoichiometric and non-stoichiometric, half Heusler, full Heusler compounds.
Natrium Superionic CONductor (NaSiCON; e.g. $Na_{1-x}Zr_2Si_xP_{3-x}O_{12}$, $0 < x < 3$) compounds and ion conductivity in NaSiCONs.
Topological insulator, topological crystal insulator, Dirac semimetal, Weyl semimetal.

Metal halides:
All-inorganic halide perovskites and hybrid halide perovskites, structural descriptors (tolerance factor and octahedral factor), layered metal halides (α-$RuCl_3$), and their optical and topological quantum behavior. Chemical control over dimensionality (0D, 1D, 2D and 3D). Metal to metal charge transfer in mixed-valence metal halides and ligand to metal charge transfer in metal halides.

2D nanomaterials:
Introduction, structure, classification of 2D materials the compound and the elemental materials. Rise of various post-graphene elemental 2D materials; borophene, silicene, phosphorene, arsenene, antimonene etc. Binary, ternary and quaternary 2D materials; metal dichalcogenides (MoS_2, $MoSe_2$), metal phospho-chalcogenides ($Mn_2P_2S_6$, $AgInP_2S_3$), MXenes. Top-down approach for synthesis of 2D materials; liquid and electrochemical exfoliation Tuning properties of 2D materials by chemical functionalization, self-assembly and heterostructures. Electronic, transport properties, and lattice anharmonicity.

Desirable prerequisites: basic knowledge of crystallography, ligand field theory, geometric aspects of metal complexes.

References:

1. Perovskites Structure–Property Relationships - Richard J. D. Tilley
2. Perovskite Photovoltaics and Optoelectronics: From Fundamentals to Advanced Applications - Tsutomu Miyasaka
3. N. Kumar, et al., *Chem. Rev.*, 2021, **121**, 2780–2815
4. X. Li et al., *Chem. Rev.*, 2021, **121**, 2230–2291