SCIENCE OF HIGH ENTROPY ULTRA-HIGH TEMPERATURE THIN FILMS: SYNTHESIS AND CHARACTERIZATION

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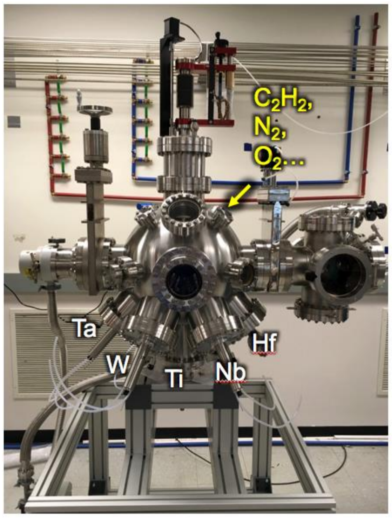
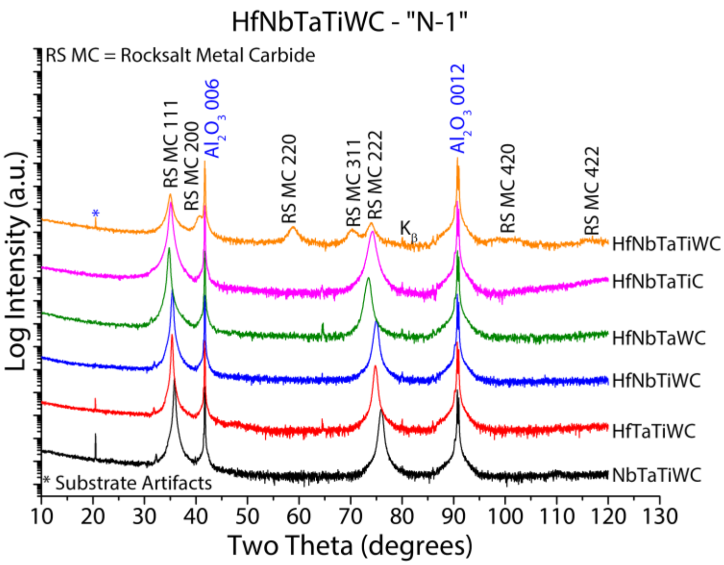


The authors describe the use of a 5-cathode reactive RF magnetron sputtering system to fabricate up to 5-component refractory high entropy carbides which form a robust class of high temperature materials. Magnetron sputtering is an appealing fabrication method it allows for deposition of high density films of many compositions at relatively low temperatures compared to bulk processing techniques. Thin films of mixed carbides consisting of the following elements: Ti, Zr, Hf, Nb, Ta, Mo, and W, will be discussed. All films are sputtered reactively in a gas atmosphere where Ar is the inert sputter gas with methane as the carbon source. Carbon stoichiometry is controlled via methane flow rates and assessed with density measurements. Use of 5 cathodes allows for rapid exploration of the 5 metal composition space from unary to quaternary or quinary carbides in short time spans.

A broad range of metals can be incorporated into single-phase rocksalt structures across a broad range of temperatures from room temperature to 800°C, although substrate interactions must be considered. Furthermore, despite challenges with integrating W and Mo into a rocksalt carbide structure using bulk processing, both elements are readily incorporated into the structure in thin film form. This includes compositions which use W and Mo simultaneously, despite both materials only forming a rocksalt carbide structure at high temperatures. It is suspected that the high kinetic energy of the incoming adatoms due to the low sputter pressures (typically 5 mT) provides adequate kinetic energy to form and quench rocksalt phases at far lower temperatures than achievable in the bulk powder processing.

The structural quality and uniformity of the thin films (ranging from 100 nm to several microns thick) and sharp, clean interfaces between layers of different compositions can allow for characterization of the thermal properties and stability of these new materials including thermal transport and chemical diffusion in elevated temperatures. Such information can prove valuable in developing compositions to withstand elevated temperatures without chemical leaching and degradation in oxidative environments.



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