# ABSTRACT

This work is motivated by the remarkable mechanical, tribological, optical and electrical properties of tantalum and niobium based nitride and oxy nitride thin films. The presented work addresses the utilization of plasma and plasma emanated beams in dense plasma focus device for materials processing. A major concern is to establish the optimum processing conditions for the synthesis of tantalum and niobium based nitride and oxy nitride films in the plasma environment. The synthesis of these films using different deposition techniques have been reported earlier but the use of plasma focus technique is one of the prospective hybrid deposition methods which is not only economical, simple and efficient but also provide high deposition rate and good adhesion in less time compared to other available thin film synthesis techniques. The plasma synthesized films are characterized for structural, morphological changes, compositional profiles, surface hardness and electrical properties by employing multiple techniques.

A brief over-view of the performed experimental works is described as follows:

In the **first experiment**, plasma assisted growth of tantalum nitride films in Mather type dense plasma focus device (DPF) is reported. Effects of variation in number of plasma focus shots on structural, morphological, compositional and mechanical characteristics of synthesized tantalum nitride thin films have been investigated. The study also includes parametric study of plasma emanated ion beam in conventional 2.3 kJ DPF device which are utilized for the deposition of thin films. These energetic ions are characterized by employing BPX65 photodiode detector placed at 9 cm along the anode axis to estimate energy and number density of the ions emitted during one plasma focus shot. Better crystallinity with thermally assisted coagulated growth patterns are observed for films synthesized by maximum (fifteen) plasma focus shots. Nano-hardness of films is observed to increase with increasing plasma focus shots whereas the maximum nano-hardness of 16.24 ± 01.54 GPa is observed for film synthesized with fifteen plasma focus shots. Film roughness investigated by atomic force microscopy revealed influence of variation in plasma focus shots on surface roughness which is found to be increased with increase in plasma focus shots.

In the **second experiment**, influence of variations in plasma deposition parameters on the structural, morphological and mechanical characteristics of the niobium nitride films grown by plasma emanated ion and electron beams are investigated. Crystallographic investigation made by x-ray diffractometer shows that the film synthesized at 10-cm axial distance with fifteen plasma focus shots exhibits better crystallinity as compared to the other deposition conditions. Morphological analysis made by scanning electron microscope reveals a definite granular pattern composed of homogeneously distributed nano-spheroids grown as clustered particles for the film synthesized at 10-cm axial distance for fifteen plasma focus shots. Roughness analysis demonstrates higher rms roughness for the films synthesized at shorter axial distance and by greater number of plasma focus shots. Maximum niobium atomic percentage (35.8) and maximum average hardness ($19.4 \pm 0.4$ GPa) characterized by energy dispersive spectroscopy and nano-hardness analyzer respectively are observed for film synthesized at 10-cm axial distance with fifteen plasma focus shots.

In the **third experiment**, Ta-O-N thin films are synthesized using energetic ions and electrons beams emanated from the hot and decaying plasma in DPF device. Oxygen percentage in the reactive gas admixture [O/(O+N)]% is varied from 10 to 60 for thin film synthesis. Influence of oxygen percentage on structural, morphological, compositional and electrical properties of thin films is also analyzed. Increase of oxygen percentage in the gas admixture (up to 40%) resulted in transformation of thin film from tantalum nitride to tantalum oxy nitride; however; higher oxygen percentages ($\geq$50%) caused amorphization in synthesized thin film. Morphological analysis revealed that pure nitrogen environment yields the granular structure of film in nano-meter range whereas escalation of grains is observed with the increase in oxygen percentage. Cross sectional SEM showed better film growth rate at lower oxygen percentages. Compositional profiles exhibited improvement of oxygen content in thin film by increasing oxygen percentage in the admixture. The electrical resistivity of films shifted from conducting (for 0% oxygen) to semiconducting-insulating (for 60% oxygen) material range for maximum oxygen percentage.

In the **fourth experiment**, effects of deposition angle and axial distance on the structural and mechanical properties of niobium nitride synthesized by a DPF system are studied.