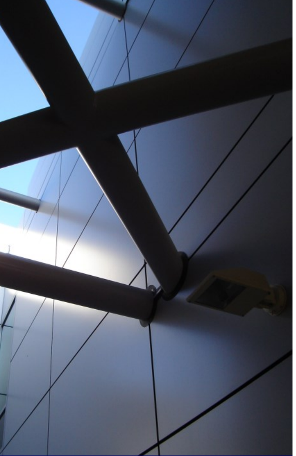

The Department of Mechanical Engineering presents:

The Ph.D. Dissertation Defense of
Kamran Shojaei

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Experimental and Numerical Characterization of Dusty and Pristine, Non-Thermal Plasmas

by

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Plasma processing is a common technique implemented in the semiconductor industry for manufacturing thin films and integrated circuits. Formation of dust in these plasma-assisted industrial processes is considered as an inevitable nuisance having detrimental effects in microelectronic fabrication. Low-temperature, low-pressure nonthermal plasmas containing particulate matter are commonly known as dusty plasmas. Even though, it's considered as a source of contamination in the industry, dusty plasmas have been utilized for controlled synthesis of monodisperse nanocrystals for a wide range of materials becoming a fundamental tool in the growing field of nanotechnology. The physics of dusty plasmas is not well understood both in academia and industry. This work focuses on studying the properties and complex physics of dusty plasmas in laboratory conditions as well as the numerical modelling of these complex environments. A design is presented to create a more forgiving environment to probe dusty plasmas that involves producing conductive dusts and injecting them in the discharge while ensuring full-consumption of any used precursor gas in the process. A non-thermal plasma synthesis method is employed to produce conductive graphitic nanoparticles, and a thermal evaporation source is utilized to synthesize copper nanoparticles. Langmuir probe measurements are conducted on discharges dosed with graphitic carbon and copper nanoparticles, and the influence of particles on plasma properties especially electron energy distribution function is fully investigated. Optical emission spectroscopy measurements also are performed to study the phenomenon of nanoparticles trapping and estimate the particle density in the plasma. A self-consistent zero-dimensional model of plasmas seeded with nanoparticles is developed to elucidate the physical origin of experimental observations. This model accounts for the ionization balance, power distribution within the plasma, particle heat transfer, and electron kinetics. The experimental and numerical work presents a step towards understanding of dusty plasmas. Moreover, probabilistic deep neural networks are also developed to characterize pristine plasmas. Non-Bayesian and Bayesian models are trained on Langmuir probe and spectroscopic data to estimate the electron energy distribution from the plasma emission spectra. Machine learning models are fully capable of describing the degree of uncertainty in their predictions. This work shows the usefulness of probabilistic neural network especially when physics-based-models fall short.

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