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Dense plasma focus device as a novel hot, dense, energetic, and transient plasma source for material synthesis and processing

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The Plasma Engineering and Applied Research Lab (PEARL) of NIE/NTU Singapore houses some of the most powerful pulsed-powered short-lived hot dense Z-pinch plasma devices, called dense plasma focus (DPF), of south-east Asia. DPF is a hydromagnetic coaxial plasma accelerator involves the transfer of electric energy stored into a capacitor bank to the magnetic energy stored behind a moving plasma current sheath and then the pumping of this energy into pinched plasma column during the rapid radial collapse phase, producing short duration (~10 to 50 ns), high temperature (~1 keV) and high-density plasma (~10^{25} m^{-3}) pinch plasma column [1]. This hot dense pinch plasma not only provides avenues to study fusion relevant plasma physics such as plasma dynamics, plasma instabilities, plasma turbulences etc. but also serves as an intense source of soft/hard X-rays, relativistic electrons, fast energetic ions, hot-dense plasma jets and fusion neutrons making it an extremely relevant test bed for developing plasma and fusion diagnostics and for several novel applications including testing/synthesizing/processing of materials under extreme conditions. Most plasma-based materials' processing and synthesis typically use low-temperature non-equilibrium plasmas for processing and synthesis of materials. This is because the ion and neutral species' temperature in non-equilibrium plasma is much lower compared to electrons and hence, they have fewer heating effects and moreover lower density provides better control over the deposition/processing rates which provides greater control over synthesis/processing conditions and hence improve depositions or processing of materials. In my presentation I will provide an overview of the work that we have in the past many decades on the use and optimization of hot-dense plasma produced in DPF device as novel tool for material synthesis and processing [2, 3]. Pulsed plasma devices normally face the criticism of lack of control over the synthesis/processing of material and their ability to reproduce results is always questioned. In this presentation, I will discuss key features of the plasmas in dense plasma focus devices demonstrate how we have used it successfully to process and synthesize various types of materials at nanoscale with great control and reproducibility. I will highlight different strategies that we have developed and different results that we have obtained to establish dense plasma focus as an alternative, efficient, unique and reliable high-temperature high-density plasma tool for material processing and synthesis [4-8].

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