# Seminar

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# Institute for Plasma Research

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**Title:** Origin and progress of controlled plasma fusion relevant, plasma surface interaction (PSI) research, at the CPP-IPR CIMPLE-PSI laboratory

**Speaker:** Dr. Mayur Kakati
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**Date:** 24th February 2026 (Tuesday)

**Time:** 10.30 AM

**Venue:** Seminar Hall, IPR

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**Abstract**

Research activities in high-pressure thermal plasma science and technology were initiated at the former Centre of Plasma Physics (CPP), Dispur under a BRNS (DAE) funded project during 2002–2006. As part of this effort, the largely theory-oriented institute collaborated with the Laser and Plasma Technology Division of BARC, Mumbai, leading to the establishment of a segmented-arc assisted plasma chemical reactor for the controlled synthesis of high-temperature nanomaterials. IPR was contemplating to bring CPP under its administrative framework, and Professor P. K. Kaw, then Director of IPR, decided to support some experiments at CPP (2006-07). At this juncture, CPP researchers were encouraged to realign their focus toward fusion research, so that this proposed remote laboratory can contribute towards IPR's mandate in the long-run. In response, an ITER-scale plasma-assisted heat source was proposed for fusion material testing, utilizing the segmented arc to generate a high-density, high heat-flux flowing plasma jet (2007–2011). This effort culminated in the successful development of the CPP-IPR High Heat Flux (HHF) device, capable of delivering plasma heat flux exceeding 10 MW $m^{-2}$ onto remote material targets. Tungsten melting experiments performed using the HHF system resulted in the production of tokamak tungsten dust analogues. Nuclear Reaction Analysis conducted at NCCCM (BARC, Hyderabad) revealed that these particles exhibited substantially higher hydrogen retention than bulk tungsten. Building on these achievements, IPR subsequently encouraged the development of a magnetized tokamak divertor simulator dedicated to fusion-relevant PSI studies. The CIMPLE-PSI facility was indigenously designed, developed, and commissioned, and was demonstrated to be among the few experimental platforms worldwide capable of simultaneously reproducing ITER-relevant ion flux ($\sim 10^{24}$ $m^{-2}$ $s^{-1}$) and extreme heat flux up to 5.1 MW $m^{-2}$ (2012–2018) [1]. Over the past several years, this facility has been extensively used to investigate the steady-state helium plasma exposure behaviour of key candidate plasma-facing materials, including tungsten, IN-RAFM steel, and high-entropy alloys such as W–Ta–Cr–V [1–4]. These studies focused on the formation and dynamic evolution of helium bubbles during plasma exposure, and their effects on the surface characteristics of the irradiated materials. A notable finding was the demonstration, contrary to prevailing understanding, that helium-irradiated tungsten can exhibit retarded recrystallization even at extreme target temperature as high as 1866 K. This body of work led to the first and only three CPP-IPR publications in the journal *Nuclear Fusion* [1–3], as well as two poster presentations, including an overview poster, at IAEA Fusion Energy Conferences. These results were continuously highlighted by ITER-India in the ITPA Coordination Committee meetings as integral part of India's domestic fusion program. More recently, CIMPLE-PSI laboratory worked with CPP-IPR Pulsed-Power Technology

Laboratory to investigate ITER-relevant thermal-shock irradiation effects in tungsten and high-entropy alloy thin films using an existing low-energy (2.2 kJ) plasma focus device. These experiments emphasized synergistic effects arising from simultaneous helium ions irradiation under extreme surface temperature conditions, exceeding even the melting point of tungsten. The presentation concludes with a brief outline of future research directions.

**References**


[1] M. Kakati *et al.*, Nuclear Fusion **59** (2019) 112008.

[2] T. Sarmah *et al.*, Nuclear Fusion **60** (2020) 106026.

[3] M. Rahman *et al.*, Nuclear Fusion **65** (2025) 016017.

[4] D. Raju *et al.*, Current Science 128 (2025) 00113891.