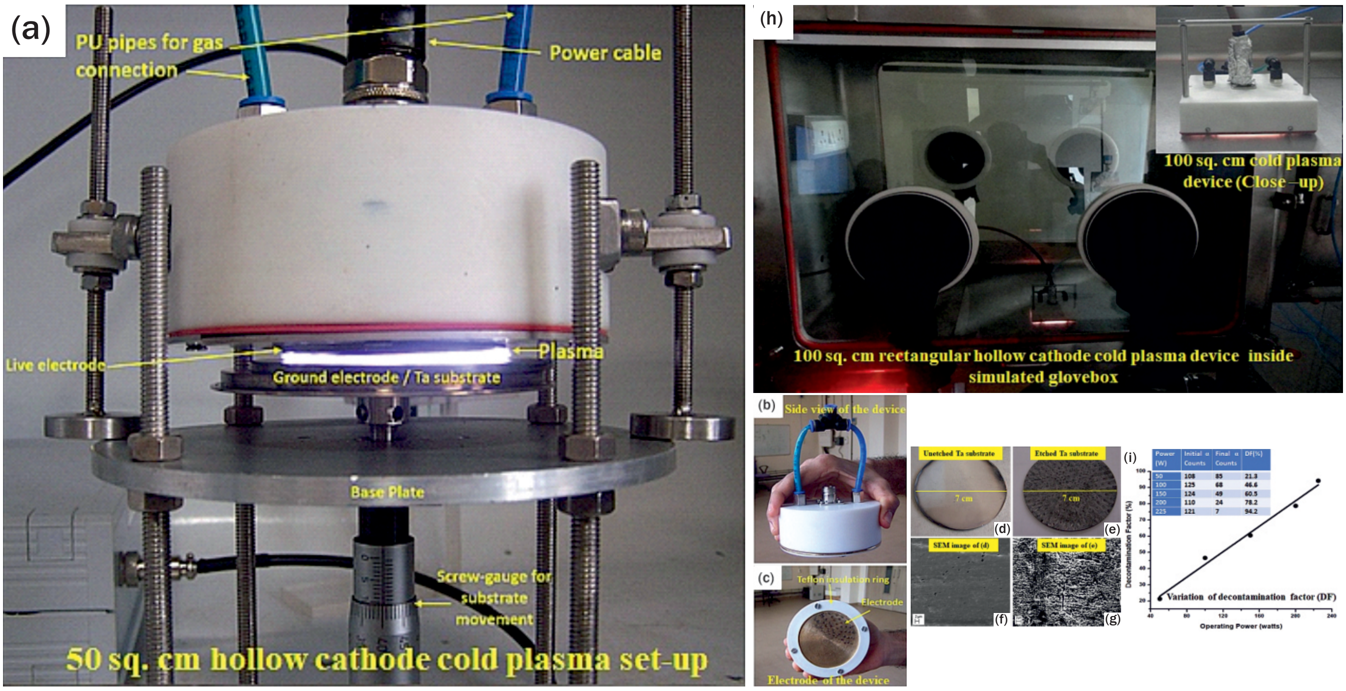
Cold Plasma Etching Tech for Solid Radioactive Waste Mitigation

From Laboratory Demonstration to Potential Glove box-Scale Deployment



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The APPJ device has been upgraded to a 100 cm² rectangular version that can be easily manoeuvred on the surface to be decontaminated. The technology holds strong promise for future applications in safe radioactive waste decontamination and disposal.

Over the past several years, the Laser & Plasma Technology Division, BARC has been engaged in the development of a cold plasma-based chemical etching technique for safe and effective decontamination of radioactive surfaces. The approach uses cold atmospheric pressure plasma generated from optimized mixtures of Ar, He, CF_4, and O. Dissociation of CF in the plasma yields reactive fluorine species that convert actinides like U and Pu into volatile hexafluorides, enabling efficient surface decontamination. Our initial success was reported in a study (*Environmental Technology & Innovation, 12 (2018), 219-229*), where a 2.45 GHz microwave APPJ device demonstrated up to 94% removal of synthetic Pu contamination from glovebox surfaces. Despite the high decontamination efficiency, the active plasma area was limited (2–6 mm^2), prompting further research. Subsequently, a 13.56 MHz RF-based hollow cathode plasma device was developed (Figure (a)), significantly scaling up the effective treatment area to 50 cm^2. Extensive testing on tantalum (a Pu surrogate) and synthetic U-laced stainless-steel samples confirmed the efficacy of the plasma-etched fluorination process. These results, recently published (*Journal of Nuclear Materials, (2025,) 156039*), showed over 94% decontamination and highlighted the critical role of oxygen in stabilizing plasma and aiding etching.

We have now upgraded the device to a 100 cm^2 rectangular version (Figure (h)) that can be easily manoeuvred on the surface to be decontaminated. Further modifications in the device and its testing in active environment are being planned. This scalable, substrate-independent, and cold plasma technology holds strong promise for future applications in safe radioactive waste decontamination and disposal.