Cross machine investigation of magnetic tokamak dust

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The presence of magnetic dust in tokamaks can be problematic due to its ability to mobilize prior to plasma initiation and the possible interference with the plasma start-up phase [1]. This investigation reveals, for the first time, the presence of in-vessel magnetic dust in tokamaks with different first wall materials.

Magnetic dust collected in Alcator C-Mod, COMPASS, DIII-D and FTU has been analyzed using Scanning Electron Microscope, Energy Dispersive X-ray Spectroscopy and X-ray Diffraction Spettroscopy. Magnetic dust can be shaped as splashes, spheres or flakes, with dimensions ranging from few microns up to several hundred microns. The basic composition is steel or nickel. The low oxygen surface coverage of spherical dust and splashes suggest that they originate from plasma-surface interactions. XRD analysis of dust collected from FTU and COMPASS reveals that dust has undergone an austenite-to-ferrite phase transformation and is mainly ferromagnetic, while the XRD spectrum of dust from Alcator C-Mod (mainly flakes) is similar to that of an austenitic stainless steel that is paramagnetic.

A preliminary evaluation of the magnetic force acting on paramagnetic dust for field values typical of Alcator C-mod (3-8T) has shown it is about ten times greater than the gravitational force, so that even paramagnetic dust flakes can be mobilized prior to the plasma discharge. Thus, the presence of magnetic dust can be an issue in future fusion reactors where plasma breakdown is critical and reduced activation steels are envisaged as a possible plasma-facing and structural material.

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