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Investigation of diamond-like carbon samples as a charge state conversion surface for neutral atom imaging detectors in space applications

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The detection of energetic neutral atoms is a substantial requirement on every space mission mapping particle populations of a planetary magnetosphere or plasma of the interstellar medium. For imaging neutrals, these first have to be ionized. Regarding the constraints of weight, volume and power consumption, the technique of surface ionization complies with all specifications of a space mission. Particularly low energy neutral atoms, which cannot be ionized by passing through a foil, are ionized by scattering on a charge state conversion surface.

Since more than 30 years intense research work is done to find suitable materials for use as charge state conversion surfaces. Crucial parameters are the ionisation efficiency of the surface material and the scattering properties. Against all expectations, insulators showed very promising characteristics for serving as conversion surfaces. Particularly diamond-like carbon was proven advantageously: While efficiently ionising incoming neutral atoms, diamond stands out by its durability and chemical inertness. In the IBEX-Lo sensor, a diamond-like carbon surface is used for ionisation of neutral atoms. Energy resolved maps of neutral atoms from the IBEX mission revealed phenomena of the interaction between heliosphere and local interstellar medium (LISM) that demand for new theory and explanations [McComas et al., 2011]. Building on the successes of the IBEX mission, a follow up mission concept to further explore the boundaries of the heliosphere already exists. The Interstellar MApping Probe (IMAP) is planned to map neutral atoms in a larger energy range and with a distinct better angular resolution and sensitivity than IBEX [McComas et al.]. The aspired performance of the IMAP sensors implies also for charge state conversion surfaces with improved characteristics.

We investigated samples of diamond-like carbon, manufactured by the chemical vapour and pulsed laser deposition method, regarding their ionisation efficiency, scattering and reflexion properties. Experiments were carried out at the ILENA facility [Wahlström et al., 2013] with hydrogen and oxygen atoms, which are the species of main interest in magnetospheric research [Wurz et al., 1997]. Results of very narrow scattering cones and sufficient ionisation efficiency show that diamond-like carbon still is the preferred material for charge state conversion surfaces. But our measurements show that new surface technologies offer improved diamond conversion surfaces with different properties and hence the possibility for improvement of the performance of neutral atom imaging instruments.

References:

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