Spherical EUV and Plasma Sensor (SEPS)

a Standard Monitor for Measuring the Plasma and EUV Environment in Space

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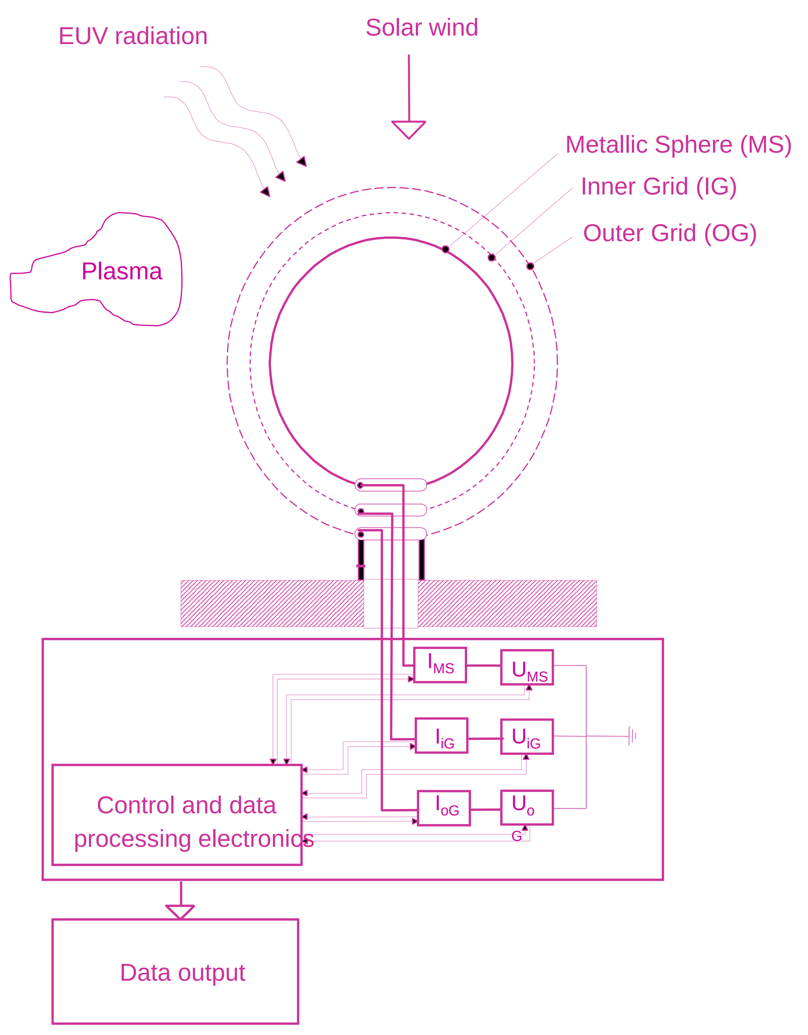

Fig. 1: SEPS-sensor consists of three isolated spheres, the metallic sphere, a highly transparent inner grid, and an outer grid

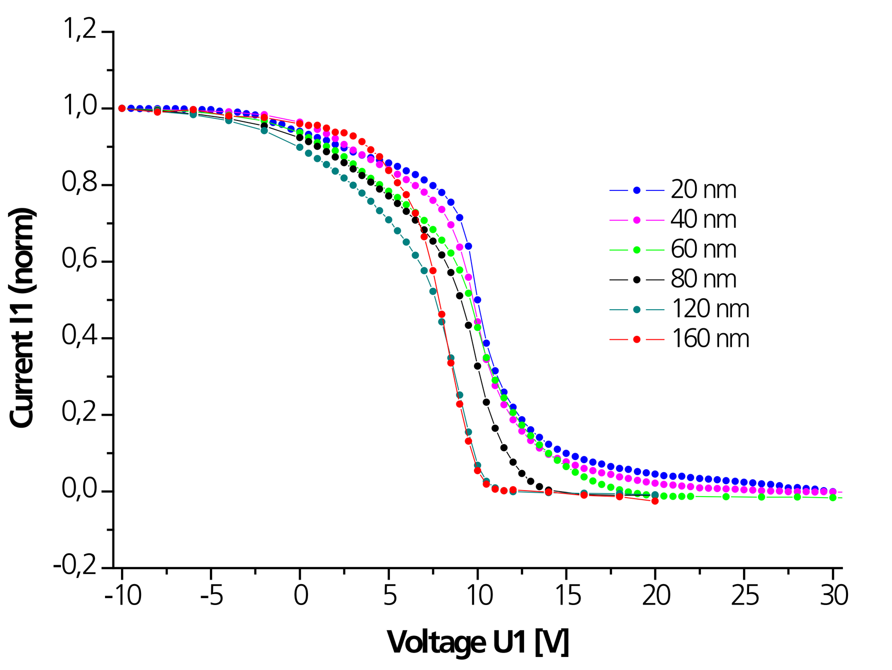

Fig. 2 EUV-Mode measurements with synchrotron radiation of different energies

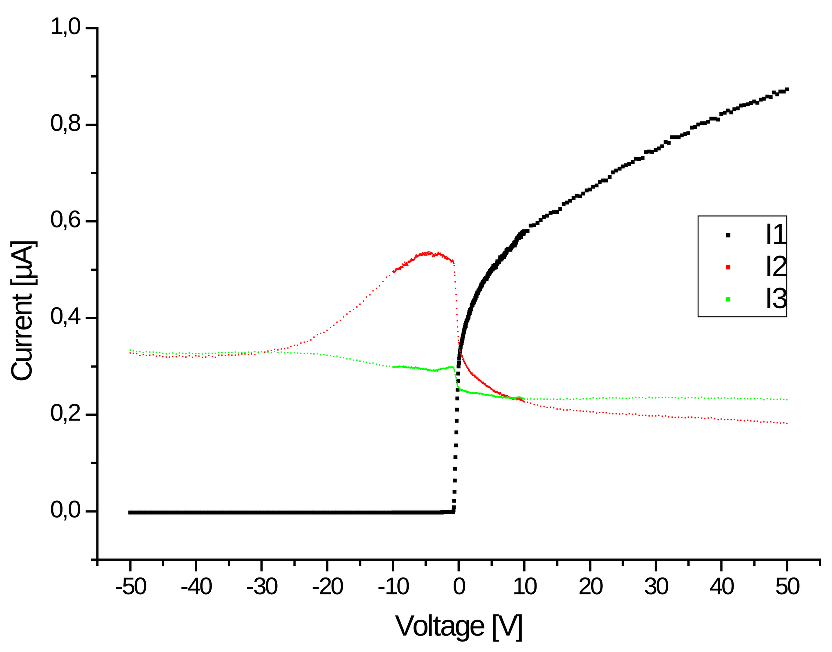

Fig. 3 Measurement with Shielded Langmuir Mode to estimate the plasma electron temperature

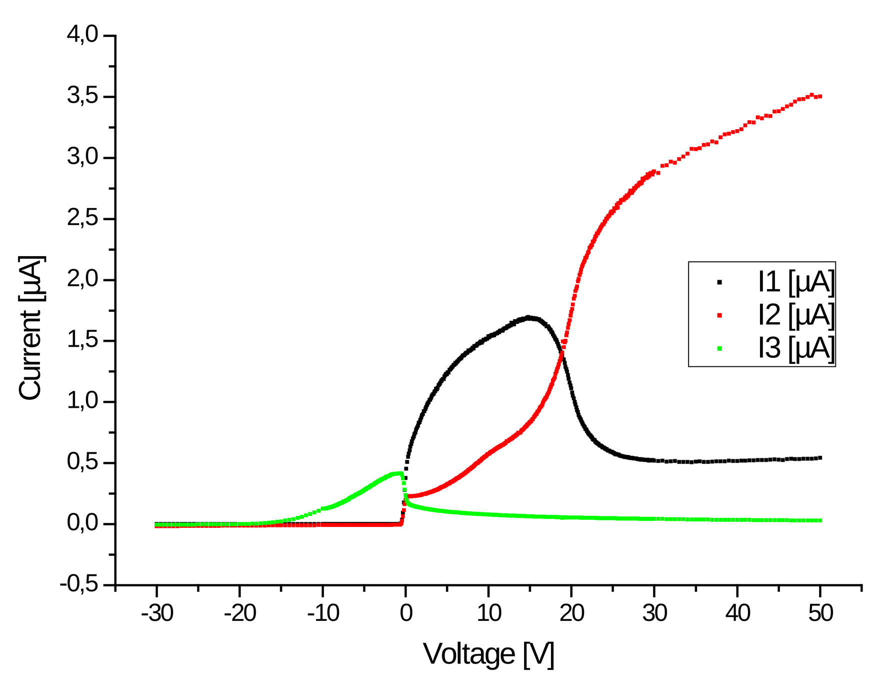

Fig. 4 Measurement with RPA-Electron Mode

Scope of the SEPS Sensor

The novel low-cost device consists of three isolated spheres, the metallic sphere (MS), a highly transparent inner grid (IG), and an outer grid (OG) (Fig.1). Each of them is connected to sensitive floating electrometers. Simply by setting different potentials to the inner and outer grid as well as to the sphere and varying the voltage either of the inner grid or of the sphere, measurements of the ambient plasma parameters and of the extreme ultraviolet (EUV) radiation can be achieved. Due to the spherical geometry, the detector does not require any (solar) pointing device.

Parameters to be Measured

The versatile instrument SEPS enables measurements of the ionising ***spectral solar EUV irradiance*** (15-200 nm), of ***plasma parameters*** such as electron and ion densities, electron energies and temperatures as well as ion composition. It can be operated in MEO orbits, in the interplanetary medium (solar wind and EUV measurements for example aboard the Solar Orbiter), and in the planetary ionospheres as well. ***Charging of satellites*** can be determined, too.

Application and Scientific Topics

The primary goal is to study the impact of solar activity events (space weather) as well as subsequent reactions of the ionospheric/thermospheric system. There are solar irradiance and wind variations in various time scales (solar cycle, seasonal, solar rotation, short scale eruptions as solar flares, which are then often inter-related with solar disturbances such as CMEs) and their appearance as plasma density variations with different time scales in different regions.

During disturbances the various influences (i.e. solar irradiance variations, geomagnetic disturbances, thermo-spheric storm effects etc.) interfere in a non-linear way and they can sum up to large variations also during short intervals. The analysis of disturbances, which result in geomagnetic, ionospheric, and thermospheric disturbances and storm events, in particular large storms like the so-called superstorms of fall 2003, should be investigated in more detail to study the impact on communication signals such as generated by GNSS navigation satellites.

SEPS Sensor Description

The outer diameter of the sensor is 8 cm. The mass is <150 g (without electronics). It is a device with very stable calibration parameters over long periods.

The following measurement modes can be carried out:

Table 1

	Voltage		
Mode	**sphere**	**inner grid**	**outer grid**
Langmuir	+8…-8	+8…-8	+8…-8
Shielded Langmuir	+20…-70	0	0
Plasma shielded Langmuir	+20…-70	V_{pl}	V_{pl}
RPA electron	+20	+10…-70	0
RPA plasma electron	+20	+10…-70	V_{pl}
RPA ion	-20	+70…-10	0
RPA plasma ion	-20	+70…-10	V_{pl}
EUV	+70…-70	-50	+50
Calibration	0	-70	+70

Fig. 5 Spherical SEPS sensor

Laboratory Measurements

For EUV radiation measurements the SEPS is taking advantage of the outer photo effect: The outer plasma is rejected by the inner and outer grids from MS by preset voltages (see Table 1). While sweeping V_{MS}, photoelectrons generated by the absorption of EUV photons in the metallic sphere are either collected by the inner grid (negative range of V_{MS}) or re-attracted in the metallic sphere potential (positve range of V_{MS}) . The positive range of V_{MS} takes into account that the energy of the photoelectron depends on the energy of the incoming EUV photons. The evaluation of the current I_{MS} provides the incoming spectral EUV irradiance data. The maximum current I_{MS} of the negative range of V_{MS} is a measure for the total EUV flux. Measurements with synchrotron radiation are shown in Fig. 2.

The plasma parameters can be estimated by evaluating the data of the Langmuir Modes and the RPA Modes. In the RPA Modes the SEPS sensor is operated as a Retarding Potential Analyser. Fig. 3 shows a measurement with the Shielded Langmuir Mode to investigate plasma parameters. Due to the potential at the outer grid, the surrounding plasma will be shielded and does not affect or influence the measurement.

Fig. 4 shows a measurement with RPA Electron Mode.

Conclusion

The measurements demonstrate the capability of SEPS for measuring wavelength dependent EUV photon fluxes as well as plasma parameters.

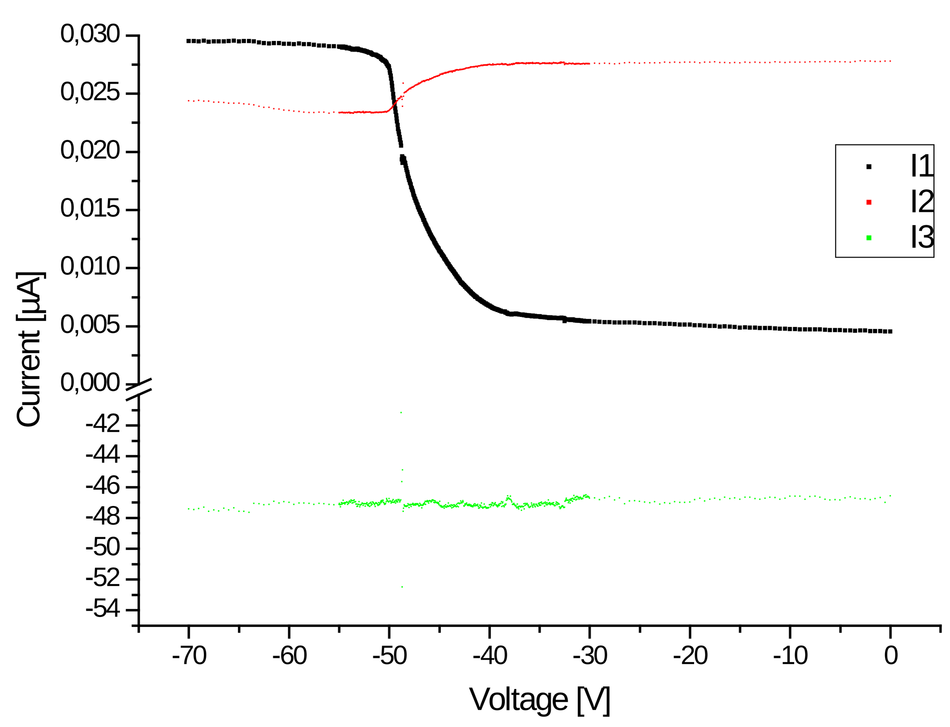

Fig. 6 Measurement of the photon current with EUV-Mode from recombined Ar atoms in the plasma chamber form ESTEC

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