Titolo: FLAIRS - eFficient pLasmA Intelligent Reflecting Surface

Codice MUR: P2022RFF9K

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Durata: 30/11/2023 - 29/11/2025 (24 mesi)

Budget totale progetto: 239.997,00 €

Budget UNIPD: 118.849,00 €

Abstract del progetto: The FLAIRS project aims at developing and investigating the very new technology of plasma-based Intelligent Reflecting Surfaces (IRSs). In these devices, reconfigurable plasma elements (e.g., in terms of density) are employed to control the reflection of an impinging Electromagnetic (EM) signal with regards to phase, amplitude, and polarisation.

Plasma-based IRSs can be included in the broader category of Gaseous Plasma Antennas (GPAs), namely devices that exploit plasma, rather than metal, to handle EM signals. GPAs present several unique features with respect to their metallic counterparts.

When the plasma is turned off, a GPA reverts to a dielectric vessel, namely it "disappears" from an electric perspective. Instead, when the plasma is on, the EM fields scattered by a GPA can be massively reconfigured electronically. In fact, the electric response of a GPA depends on the plasma properties (e.g., density), which in turn are determined by the power provided to the discharge.

Thus, GPAs are a game-changing technology for those application fields in which the need to reconfigure the radiation pattern is associated with the necessity to minimise interference or to protect sensitive data (e.g., 5G/6G networks, and satellite communications).

Generally speaking, the IRS technology is intended to support 5G/6G communication protocols and provide ultra-wide band coverage. IRSs are classically implemented via phased arrays or metasurfaces, namely each unit cell that constitutes the surface can independently impart an amplitude and phase shift to the impinging signal. Thus, IRSs are able to achieve several appealing functions, such as creating virtual line-of-sight (LoS) to bypass obstacles via smart reflection, and adding extra signal paths toward desired direction to improve the channel rank condition. Nonetheless, classical IRSs present some criticalities, for example the modulus of the reflection coefficient is substantially attenuated at 0° phase shift due to the higher losses associated with the in-phase reflection of the imping wave. The new emerging technology of plasma-based IRSs might be key to solve this issue and to enable other disruptive features (e.g., in terms of polarisation control) hardly achieved by classical systems.

Specifically, the FLAIRS project has the following high-level objectives. First, a thorough theoretical analysis will aim to explore the beam-steering and polarisation conversion capabilities of plasma-based IRSs. Second, technological improvements will be implemented to optimise plasma sources for the application in the telecommunications field. Third, the first proof of concept of the plasma-based IRS technology will be realised and tested. As a result, the target Technology Readiness Level (TRL) for plasma-based IRSs is 4, while it is expected to increase up to 6 for the plasma sources.

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