



## #PLATH00064

SOUR / Plasma sources and electrical discharges

### Power balance in microwave microplasmas generated in capillary tubes

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#### Abstract content

Over the last years, we have designed and tested several launchers able to generate microwave microplasmas in dielectric capillary tubes. Advantages of microwaves are numerous: plasmas can operate over a large range of pressures (from  $10^{-4}$  mbar to atmospheric pressure), with very low power (a few W to a few tens of W), in continuous mode, and electrodeless. The obtained microplasmas turn out to produce high electron and ion densities ( $10^{14}$  cm<sup>-3</sup> range), high power density (up to 10 kW.cm<sup>-3</sup>), high amount of active species ( $10^{12}$  cm<sup>-3</sup> range for argon metastable states) and high amount of photons, all of them interesting for a large panel of potential applications. Motivation to our study comes from the fact that the power balance in microwave microplasmas is almost never discussed. In the best cases, authors only report input and reflected measured powers and suppose that the difference is coupled to the plasma. The current work is thus dedicated to determine the microwave power really coupled to the plasma. It requires a complete power balance study taking into account all the power loss possibilities. Our measurements put into evidence the negligible nature (<1 %) of a large part of the loss channels: microwave field leakage, optical radiation from the plasma, chemistry and post-discharge heating. The power balance will therefore be made solely from measurements of incident and reflected powers, heating of the microwave coupling elements and heating of the external walls of the capillary tube. These balances will be presented without plasma, with an argon plasma at low pressure, and at atmospheric pressure and/or in a reactive argon/air mixture. Our measurements show that without plasma, almost all the incident microwave power is back reflected (> 90%) and about 5% is lost in heating of the microwave coupling elements. With plasma, overall, the reflected power becomes lower (25-60% of the incident power), the heating of the microwave coupling elements higher (15-30%) and the power transmitted to the plasma, measured via capillary heating, is relatively low (5-20%). This is striking different compared to numerous studies considering only the incident and reflected measured powers, giving power transmitted to the plasma of the order of 90 % of the incident power. A strong conclusion remains from this study: the real power coupled to the plasma is, in the best case, lower by a factor of 2 to 3 compared to what is traditionally reported in the literature.