Microwave Drilling

Executive Summary

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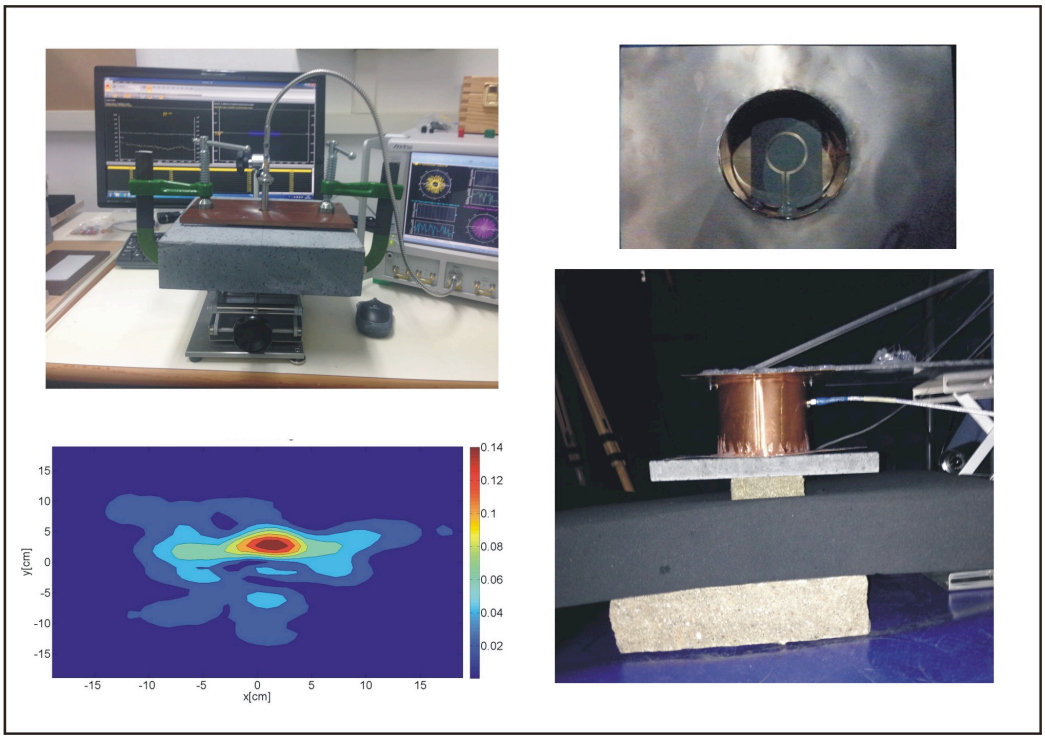
Picture:



Motivation:
The scientific goal of the study was the investigation of the electromagnetic and mechanical response of relevant basalt-like materials after near-field radiation exposure, to assess the performances of microwave-assisted drilling technology.

Methodology:
Microwave drill technology leads to overcome some severe issues of standard mechanical drill, such as the need of fast rotating parts, the presence of wear and fear and vibrations on the drill box; however, researches conducted till now have revealed some drawbacks related to the adoption of microwave-assisted drilling, namely the low penetration depth (only a few cm) and the requirement of high power (around 1kW). Thus, the specific objective of this study was the investigation of microwave–assisted drilling, based on near-field approach, to reach enhanced penetration depth, but requiring lower power with respect to existing techniques. In order to achieve the above goal, a preliminary investigation of the electromagnetic properties of basalt rocks has been conducted. Then, an innovative Bessel-beam launcher has been designed and applied to rock materials (basalt and marble), to demonstrate the ability to reach high penetration depths (about 15 cm) and to reduce the rock hardness by acting on the material permittivity.

Results:

- Successful design, realization and test of a Bessel-beam launcher, able to give reduced spot size (about 2 cm within X-band) and to reach high penetration depth (about 15 cm within X-band)
- Relatively low power requirements (about 100 W) to reach high penetration depth (about 15 cm)
- Measured permittivity decrease (and expected hardness reduction) when applying Bessel-beam launcher on rocks
- Measured hardness reduction when applying Bessel-beam launcher on basalt rocks

Publications:

- S. Costanzo, G. Di Massa, A. Borgia, A. Raffo, , T.W. Versloot, L. Summerer, “Microwave Bessel beam launcher for high-penetration applications”, submitted to *EuCAP 2016, 10th European Conference on Antennas and Propagation*, Davos (Switzerland), 11-15 April 2016.
- S. Costanzo, G. Di Massa, A. Borgia, A. Raffo, , T.W. Versloot, L. Summerer, “Dielectric and hardness effects of microwave Bessel beam to planetary rocks for enhanced drilling tools”, submitted to *Planetary and Space Science*.
- S. Costanzo, G. Di Massa, A. Borgia, A. Raffo, , T.W. Versloot, L. Summerer, “Microwave Bessel beam launcher for microwave-drilling applications: design and experimental validations”, submitted to *IEEE Transactions on Geoscience and Remote Sensing*.

Highlights:

An X-band Bessel-beam launcher, giving a non-diffracting field with a 2 cm spot size and a maximum propagation distance of about 15 cm, with only 1% of reflected power, has been designed and experimentally validated. By acting on rock materials, a good temperature effect on lowering the permittivity and thus the rebound hardness is experimentally obtained, so leading to avoid the actual melting process. If addressing future researches to the design of high frequency (30 GHz or above) launcher, the power density could be increased, and a 'remote' drilling could be realized.