

Hyperthermia properties of fiducial markers used in Image-Guided Radiation Therapy

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SCOPE Investigating the hyperthermia properties of the fiducial markers employed in Image-Guided Radiation Therapy (IGRT) under application of external alternating current field, in order to find out possible therapeutic effects, currently unexplored, and to study the physics mechanisms of the observed macroscopic effects.

SAMPLES

Typical gold fiducial markers, are dispersed in gel samples, using various geometric configurations simulating the actual position of the markers in the clinical practice.

Hydrogel matrices used as tissue mimicking materials:

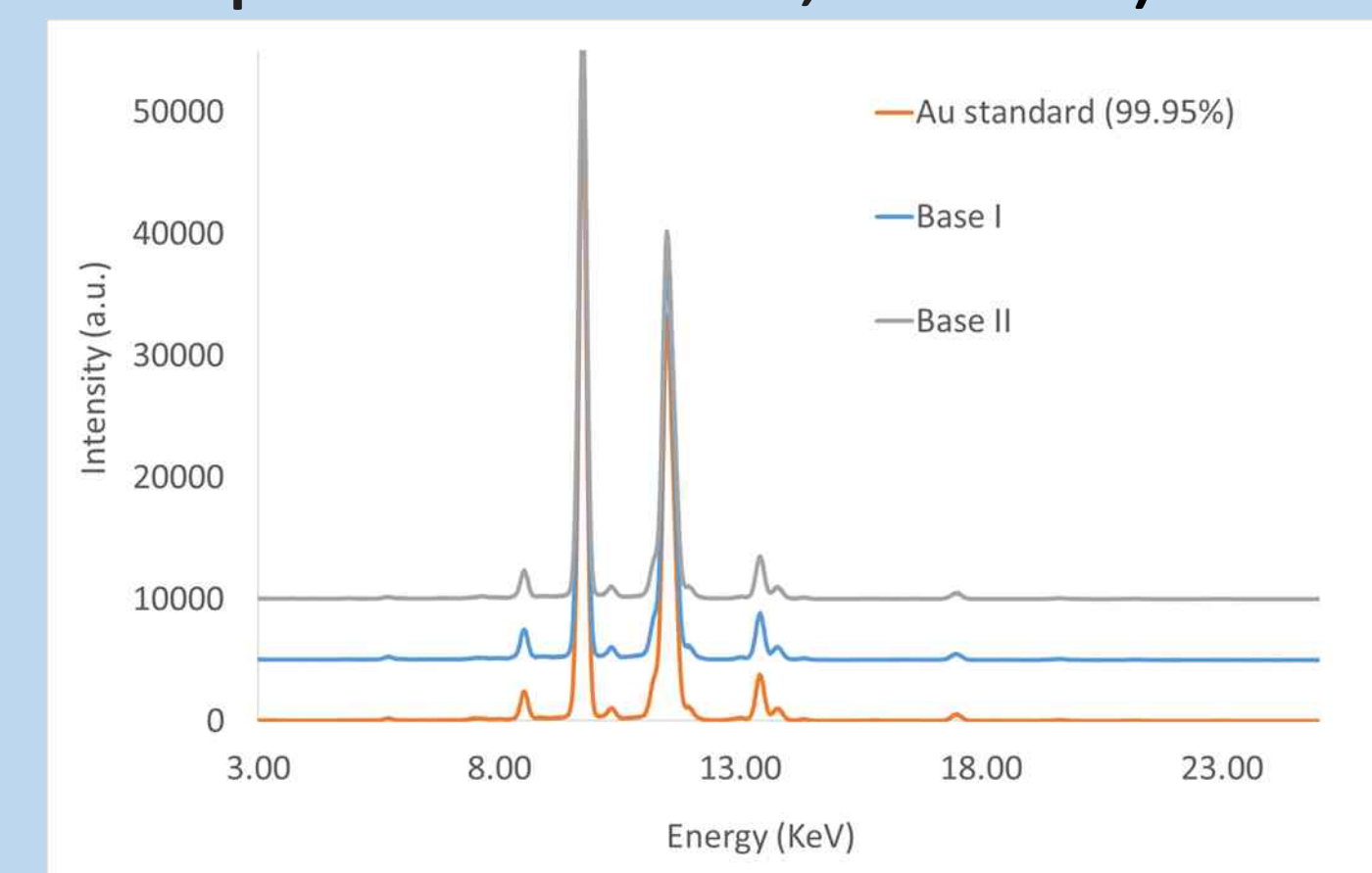
- 1.5% Agarose gel,
- 8.0% Glutaraldehyde-crosslinked poly(vinyl alcohol) (PVA) gel



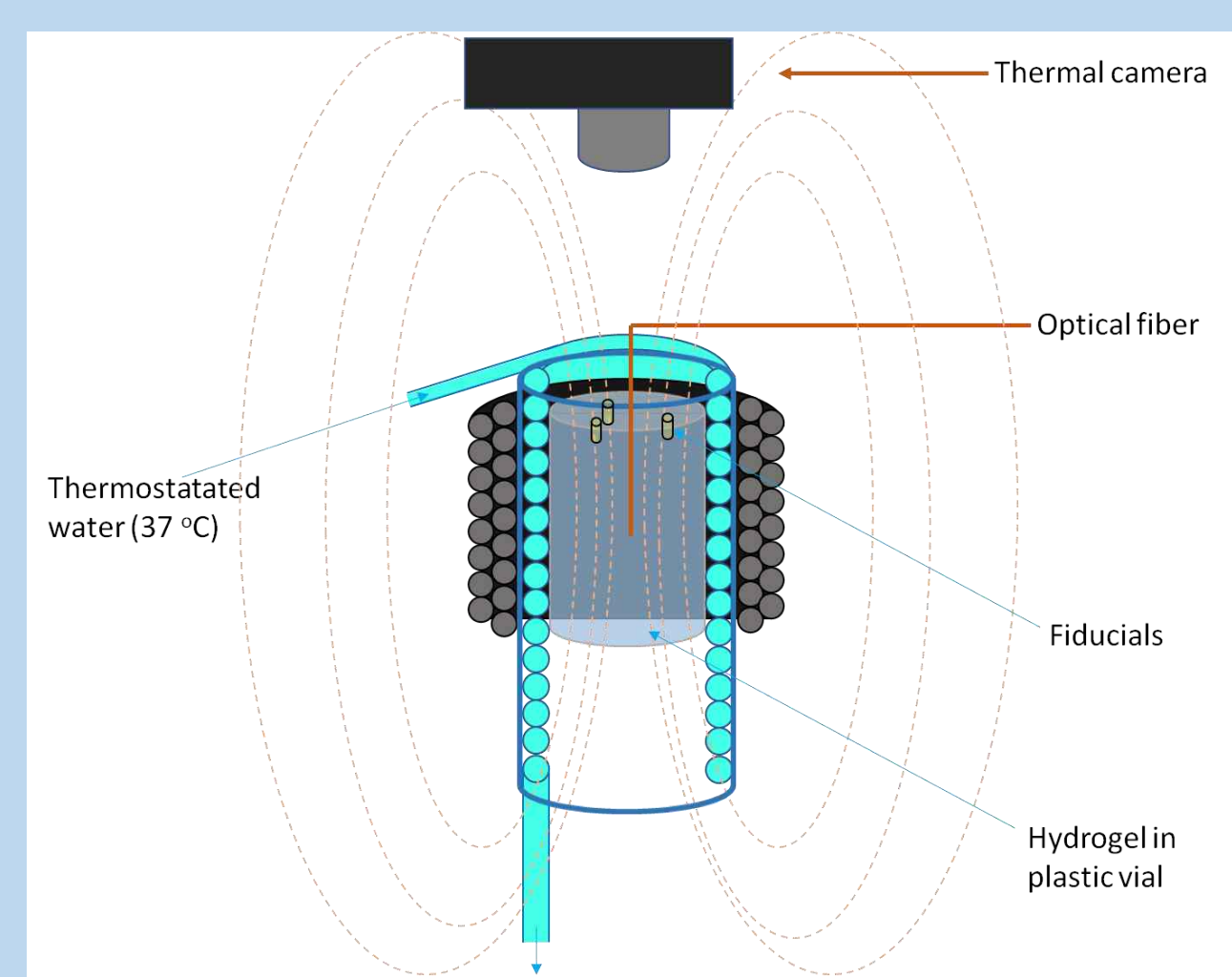
MATERIAL CHARACTERIZATION

The chemical composition of the samples was determined by XRF (Bruker Artax 200 spectrometer, filtered Mo anode tube, 40 kV and 0.8 mA, 0.65 mm spot diameter, 300 s) after cleaning in ultrasonic bath.

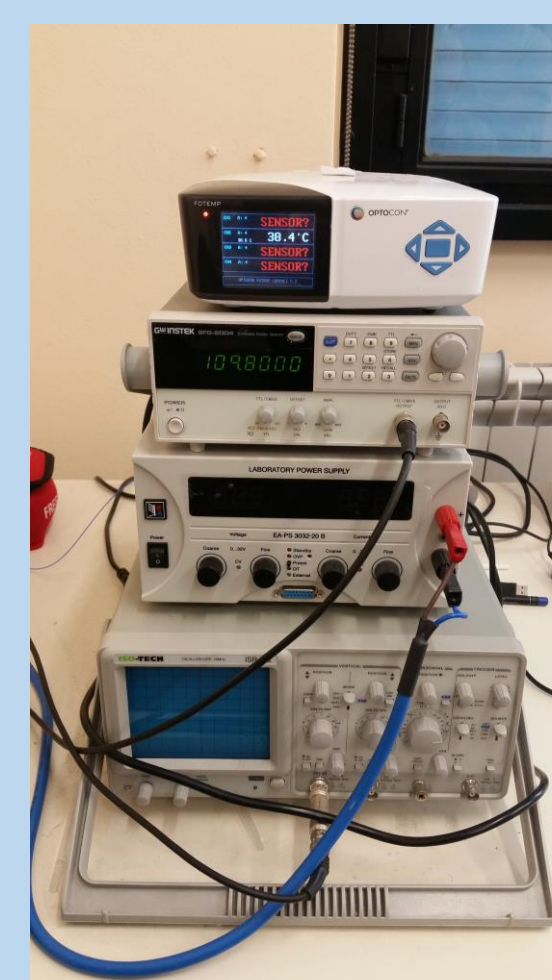
The obtained spectra show an excellent agreement of the two cylindrical sample bases and a Au metallic standard (99.95% certified)



EXPERIMENTAL SETUP



External thermalization system (liquid tube circulating system connected to a reservoir at controlled temperature) used to reach a quasi-adiabatic condition



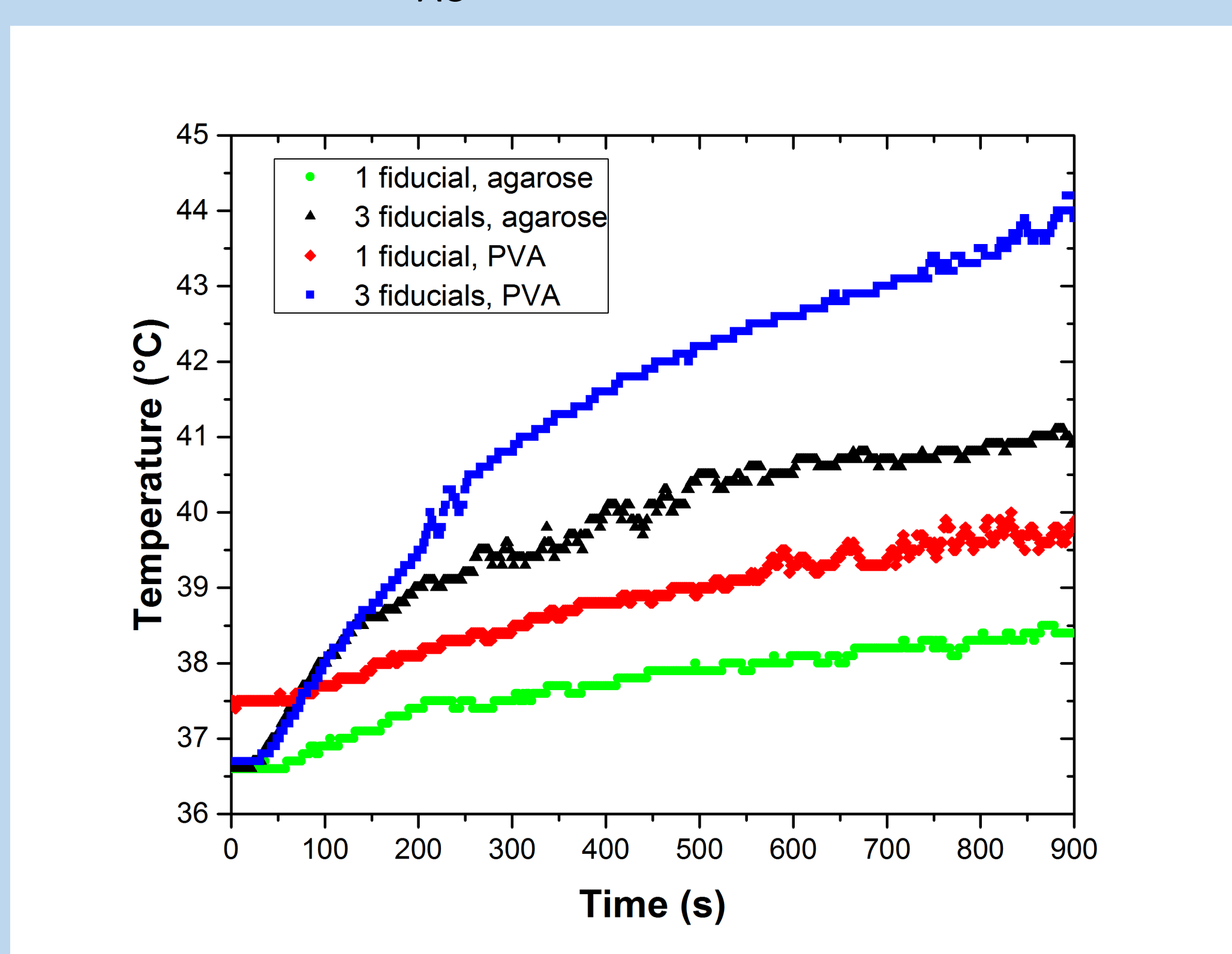
Magnetic stimulation:

- alternating current field (H_{AC}): from 7 to 20 kA/m
- frequency from 100 to 1000 kHz

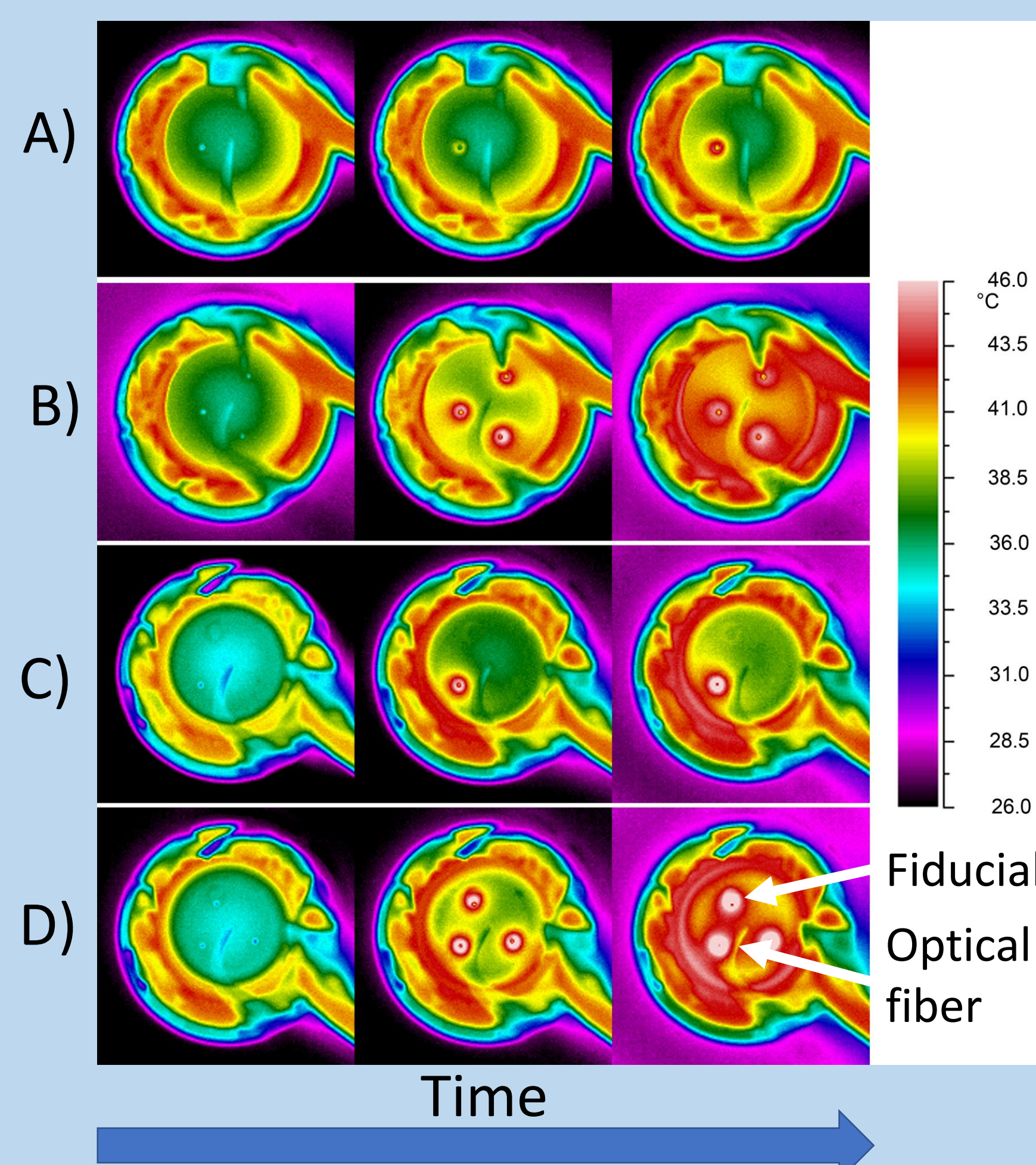
Temperature measurement:
- optical fiber based sensor
- high resolution thermal camera (FLIR A065, 640x520 pixel, 0.05 K thermal resolution)



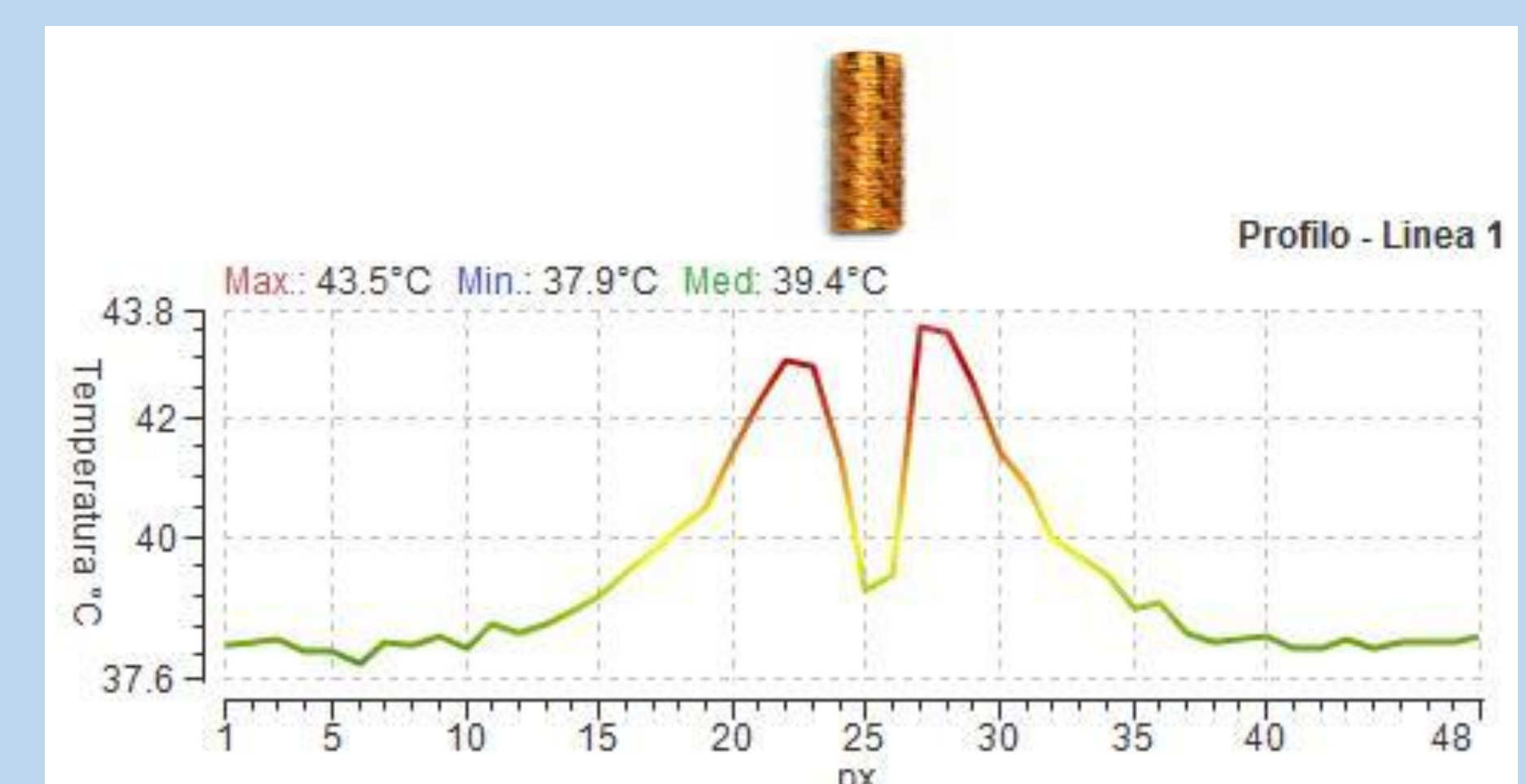
RESULTS H_{AC} of 109.8 kHz and 16.15 kA/m



Temperature traces measured by the optical fiber for different fiducial configurations under the application of magnetic field. The optical fiber was positioned ~ 7 mm far from each fiducials.



Images of the hydrogel matrices acquired by the thermal camera at different times after starting the magnetic stimulation. A) one fiducial in agarose, B) three fiducials in agarose, C) one fiducial in PVA, D) three fiducials in PVA.



Thermal profile of few cm long passing over one fiducial, in agarose gel sample, registered at $t = 120$ s after starting the magnetic stimulation. The temperature of the fiducial appears low due to its very low emissivity ($\epsilon = 0.01$).

CONCLUSIONS

Preliminary results attested an increase of the temperature in the gel matrices as effect of the heating of the gold fiducial markers under a suitable magnetic stimulation. Hyperthermia evidences were also evaluated in the typical experimental conditions ($2 < H_{AC} < 15$ kA/m and $f = 100$ kHz) employed at present in Fluid Magnetic Hyperthermia clinical trials.

Such evidences pave the way to extend the study to other types of fiducial markers and tissue samples, in order to interpret and model the observed phenomena.

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